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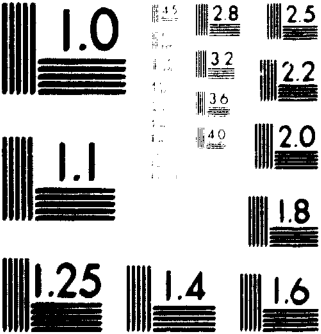


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

UNIDO CONTRACT 75/22

10080

TECHNO-ECONOMIC FEASIBILITY STUDY

FOR THE ESTABLISHMENT OF A PLYWOOD MILL IN THE SUDAN

F i n a l R e p o r t

to the United Nations Industrial Development Organization

Vienna

prepared by the Forest Research Institute in Zvolen
and Polytechna, Foreign Trade Corporation, Prague

J a n u a r y 1976

رُبَّ صَحْرَاءَ قَطَعْتُهَا
وَ ذَخِيرَةٍ وَجَدْتُهَا
وَ مُشْكِلَةٍ حَلَلْتُهَا

Many a desert have I crossed,
many a treasure discovered,
and many a difficulty solved.

Contents

I - Summary

In summer 1975, a Polytechna team consisting of team-leader F.PAPÁNEK, Forest Economics Expert, A.POLÁČIK, Wood Technologist, and J.BIM, Industrial Engineer, undertook a mission to the Sudan for UNIDO spending there a total of 22 manweeks.

The findings of the team can be summed up as follows.

The present market of plywood in the Sudan is characterized by exorbitant consumer prices and an acute shortage of plywood. Annual imports of plywood amount to 2,500 m3, but consumption could be easily doubled, if the plywood price could be substantially reduced.

In Equatoria and Bahr-el-Ghazal provinces there are important timber resources in the surroundings of Katire, Nzara and Wau, where an annual yield of between 12 and 13 thousand m3 of peeler logs can be expected. A detailed forest inventory in the area of the potential plywood mill is necessary for the preparation of a utilization plan of forests for plywood production.

From among sites mentioned, Wau is recommended, for the existing sawmilling capacities installed in the region and for other reasons, as the best possible site for establishing a plywood mill in the Sudan. The annual output of the plant is expected to be 5,000 m3 of plywood, the necessary timber supply is 11,100 m3 of peeler logs, the required labour force is 123 people. About the same number of people shall be employed in logging and forestry operations.

The locally produced plywood could be sold with an adequate profit in Khartoum to wholesalers for £S 180 per m3 instead of the present price of £S 390 per m3, and its retail price would be £S 198 per m3 instead of £S 500 per m3 as at present, thus reducing the present price level by 54 % and 60 %, respectively.

At the same time, important savings of foreign currency would be achieved. The project would bring to the Sudan important gains both in commercial profits and in macro-eco-

nomic benefits. The Costs/Benefits Analysis shows an internal rate of return of 23.2 %. The accumulated surplus after 15 years of operation according to the cash-flow forecast amounts to LS 1,593,317. The return on investment as ratio of net profit to investment is 8.3 % for the average year. Total value added is LS 492,442 in the eigth year.

As shown by these figures, the seller's market existing at present in the Sudan can be reversed by establishing a domestic plywood industry. After the first plywood mill in Wau a second and third mill should be established in quick succession in the South in order to reach larger production which would meet increasing demand and allow even for plywood exports.

Terms, Abbreviations, Conversion Factors

Measures

1′/one foot/ = 30.48 cm
1"/one inch/ = 2.54 cm
1 feddan = 0.42 ha
1 m3 /cubic metre/ = 35.31 cubic feet

Weights

1 m3 of logs /fresh/ = 1,000 kg
/air dry/ = 800 kg
1 m3 of plywood = 720 kg

Conversion

1 m3 of plywood = 150 sheets of 4′ x 6′ x 3 mm

Currency and exchange rates

One Sudanese Pound /£S/ = 100 Piasters /Pt/ = 1,000 milliemes /mms/

£S 1 = £ 1.33 = US $ 3
£ 1 = £S 0.75 = US $ 2.25
US $ 1 = £S 0.333 = £ 0.44

One Egyptian Pound /£Eg/ = 100 Piastres /Pt/ = 1000 milliemes /mms/

£Eg 1 = £ 0.8 = US $ 1.8 = £S 0.6
£ 1 = £Eg 1.25
US $ 1 = £Eg 0.555
£S 1 = £Eg 1.666

II Report

1 Introduction

In response to a request of the Governement of the Sudan for a feasibility study for plywood production a contract has been signed by UNIDO in Vienna and POLYTECHNA in Prague on 9 September 1975. According to this contract, the study should cover the following topics:

a/ present market for plywood in the Sudan and neighbouring countries and its future development;

b/ evaluation of the raw material situation;

c/ elaboration of a specific proposal for the erection of a plywood factory.

This work has been entrusted to a team consisting of the team leader, F.PAPÁNEK, Forest Economics Expert; A.POLÁČIK, Wood Technologist; and J.BÍM, Industrial Engineer.

The team spent a total of 22 weeks in the field, collecting necessary data and information and visiting potential sites for a plywood mill in the South of the country. The duration of stay of the members of the team in the field was as follows:

F.PAPÁNEK:	10 July to 6 October 1975	89 days
A.POLÁČIK:	10 July to 22 August 1975	44 days
J.BÍM :	14 August to 3 September 1975	21 days
		Total 154 days

The field work was hampered by the rainy season in the South and, in a certain way, also by the month of Ramadan in the North and in Egypt as is explained in detail in Annex 1/A.

The names of people contacted in the Sudan and in Egypt are given in Annex 1/B.

Acknowledgement

This study has been prepared by the team of experts in close cooperation with Sudanese authorities, institutions, counterparts and staff. In carrying out the necessary in-

quiries and field trips a great number of organizations, both public and private, have been contacted and a very large body of informers approached. It is a pleasure to recall these numerous visits and meetings with people who were all extremely kind and helpful and did their best to assist the experts in their task.

Special mention should be made of the Industrial Research and Consultancy Institute in Khartoum and its Director, Mr.Abdel Rahman Abdel Halim Obeid who provided in Mr.Ahmed Ali Ahmed an excellent counterpart for Khartoum. In the South the responsibilities of the counterpart were taken over very successfully by Mr.Cuor Deng Mareng, Inspector of the Regional Ministry of Commerce, Industry and Supplies in Juba. Also the Forestry Department made its staff available and several Conservators and their subordinates assisted the team-leader during his field trips in Equatoria and Bahr-el-Ghazal provinces.

Only thanks to the understanding, cooperation, and help of all these people and the sympathetic attitude of all the Sudanese autohorities, officials, managers and indeed the public at large could the present work be carried out. This is here gladly acknowledged.

2 The Market

Present Situation

For a long time it has been thought that there is an insufficient market for plywood in the Sudan, and only a few years ago the possibility of establishing a plywood and veneer factory was ruled out for want of adequate demand /1,2,3/.

Present annual plywood imports are in the range of 2,500 m3. In the last five years a slight tendency to increase has appeared. The main suppliers of plywood are China and Romania. Details are given in Annex 2/A.

Plywood is used mainly in furniture manufacture /about 80 %/, to a much smaller extent in construction for partitions and ceilings /20 %/. The use of plywood as a packaging material and for containers is only at its initial stages.

Governement agencies account for some 20 % of plywood consumption, the main bulk of plywood /80 %/ being used by the private sector.

The territorial distribution of plywood consumption in the country is essentially identical with the distribution of urban population and with the overall level of urbanization. Most urban centres have small scale workshops making furniture. Housing and construction in which plywood could be used is, like carpentry workshops, also limited only to urban communities.

By far the largest consumption of plywood is concentrated in the capital Khartoum, i.e. in the so called "Three cities" /Khartoum, North Khartoum and Omdurman/. Here occur the most important construction activities requiring plywood as a building material. Here also the furniture industry is concentrated as is shown by the following data: /3/

Furniture industry in the Sudan

	Number of workers in a plant		
	25 and more	less than 25	
	all in Khartoum	in Khartoum	outside Khartoum
Number of establishments	7	64	63
Number of workers	455	423	334
Output in LS	17,000	316,000	157,000

The rural population is using virtually no plywood. The per capita consumption of plywood in the capital is estimated to be four times the consumption of the remaining urban /and semiurban/ population. Consequently, the territorial distribution of plywood consumption is assessed as follows:

Area	Population total million	urban	Relative level of consump.	Weirhting	Estimated plywood consumption
Three Cities	0.8	0.8	4x	3.2x	1,600 m3
Remaining North	11.2	1.3	x	1.3x	700 m3
Southern Region	4.0	0.3	x	0.3x	200 m3
Total Sudan	16.0 mil.	2.4 mil.		4.8x	2,500 m3
Percentage	100 %	15 %			

The usual size of imported plywood is 4´x 6´x 3 mm. The wholesale price for this plywood is ₤S 390 /m3, the retail price varies from about ₤S 500 /m3 in Khartoum to more than ₤S 800 /m3 in the South. Details concerning the price of plywood are given in Annex 2/B.

The present excessive price of plywood in the Sudan is a consequence of inadequate supply of this commodity which does not meet actual demand.

The use of plywood and its future development should be viewed in close interrelation with the use of other wood-based panels and of sawn timber.

There is a small particle board plant producing in Khartoum which is protected from competition from abroad. Its products are used mainly in construction. The wholesale price of particle boards is ₤S 122 /m3, the retail price is ₤S 144/m3.

Small quantities of hardboards - not mentioned in the Foreign Trade Statistics - are imported from time to time and sold on the retail market for ₤S 340 /m3. Information concerning particle boards and hardboards is contained in Annex 2/C.

A considerable drain on the country´s foreign currency resources is caused by imported coniferous sawnwood which, according to the Foreign Trade Statistics, amounted in 1974 to over 32,000 tons with a corresponding value of over £S 3.6 million. Domestic sawnwood production, consisting almost entirely from hardwoods, is insignificant. For details see Annex 2/D.

Besides the sawmills, there is in Khartoum a match factory operating since the early 1960's /the splints are mostly imported/, and a packaging and carton factory which started production in 1960 and uses also imported raw material.

With regard to this situation in the market of forest products there is no doubt that the establishment of a plywood industry based on domestic raw material would greatly alleviate the existing shortage of wood-based building materials and of furniture and ease the strain timber imports make on the country's balance of payment.

Trends and Projected Consumption

Present consumption of plywood in the Sudan is 0.16 m3 per 1,000 inhabitants which is only one fifth of that in Africa /1970 - 0.8 m3 per 1,000 inhabitants/.

Consumption of plywood in the Sudan is expected to increase due to:

- elimination of exaggerated wholesale and retail price margins by matching supply with demand
- growth of population, especially urban
- higher living standards related to GDP
- further technical development and progress.

The rate of growth of population is 3.1% /4/ and, with the enormous land surface of the Sudan, and the improving living standards this rate will be probably maintained for some time in the future.

But much more important for the increase of plywood consumption is the growth of urban population. The percentage of urban population increased annually in the 9 years from 1955/56 to 1964/65 by 4.9 % /5/. This rate of increase may safely be projected also for the next 10-15 years in view of the influx of rural population into urban centres and the fast growth of towns and cities.

The population of the Sudan is expected to increase at the following rate:

Year	Total population /3 % growth/	Urban population /5 % growth/
1975	16.0 million inhabitants	2.4 million inhabitants
1980	18.6 " "	3.1 " "
1985	21.5 " "	3.9 " "
1990	25.0 " "	5.0 " "

The 1971/72 Gross Domestic Product per inhabitant in the Sudan is US $ 141 which is about two thirds of the average GDP for Africa /6,7/. The GDP is expected to grow in the Sudan at a rate of 3 % reaching

in the year	GDP in US $
1975	154
1980	179
1985	207
1990	240

According to an FAO study /7/ the recent and projected per caput consumption of plywood and veneer by regions is for Africa as follows:

Year	1961	1971	1981	1991
m3/1000 inhabitants	0.5	1	3	5

The rate of growth in % per annum is:

1961-1971	1971-1981	1981-1991
7.2	11.6	5.2

According to this same source the average GDP for Africa is, or is expected to be:

Year	1961	1971	1981	1991
US $ per caput	159	210	283	404

The rate of growth for GDP in % per annum is:

1961-1971	1971-1981	1981-1991
2.8	3.0	3.6

Plywood consumption in m3/1000 capita grows, in general, with increasing GDP in US $/caput, but consumption per 1000 capita is smaller in the Sudan than in Africa, as shown on the following table which is based on an assumed 10 % growth of plywood consumption:

Year	Population in mill.	GDP in US $ per caput	Plywood consumption m3/1000 capita	total in m3	at a growth rate of 10 %
1975	16.0	154	0.16	2,560	2,500
1980	18.6	179	0.22	4,092	4,000
1985	21.5	207	0.30	6,450	6,500
1990	25.0	240	0.42	10,500	10,400

The assumed 10 % growth rate of plywood consumption for the Sudan is consistent with the average annual growth rate for plywood consumption for Africa which is /7/:

8.4 % for the period 1950-1960

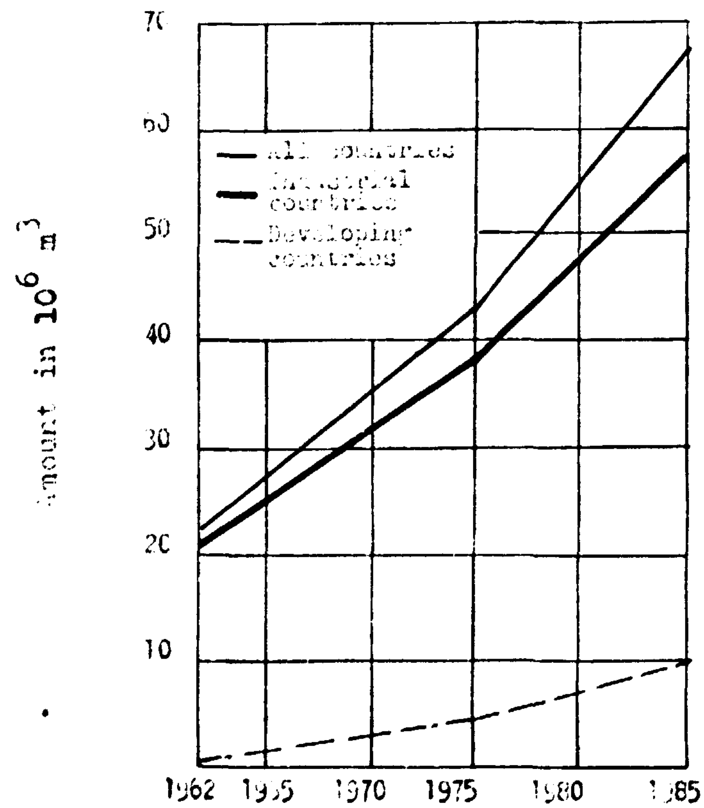
9.7 % for the period 1960-1970, and estimated to be

8.7 % for the period 1971-1981

11.1 % for the period 1981-1991.

The average annual growth of apparent plywood consumption in Africa from 1970 to 1973 even reached 13.3 %, and FAO /8/ anticipates a 15 % growth of plywood production in developing countries for the period 1975 - 1985 /see Chart 1/.

Chart 1



Projecting the present annual plywood consumption of 2,500 m3 at a 10 % growth rate into the future, the following target figures for plywood consumption are obtained:

in five years´time /1980/	4,000 m3
in ten years´time /1985/	6,500 m3
in fifteen years´time /1990/	10,400 m3

In attempting a break-down of this annual consumption of plywood according to end-uses the following assumptions are made:

1. Plywood consumption for furniture making will retain its dominant position but will grow at a somewhat slower rate than other consumption so that its weighting will be reduced in 15 years´ time from the present 80 % to about 63 %. Thus the volume of plywood consumption will increase 3.3 times in 15 years.

2. On the contrary, plywood consumption for construction, including waggon construction, will increase at an ever faster rate with a 6 times increased volume consumption in 15 years´ time. The corresponding increase in its weighting would be from 20 % to 29 %.

3. In the Southern Sudan, an extensive tea and tobacco plantation programme is under way. Already now a shortage of crates for packing tobacco is felt and the tea development will result in an ever growing demand for tea chests. The Army complains of the poor quality of particle board manufactured in the Sudan and would warmly welcome locally produced plywood for such end-uses as packing ammuniton etc. Plywood could replace metal in containers for air transport, for beverages /like Coca Cola bottles/ and fruits. The consumption of plywood for these and related uses is estimated to reach 200 m3 in 5 years, 500 m3 in 10 years and 800 m3 in 15 years.

Consequently, the following picture of plywood consumption according to end-uses can be expected:

Year	Furniture	Construction	Containers	Total consumption
1975	2,000 m3	500 m3	-	2,500 m3
1980	3,000 m3	800 m3	200 m3	4,000 m3
1985	4,500 m3	1,500 m3	500 m3	6,500 m3
1990	6,600 m3	3,000 m3	800 m3	10,400 m3

Potential exports

Sudan lies in the transitory belt connecting the tropical forests in the South and the desert in the North. Consequently, she would seem to be in a unique position to use her forest resources not only for meeting the country's own requirements in plywood, but also for plywood exports to neighbouring countries which have no forests, or which have not yet developed, or sufficiently developed, their own plywood production. Of special interest could be plywood exports to Saudi Arabia and Egypt, which are by sea within easy reach of the Sudan, but also to Sudan's southern neighbours like Zaire.

A striking development in world plywood trade is the changing international pattern stemming from the growth of exports from developing market economies, as has been pointed out at the New Delhi World Consultation on Wood-based Panels in 1975. Due to a number of factors such as its high value per unit of volume, plywood appears to have the greatest potential for international trade of all wood-based panel products. Veneer exports have grown over the past years nearly as fast as plywood exports.

In world trade sudden reverses may always occur, therefore exports of plywood should not be so big as to make the country heavily dependant on foreign sales. Such an approach would particularly suit the Sudan, since her timber resources are not so large as to enable considerable plywood exports, but nevertheless are sufficiently important to allow a minor part of the plywood production to be diverted to foreign markets, improving thereby the economic effect of the plywood industry. It is suggested that between one fifth and one third of the envisaged Sudanese plywood production could be set aside for exports. Such exports would off-set the adverse effect of imports of adhesives on the balance of payments, indeed they could result in net earnings of foreign currency by the plywood industry, if the price of Sudanese plywood were competitive in the world market.

During field work a short market survey was made in Egypt the results of which are given in Annex 2/E.

Egypt is consuming annually some 50,000 - 60,000 m3 of plywood, both imported and locally produced, and thus represents an important potential market outlet. Annual imports of plywood may amount to anything between 30,000 and 50,000 m3. Mahogany plywood of good quality, produced in the Sudan, would have a value exceeding by at least 20-30 % the usual sort of imported plywood, consequently it could be sold in the present market situation in Alexandria for a C and F price of about US $ 350-360 /m3. The freight rate for plywood from Port Sudan to Alexandria being US $ 48.26 /m3, the FOB price in Port Sudan for Sudanese plywood would be around US $ 300 per m3 which could be interesting and incite plywood exports from the Sudan to Egypt.

Still more than Egypt, Saudi Arabia would seem to be a possible outlet for Sudanese-made plywood, since the freight rate for plywood from Port Sudan to Jedda would be only US $ 23.33 /m3. No market survey regarding plywood has been made in Jedda, but later this may become necessary in order to promote plywood exports from the Sudan to Saudi Arabia.

In considering potential plywood exports, it should be borne in mind that mahogany-faced plywood sheets would represent on the international market a commodity that could compete as to quality and decorative value with any available brand of plywood and would easily compete with the kind of plywood supplied at present to countries in the Middle East. Sudanese plywood would have the advantage of the raw material not being expensive, and if in spite of the small capacity of the plant and the one-shift operation a reasonable production cost could be achieved by efficient management, if costs of internal transport would be lowered, and if a premium on foreign exchange earned is granted, then exports of plywood from the Sudan are a possibility which should be earnestly attempted.

Conclusion

Growing requirements for plywood in the domestic market and also potential opportunities for plywood exports to neighbouring countries warrant the establishment of a plywood industry in the Sudan. In determining the capacity of a plywood plant for the Sudan both the extent of present and future market requirements and the availibility of timber should be considered. Estimated demand for plywood in 1980 - when full production of the proposed plywood mill would have been reached - is 4,000 m3 per annum. The normal minimum economic capacity of a plywood plant is considered to be 5,000 m3 of plywood per annum. This capacity represents, at the same time, the maximum concentration of peeler logs which is economically feasible with regard to existing forest resources in the Sudan. Consequently, the only solution is the establishment of a 5,000 m3 plywood mill which would operate one shift. This would meet the country's demand for plywood in 1980 and, at the same time, allow for plywood exports of the order of 1,000 m3 per annum, should Sudanese plywood be available at a competitive price.

Looking further ahead, beyond the scope of this feasibility study, the following development of the plywood industry in the Sudan could be contemplated:

Period	Number of plants	Annual plywood production	Domestic consumption	Exports
1976-1980	1	5,000 m3	4,000 m3	1,000 m3
1981-1985	2	10,000 m3	6,500 m3	3,500 m3
1986-1990	3	15,000 m3	10,400 m3	4,600 m3

The successive increase of the number of plants instead of shifts is necessary because of the low stocking of forests which does not enable the economic concentration of larger quantities of logs at the factory site. According to the expected end-uses the following specification of plywood is recommended for the 5,000 m3 plant which is to be established:

Thickness	End-uses: Furniture	Construction	Containers	Exports	Total
3 mm	1,800 m3	-	100 m3	600 m3	2,500 m3
4 mm	800 m3	-	-	200 m3	1,000 m3
5-10 Ø 6 mm	200 m3	-	100 m3	200 m3	500 m3
15 mm	-	1,000 m3	-	-	1,000 m3
Total	2,800 m3	1,000 m3	200 m3	1,000 m3	5,000 m3

Dimensions	3-4 mm	10 mm	15 mm	Total
122 x 220 cm	2,000 m3	500 m3	-	2,500 m3
122 x 183 cm	1,500 m3	-	1,000 m3	2,500 m3
Total	3,500 m3	500 m3	1,000 m3	5,000 m3

For all boards urea formaldehyde adhesive should be used with the exception of 122 x 183 cm, 15 mm boards representing water and boil proof plywood for which the use of phenolic foils is recommended.

The size 122 x 183 cm, i.e. 4'x 6' is recommended because of the established market requirements for plywood sheets in the Sudan. But for the second plywood mill to be constructed in the Sudan a larger size, i.e. 122 x 244 cm /or 4'x 8'/ should be contemplated. Though such a size requires more expensive equipment, it could stimulate new uses for plywood and thus enlarge plywood consumption in the Sudan.

At present, no special measures for sales promotion seem to be necessary, in order to attain projected consumption figures with the only exception of one essential task: namely to make plywood of an acceptable quality available in sufficient quantity at a reasonable price.

In the calculation made in this feasibility study it is assumed that the present exorbitant consumer price for plywood sheets will be reduced by more than half, i.e. from £S 3.00 per sheet to £S 1.30 per sheet, if plywood imports are substituted by domestic production. It is needless to say that such an important price reduction would automatically increase demand for plywood to a multiple of its present level.

In order to improve the profitability of plywood production direct commercial relations with the end users are recommended through the establishment of a warehouse in Khartoum. The plywood mill in Wau would ship the plywood to Khartoum and sell it ex warehouse to consumers in Khartoum at the retail price and to wholesalers in the other urban centres in the North at the wholesale price. The plant in Wau would sell plywood ex factory to wholesale dealers in the South, as well as to plywood exporters. By establishing a retail outlet in Khartoum and Wau the selling price of plywood will be minimized and unnecessary intermediaries avoided.

3 The Raw Material

Present Situation and General Observations

Not much is known about the forests of the Sudan, though there are important timber resources in the South of the country. In the absence of any forest inventory, in lack of forest maps and working plans, it is extremely difficult to estimate potential yields of the forest.

The use of these forest resources is only beginning. Sawmilling capacity is only a fraction of the potential yield of the forests, and actual sawnwood output is still much lower than the installed capacity. Some data on forest resources and their utilization are given in Annex 3/A.

The sawmills are owned and operated by the Forestry Department, consequently no stumpage fee is paid for saw logs. Royalties are collected only on fellings made outside the forest reserves, their aim being the protection of timber resources by concentrating timber fellings in the forest reserves where plantations can be established after the fellings. In order to accumulate funds for the establishment of plantations after the utilization of the natural forest a recommendation is made in Annex 3/B to introduce a stumpage fee for peeler logs amounting to 60 Pt/m3.

The feasibility of plywood production depends largely on its integration with sawmilling. Indeed, only in this way will a rational utilization of the forest resources be achieved. Besides that, there is a close interrelation between the production of saw logs and peeler logs. As a matter of fact, both peeler logs and saw logs occur usually in the same tree and their seperation by crosscutting the stem of the tree is by far the decision involving the highest responsibility in logging operations. Only a well-trained forester, who is well acquainted with the requirements of timber for plywood production, should determine the actual line of separation betwen peeler log and saw log in the felled tree. The operation of crosscutting is of primary importance for the outturn of peeler logs. The relatively high percentage of 30 % peeler logs from the total volume of felled timber which is calculated in this report can be reached only with very careful and responsible crosscutting. Any lack of attention, interest or professional training with respect to this operation will result unavoidably in spoiling veneer and peeler logs and lowering their outturn. It is therefore absolutely essential for the successful utilization of timber resources for plywood production that logging operations for sawmilling and plywood manufacture should be carried out by highly qualified and responsible field staff who does not prefer supplying raw materials to a sawmill rather than to a plywood mill on departamental grounds but is on the contrary whole-heartedly interested in supplying the raw material needed to both operations according to the quality of the logs.

Peeler logs should be of the following lengths: 130, 190, and 230 cm, or their combinations: 260, 320, 360, 380, 420, 460 cm or more, if conditions of transport permit it. To these lengths 7 % should be added when cutting logs in the forest.

The present girth limit of 45" /i.e. 36 cm b.h.diameter/ is from the standpoint of plywood production too high and could be reduced to a girth limit of 37" /i.e. 30 cm b.h. diameter/, if silvicultural considerations would allow it.

It should be borne in mind, when establishing a plywood plant, that the plywood industry manufactures goods from raw material supplied by forestry. Consequently, this production is, from the viewpoint of national economy, a combined venture of agriculture and industry. The closer and smoother the cooperation between these two sectors, the better will be the results achieved by the plywood plant.

Another point that should be taken into account in planning logging operations is the rainy season which occurs all over the South of Sudan with rainfall concentrated in the summer months. In general, rainfall increases both as to amount and duration in the direction from North to South, from East to West, and, of course, with elevation. In the Imatong mountains the annual rainfall reaches an average of

1400 - 2000 mm most of which is precipitated during the seven months from April to October. A distinct dry season is only from December to February. In Juba the mean annual rainfall is 969 mm, the rainy season lasts from April to September. In Wau the mean annual rainfall is 1127 mm and the rainy season lasts from May to October /9/.

Logging operations should be concentrated as far as possible into the dry season and an adequate supply of roundwood should be stocked at the factory yards of the timber processing plants. In preparing working plans for the forests a distinction should be made between areas accessible only in the dry season and areas where logging could be carried out also in the rainy season. In these latter parts of the forest logging operations should be avoided during the dry season.

Normally logs should not be stored in the yard for more than three months. This would prevent the deterioration of logs by long storage. Insects or fungi seem to be of little peril for tropical hardwoods in log yards in the Sudan; the main concern should be the prevention of cracks, therefore protection of the log supply from direct sunrays is recommended. Should adverse climatic conditions require the stocking of a log supply for more than three months, sprinkling or other forms of log protection may become necessary /e.g. protective coating of log ends against checks and splits using tar oil, lime or paraffin, treatment with 4 % solution of $CuSO_4$ or $ZnCl_2$, protection by Wollmanit from the German Federal Republic, by UL salts from the German Democratic Republic, by Lastanox from Czechoslovakia etc./

Assessment of Timber Resources

At the time of the team's visit to the Forestry Department in Khartoum the Director, Mr.Kamal Osman Kalifa, pointed out that in his opinion there were four potential sites for the establishment of a plywood mill in the South, i.e.

1. the Imatong mountains
2. the Loka-Nuni area
3. the Yambio-Nzara area, and
4. the Wau-Raga area.

All these four sites were visited by the team and as far as possible short trips to the forest were made. At the Survey Department in Khartoum aerial photographs of some strips of forest surveyed ten to twenty years ago in the Imatong mountains, the Nzara region and halfway between Wau and Raga were inspected. Based on information provided by the local forest staff, on data contained in various reports, on the inspection of aerial photographs, and on personal impressions a preliminary evaluation of timber resources for the purpose of plywood production is made in Annex 3/C.

Among the forest regions inspected one - the Loka-Nuni area - was eliminated as unsuitable for plywood production. In the remaining three forest regions an annual supply of between 12 and 13 thousandt m3 of peeler logs seems to be guaranteed. In the Imatong Forest Reserve Katire was chosen as a possible location of the plywood mill, the other two contemplated sites are Nzara in western Equatoria and Wau in Bahr-el-Ghazal province. The logging cost is different in each case and the total cost of the peeler logs at the factory yard has been assessed as follows:

	Cost in £S per m3		
	Katire	Nzara	Wau
Stumpage	0.60	0.60	0.60
Felling and crosscutting	0.75	0.60	0.53
Skidding	2.50	2.00	0.75
Hauling	5.40	7.20	5.40
Road construction	1.92	2.12	1.00
Further cost items	1.16	2.32	2.47
Cost at factory yard	12.33	14.84	10.75
Supplement 10 % } Contingency 10 % } 20 %	2.47	2.97	2.15
Total cost of raw material	14.80	17.80	12.90

Because there is no experience with large-scale logging operations in the Sudan, a supplement is added as a safeguard against possible increase of logging cost in case large-scale operations should raise the present cost of contracting or require the stepping in of the Forestry Department.

It should be noted that the assessment of the raw material supply may convey a true general picture of each site, but needs further clarification and verification as to the surface of the forest, its compositon by species and its standing volume.

The need for a forest inventory to base the decision for any industrial development based on timber resources has been stressed many times in a number of reports. The idea of a plywood mill in the Suden which emerges in various reports during the 60's and 70's has been up to now always either evaded and deferred until the completion of a forest inventory, or rejected outright beause of an alleged lack of timber.

In this connection, special mention should be made of the Romanian report on wood utilization in the Sudan, presented by three foresters in 1972, which denies the existence of sufficient raw material for the establishment of a plywood mill with an annual output of 5,000 m3 and suggests the importation of peeler logs from the Central African Republic and from Zaire /10/.

Yet in spite of this report, all the evidence points to the fact that there exist in the southern Sudan - at least at the three mentioned sites - important resources of natural forests with large-sized trees of valuable species which occur in sufficient quantity to be used for plywood production. At the present stage of information regarding this forest resource it may be safe to assume that though a forest inventory - at least of the crudest type and confined only to the influx area of the potential mill site - is absolutely necessary to provide more information on timber resources and to start their rational utilization, there could be nevertheless no justification for claiming that a plywood plant cannot be erected on the grounds of an insufficient survey of the raw material. On the contrary, a positive decision on the establishment of a plywood mill would serve as an impetus and will be an economic justification for a closer survey of the forest, as well as hasten the collestion of information and data on the existing timber resources of the areas considered.

In considering this matter, distinction should be made between the viewpoint of feasibility of plywood production and its actual production. While it would be impossible, at the present stage of knowledge concerning the forests, to prepare a detailed technical project for the production of plywood, our information regarding the forest is sufficient to confirm, both with regard to quality and quantity of forests, the feasibility of such a project. Admittedly, assumptions were made in the calculations concerning the timber supply at the various potential sites, as to forest area, tree species and volume, which are at best "guesstimates" and may be altered by a subsequent inventory. Nevertheless, because of this uncertainty, provision has been made in the calculations to remain always on the safe side. But even if it should turn out that the quality of logs in the forest area selected or its volume have been overestimated there always remain two safeguards by which necessary adjustments could be made. The first adjustment measure would be the increase of the influx area so that additional timber supplies could be reached, though of course at a higher cost. This would be always feasible regarding the low cost of the raw material. The other means consist in a decrease of the supposed time period for using up the supply which in our calculations we took as 30 years, though ultimately a period of 15 years could well be accepted.

Conclusion and recommendations

From among the three forest regions where sufficient timber resources for plywood production can be found preference is given to Wau for several reasons.

Wau has the cheapest and best raw material, and the easiest terrain for large-scale logging operations. It has a railway connection with the North of the country and thus can provide the cheapest, quickest and most reliable transportation of plywood to the consumer centres. Development in and around Wau benefits of a high priority both socially and economically because of the need to create employment. The authorities of the Southern Region, and especially the

Forestry Department, put high priorities for the industrial development of the Bahr-el-Ghazal province, as they consider it the most backward part of the South.

The establishment and development of a plywood industry should be encouraged and facilitated by the Forestry Department. In order to achieve this as quickly as possible they must take the following measures.

Short-term measures

The most important conclusion from the present survey is to start with the least possible delay a forest inventory in the vicinity of the site selected for the plywood plant, as a follow-up to the feasibility study, either as part of the multinational aid programme for the Sudan, or on a bilateral basis. This forest inventory should prepare forest maps of the respective areas, determine stocking, tree species representation and annual yield, plan the outlay of a network of forest roads, and assist in testing mechanical properties and carrying out peeling tests of prospective tree species at the Soba Research and Education Institute and at the match factory in Khartoum. Terms of reference and a cost estimate are given in Annex 3/D.

It was originally intended to carry out peeling tests of up to five tree species in Czechoslovakia as part of the present feasibility study. Subsequent experience showed that there is no justification in carrying out tests in Czechoslovakia for the following reasons.

First, all the main tree species occurring around the possible site of plywood production have been already tested as to their suitability for plywood production by M.Tag Eldin Hussein Nasroun from the Soba Research and Education Institute in 1974 /Annex 3/E/. Besides that, the following 10 tree species have been tested at the Federal Forest Research Institute in Reinbeck /Federal Republic of Germany/: Cordia africana, Afzelia africana, Burkea africana, Prosopis africana /all excellent in technological qualities/, and Terminalia glaucescens, Acacia polyacantha, Acacia sieberiana, Albizzia ayloneri, Albizzia zygia, Vitex doniana /11/. Five species have been tested also in Czechoslovakia in 1973 as a preparatory stage for this Polytechna-UNIDO contract /Annex 3/F/.

Second, though some tree species may occur which should be tested for plywood production, it is impossible to say at this stage which tree species these are, since only a forest inventory in the area of the site chosen for the mill can show which untested tree species occur in sufficient numbers and dimensions to be of interest for plywood production.

Third, testing of tree species both as to mechanical properties and peeling characteristics can be successfully carried out in the Sudan in the Soba Research and Education Institute and in the Khartoum match factory, as indeed has been already done for quite a number of tree species. Consequently, this kind of testing outside the Sudan as part of the international aid programe is not warranted.

What could be a matter for international or bilateral aid is advice as to what tree species should be tested in connection with the results of the forest inventory and, if so requested by the Sudanese government, operational assistance in efficient organization of the testing.

In preparation of the forest inventory an aerial survey should be carried out without delay. Recommendations are given in Annex 3/G.

Medium-term measures

On the basis of the forest inventory forest land which could yield a supply of timber for plywood production should be declared a Central Forest Reserve. This would be in line with the pursued policy of extending the area of forest reserves. The present area of forest reserves is

Province	Area		
Equatoria	740,000 feddans,	or	311,000 ha
Bahr-el-Ghazal	810,000 feddans,	or	340,000 ha
Upper Nile	200,000 feddans,	or	84,000 ha
Southern Region	1,750,000 feddans,	or	735,000 ha

This area represents only 1.1 % of the total surface of the Southern Region. The target figure is 15 %. In order to safeguard the raw material basis for plywood production at least another 700,000 ha of forests should be added to the forest reserve estate in the near future.

Long-term measures

Finally, a new impetus should be given to the establishment of plantations on a certain part of the forest land. These should ultimately replace the natural forests as a raw material basis for both sawn-wood and plywood production.

There are at present about 8,600 ha of teak plantations: 5,400 ha in Equatoria and 3,200 ha in Bahr-el-Ghazal. The plantations were started after World War II and their age distribution is fairly even in Bahr-el-Ghazal, in Equatoria there were no plantations between 1962 and 1972. The annual increment may be around 6 m3 per ha. At present only poles from thinnings are utilized, but in 15-20 years time the plantations will yield saw logs and also a certain amount of peeler logs.

The continuous planting of teak should be encouraged and further increased, but teak should not remain the only species to be planted. Experiments should be started with the introduction of fast-growing softwood species in the savanna woodlands and continued in the Imatong mountains. This would require the establishment of two research stations, one in Equatoria for the montane forests and one in Bahr-el-Ghazal for the savanna type and gallery forests. These research stations should be under the guidance of the Research and Education Institute in Soba which could organize the research work and provide the necessary research workers.

4 Transport

Evaluation of Sites

In any industrial development in the Sudan transportation is the major constraint. This is especially true of plywood production in which both the raw material and the commodity produced are heavy, bulky and costly to transport and distances involved between the timber resources in the South and consumer centres in the North are enormous.

In plywood production transportation cost depends on a number of factors among which the distance from the forest to the plywood mill and further from the plywood mill to consumer centres is of decisive importance. Therefore the selection of the site for the plywood mill, i.e. its location between the forest and the consumer, is of greatest importance for the feasibility and profitability of the enterprise.

Five possible sites for a plywood mill in the Sudan are being considered and their economic implications discussed in this report. These locations are Katire, Nzara, Wau, Juba and Khartoum. Furthermore, export possibilities of plywood to neighbouring countries through the ports of Port Sudan and Mombasa are examined.

The distances involved and the freight rates are given in Annex 4/A.

On the basis of the freight rates and handling charges quoted in Annex 4/A total transportation costs of logs and plywood for various locations of the plywood mill are computed, assuming the following concentration of sales:

Wau	10 %	or	500 m3	of plywood
Khartoum	70 %	or	3,500 m3	of plywood
Port Sudan	20 %	or	1,000 m3	of plywood
Total	100 %	or	5,000 m3	of plywood

For the site in Juba transportation of logs from Katire, for the site in Khartoum transportation of logs from Wau is the cheapest.

	Cost in £S per m3				
	Katire	Nzara	Wau	Juba	Khartoum
Logging cost	14.80	17.80	12.90	14.80	12.90
Transport of logs	-	-	-	11.48	14.17
Cost of logs at factory yard	14.80	17.80	12.90	26.28	27.07
Cost of logs per m3 of plywood	32.86	39.52	28.64	58.34	60.10
Transport of plywood					
To South	8.67 1/	17.31 4/	-	-	1.09 11/
To Khartoum	19.89 2/	19.89 5/	7.64 7/	19.89 9/	-
To Port Sudan	1.19 3/	1.19 6/	3.11 8/	1.19 10/	1.19 12/
Final cost of site	62.61	77.91	39.39	79.42	62.38

	£S/m3
1/ Katire-Juba	8.27
Handling	0.40
Total	8.67
Cost share 100 %	8.67
2/ Juba-Khartoum	21.70
Handling	0.40
Total	22.10
Cost share 90 %	19.89
3/ Khartoum-Port Sudan	5.55
Handling	0.40
Total	5.95
Cost share 20 %	1.19
4/ Nzara-Juba	16.91
Handling	0.40
Total	17.31
Cost share 100 %	17.31
5/ Juba-Khartoum	21.70
Handling	0.40
Total	22.10
Cost share 90 %	19.89
6/ Khartoum-Port Sudan	5.55
Handling	0.40
Total	5.95
Cost share 20 %	1.19

	£S/m3
7/ Wau-Khartoum	10.52
Handling	0.40
Total	10.92
Cost share 70 %	7.64
8/ Wau-Port Sudan	15.13
Handling	0.40
Total	15.53
Cost share 20 %	3.11
9/ Juba-Khartoum	21.70
Handling	0.40
Total	22.10
Cost share 90 %	19.89
10/ Khartoum-Port Sudan	5.55
Handling	0.40
Total	5.95
Cost share 20 %	1.19
11/ Khartoum-Wau	10.52
Handling	0.40
Total	10.92
Cost share 10 %	1.09
12/ Khartoum-Port Sudan	5.55
Handling	0.40
Total	5.95
Cost share 20 %	1.19

The above calculation shows the economic implications of each site, but does not tell the whole story. The selection of the most suitable site must take into account that transportation of any sort is the bottleneck of every industrial development and has to be kept at a minimum in order to make a project viable. If the transportation task is evaluated in t/km, the following picture is obtained for the five potential sites:

	Katire	Nzara	Wau	Juba	Khartoum
			000´t/km		
Location	Katire	Nzara	Wau	Juba	Khartoum
Hauling	375	500	375	375	375
Log transport by road	-	-	813	2,075	813
by rail /Wau-Khartoum/					18,725
Plywood transport					
by road	648	1,879	-	-	-
by rail	-	-	3,883	-	-
on Nile	5,378	5,378	-	5,378	598
exports	567	567	567	567	567
	6,968	8,324	5,638	8,395	21,078

This shows that Wau and Katire are the sites with the smallest and cheapest overall transport. A larger cost and a larger volume of transport is involved by selecting the Nzara and Juba site. As to the site in Khartoum, though economically it still seems to be a possibility, it is not feasible technically. The railway line from Wau to Khartoum could not handle this volume of transportation.

<u>Communications between North and South</u>

It should be noted that the weakest link in all the chain of transportation is always the connection between the North and the South of Sudan. There are practically two lines of communication: the Nile from Juba to Kosti, and the railway line from Wau through Babenousa to Khartoum. It is difficult to say which means of transport is less efficient and less reliable and should therefore be avoided. Both transportation lines are in very poor state.

Theoretically, transport from Juba to Kosti down the Nile takes 6 days, to Khartoum 10 days; upstream the duration of transport should be 10 days from Kosti, 15 days from Khartoum. But practically it takes weeks and months to get much needed supplies through this route. Maximum lifting capacity of crane is 30 t in Khartoum North, 10 t at Kosti and 5 t in Juba. But the army and the Mechanical Transport Department in Juba have cranes of over 20 t lifting capacity. There are no storing capacities at Juba and the handling of goods, both loading and unloading, should be done by the owner of commodities.

Railway transport from the South to Khartoum would seem to be faster than on the Nile, since it takes a train 3 to 5 days to travel from Khartoum to Wau. But the team leader had the pleasure of drinking beer in Wau which took two and a half months to come from Khartoum.

There are no loading or storage facilities in Wau. Loading and unloading should be done by the owner of goods. There is no waggon scale, consequently freight rates are charged for a 16 t load whatever the real load is. The railway extension from Babanousa to Wau was built in the 1960's with haste and is probably the weakest and least efficient link in all the network of Sudan Railways.

Both communications, the railway and the Nile, are fully loaded on the way from the North to the South. In the opposite direction, from the South to the North, most railway cars and barges go empty. This one-way traffic favors the location of any industrial plant in the South since it helps to utilize better the return movement of vehicles by sending its output to the consumer centres in the North.

For the time being no radical improvement in either Nile shipping or railway transport can be expected. Wherever the plywood plant will be situated, serious trouble must be anticipated arising out of the long and unreliable transport connection between North and South Sudan. It would be therefore essential to pledge the Government's support to this industrial development and assure the granting of a high priority and negotiation of special agreements with Sudan Railways /or the River Transport Corporation/ for all transport connected with the establishment and operation of the plywood mill.

Road traffic

Another major concern in establishing a plywood mill is the inadequate and unsatisfactory infrastructure of the Southern Region especially with respect to road communications. There are in Equatoria and Bahr-el-Ghazal provinces five main road links /called in Michelin's map "partially improved roads"/ which are said to be all-weather roads:

Juba - Torit - Kapuete - Kenya /last section in construction/

Juba - Nimule - Uganda

Juba - Yei - Zaire

Juba - Maridi - Tumbura - Wau /leading also into the Central African Republic/

Juba - Rumbek - Wau.

All these roads could be also of importance for a plywood plant. But economic transportation on these roads would require:

- considerable road improvement by investment
- better road maintenance
- replacement of the ferry operating on the Buseri river by a bridge
- more training and control of drivers and maintenance mechanics
- better maintenance of vehicles.

Consequently, when using road transport, the following precautions should be taken:

1. Transport should be concentrated as far as possible into the dry season, and restricted during the rainy season.

2. High priority should be given to road improvement and maintenance.

3. A speed limit should be set up and the time of departure and arrival of lorries checked by control posts.

4. The training of drivers and maintenance mechanics should be intensified and improved and, when necessary, expatriate instructors should be hired.

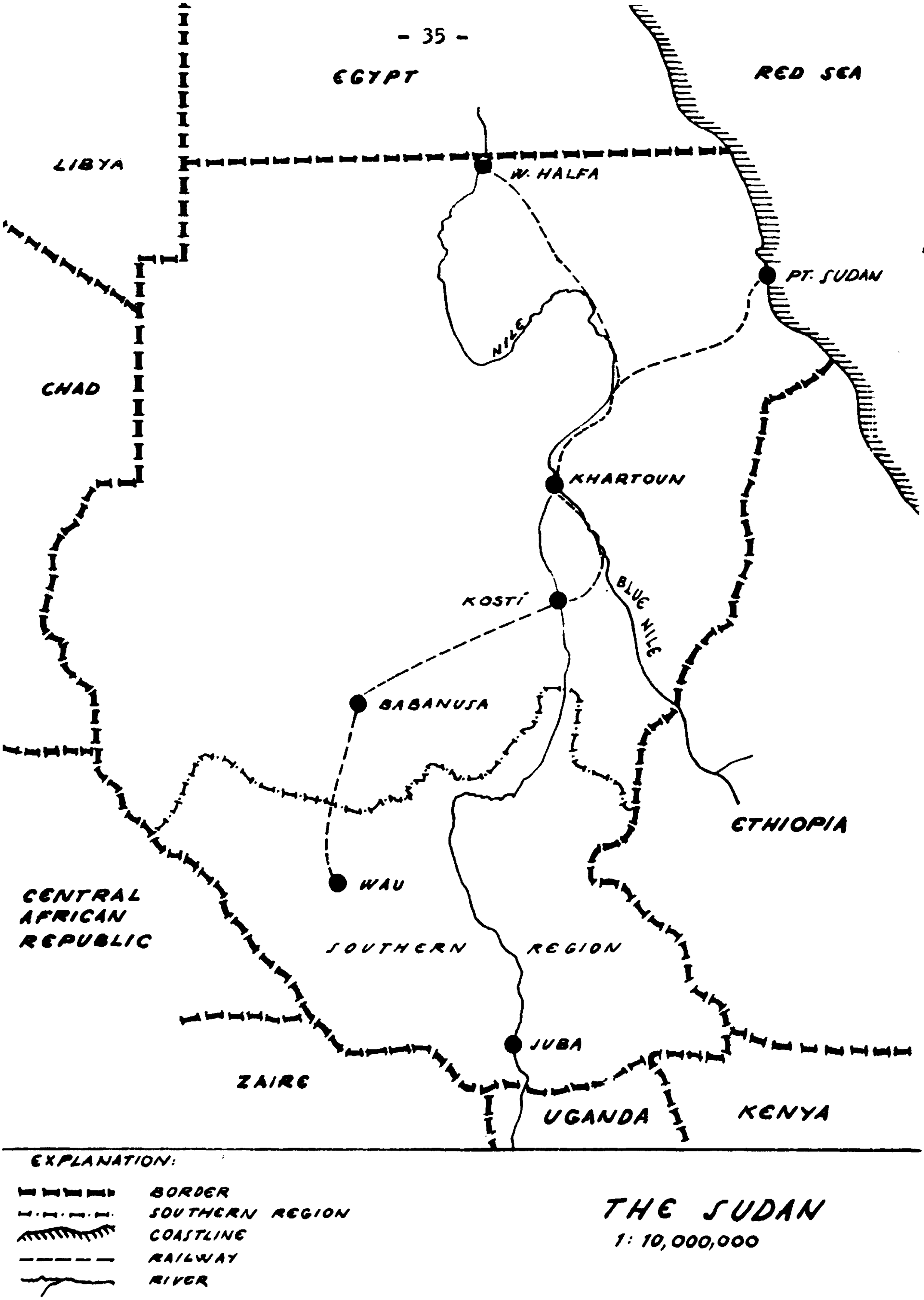
5. More attention is to be paid to the supervision and control of drivers.

6. Maintenance of vehicles should be better organized.

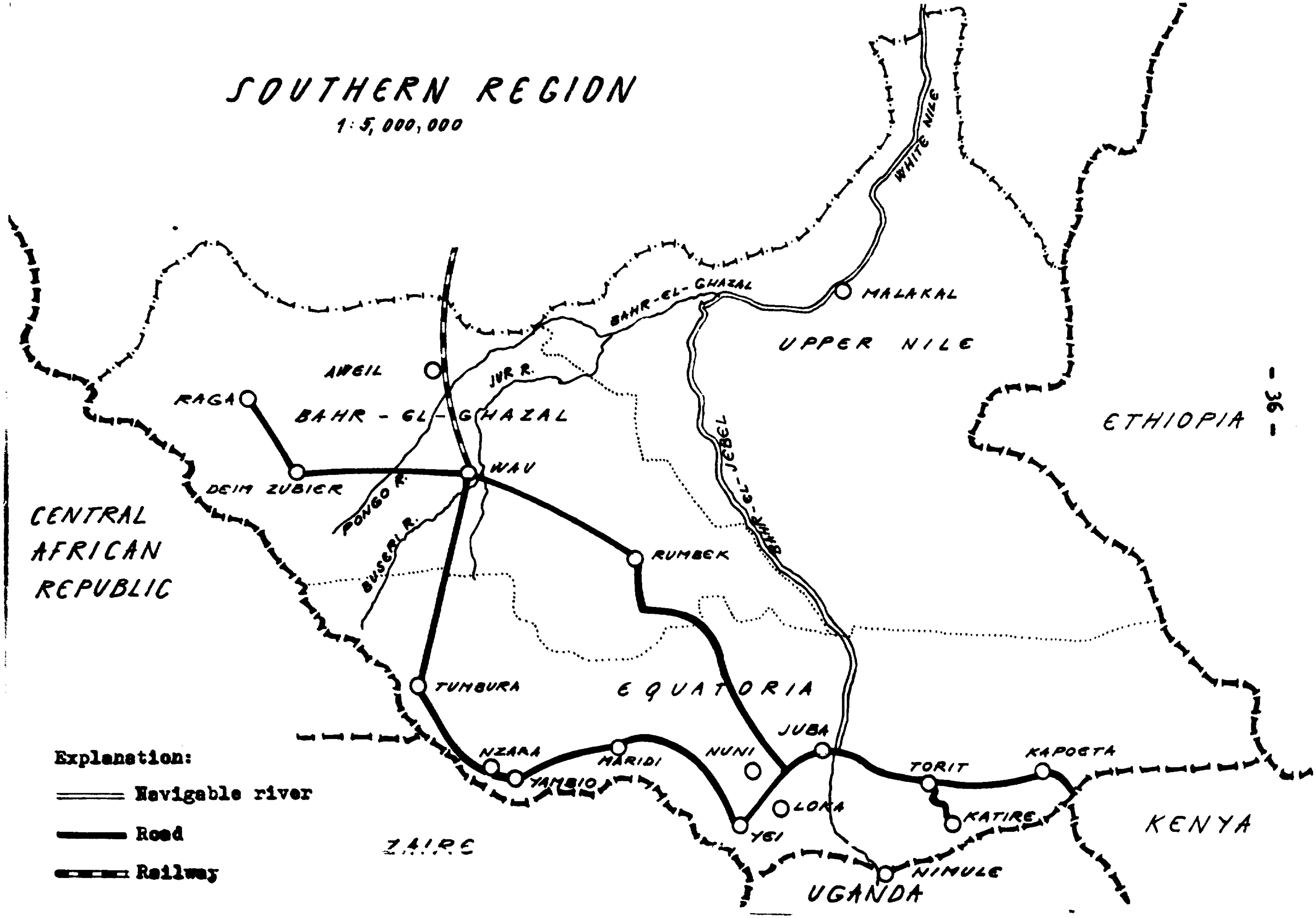
Conclusion

From the viewpoint of transport Wau is recommended as the best site for a plywood mill for the following reasons:

- Location of the plywood mill in Wau results in the smallest volume of overall transport of logs and plywood
- Logging in the Wau area is the cheapest and the cost of logs at the factory yard is the lowest of all alternatives
- The site in Wau has the advantage of reducing road transport to a minimum
- Communication with the North of the country is cheapest by the railway.



THE SUDAN
1: 10,000,000


SOUTHERN REGION
1:5,000,000
SUDAN
WHITE NILE
MALAKAL
BAHR-EL-GHAZAL
UPPER NILE
AWEIL
JUR R.
RAGA
BAHR - EL - GHAZAL
JEBEL
BAHR-EL-JEBEL
ETHIOPIA
WAU
DEIM ZUBIER
PONGO R.
CENTRAL
AFRICAN
REPUBLIC
BUSERI R.
RUMBEK
TUMBURA
EQUATORIA
JUBA
NZARA
MARIDI
NUNI
TORIT
KAPOETA
YAMBIO
LOKA
YEI
KATIRE
KENYA
ZAIRE
NIMULE
UGANDA
Explanation:
Navigable river
Road
Railway

5 The Plant

Basic Data

The plywood factory in Wau should have an output of 5,000 m3 of plywood sheets per annum based on one shift operation, corresponding to the smallest economically feasible production capacity of a plywood plant by internationally accepted standards. Such a size of production is justified by the full utilization of machinery on the one hand and by the feasible distance of log transport and corresponding log supply on the other hand.

The rate of utilization of timber in plywood production depends mostly on the quality of timber and the skill of the workers and may vary between 40 and 50 %. For the Wau factory it is put at 45 % for the next four to five years, but later this rate of utilization may rise to 50 % as workers shall learn how to process first class raw material to best advantage.

The expected rate of utilization of 45 % represents a requirement of 2.22 m3 of logs per m3 of plywood, or an annual timber consumption of 11,100 m3 of peeler logs in order to operate the factory at full capacity.

It should be noted that the amount and quality of timber supply available in Wau would permit, besides plywood production, also an additional production of sliced veneer. In this way logs of highest quality and large dimension, especially over 120 cm diameter, could be utilized to best advantage, especially for exports. Approximate cost of production for sliced veneer are given in Annex 5/A. Data on raw material and market will need further study.

With 275 working days a year /recommended by the Regional Ministry of Industry as the usual approach in the Sudan/ the daily output averages 18 m3 of plywood, corresponding to a daily consumption of 40 m3 of logs.

The log supply is expected to be composed of the following tree species:

Khaya senegalensis	67 %
Afzelia africana	10 %
Daniella oliveri	10 %
Isoberlinia doka	10 %
Miscellanous	3 %
	100 %

The expected structure of plywood sheets derived from the market survey is composed of

3 mm thick plywood, size 122 x 220 cm	1,300 m3
4 mm thick plywood, size 122 x 220 cm	700 m3
3 mm thick plywood, size 122 x 183 cm	1,200 m3
4 mm thick plywood, size 122 x 183 cm	300 m3
5-10,Ø 6 mm thick plywood, size 122 x 220 cm	500 m3
15 mm thick WBP plywood, size 122 x 183 cm	1,000 m3
T o t a l	5,000 m3

The 3 and 4 mm plywood sheets are intended for furniture production. The 10 mm sheets shall serve mainly for furniture sections replacing the uneconomic use of massiv wood /cupboards, couches, shelves etc./. Water and boil proof plywood /WBP - BS 1203:1954/ should be used, in the first instance, as a replacement of imported coniferous sawnwood as shuttering in construction. One m3 of waterproof plywood can replace at least 15 m3 of coniferous sawnwood in shutterings.

For the cores of 10 and 15 mm plywood sheets Isoberlinia doka /Vuba/ should be used.

Technology

In planning the plywood plant the following principles were applied as guidelines for establishing preferencies:

- wherever possible to select equipment and procedures which provide employment to the greatest possible number of people, as far as economics justify such a selection
- to avoid expensive equipment and procedures which would represent a heavy drain on foreign currency resources
- to plan simple and "foolproof" equipment and procedures which are easy to handle and do not require very high skill and training.

The main pieces of equipment in a plywood plant are the log peeler, the drier and the press. For complete list of equipment see Table 5.

The peeling machine should be able to process logs of 130 and 230 cm length. The feeding should be done by a monorail with an electric hoist, but logs should be transported to the peeling machine by carriage and the reeling of veneer should be done by hand.

A drier of higher capacity has been selected in order to operate in one shift only and to have thus the option of using it in a second shift for drying sliced veneer which remains a promising possibility.

For pressing, a press with platen sizes of 2,600/1,300 mm with manual loading and hydraulic lifting table is recommended. This dimension enables the pressing of all plywood sizes and - what is of special importance - retains the option of producing partitions covered with sliced veneer for appartment interiors /required length 2,400-2,500 mm/.

The whole production process from the spreading of glue, the assembly of plywood and pressing can be organized also in an automatic line, the whole equipment being controled from the press. The price of the whole automatic line is around £S 250,000, but investments of this order of magnitude would be economically not justified in the local conditions in Southern Sudan and for the small capacity envisaged.

As to glue, for plywood sheets used in furniture production urea formaldehyde in powder form as well as a hardener is most advantageous both from the viewpoint of transportation and storage. Adhesive in liquid form cannot be recommended because of short shelf life and higher transport cost. For WBP plywood only phenol formaldehyde in foil form should be considered because liquid phenol-formaldehyde glue has a still shorter shelf life and its transport is expensive and risky.

The production process of plywood shall be organized as explained in detail in Annex 5/B.

The plywood plant in Wau should be situated near the railway station adjoining the Wau Training Sawmill with which it shall have the log yard in common. This close neighbourhood will facilitate cooperation between the two plants and integration of production with respect to

- the selection of peeler logs from among the saw logs delivered
- the utilization of sawmill waste in the boiler of the plywood plant
- the conversion of peeler log cores into sawnwood at the sawmill
- the use of expensive equipment for maintenance and repair
- eventually the use of a stand-by generator.

Data on material and energy consumption are contained in Annex 5/C, and the calling for tenders is given in Annex 5/D.

Construction

The lay-out of the main operational building of the plywood plant shall be 150 x 24 m. The building shall be enclosed so as to prevent rain and weather influences to enter the space and to protect the plywood against fluctuations of relative air humidity. A skeleton construction with brick wall shall be used. The building contains the production hall, maintenance shop, the grinding shop, the compressor station laboratory, glue store, and the store for spare parts.

Next to the main operational building is an administrative building, with a 200 m2 ground-floor. It contains the offices of the management and administration personnel.

The building for the boiler, measuring 150 m2 contains in the front part of 6 x 9 m the circular saw for crosscutting the wood waste and the hogger.

Four steaming vats with dimensions of 12 x 3 x 3 m shall be made of concrete with stone cladding /concrete alone and brick are not a suitable material/ in such a way that to a depth of 2 m they will be sunk in the ground and with 1 m they will protrude above the ground. Inner equipment and covers are given in the price of the machinery.

Hygienic facilities are dimencioned for 130 people, half of them being men and half women. These facilities comprise lavatories, showers, water-closets and a dining-hall. Totel required space is 300 m2.

In the timber yard which shall be in common with the Wau Training Sawmill supporting poles under logs should be provided.

All other construction and its cost are given in chapter six.

Training programme

Before the installation of the machinery of the plywood plant suitable workers chosen very carefully from among operators in the Wau Training Sawmill or in other sawmills of Bahr-el-Ghazal province should be sent abroad for training to the company which will deliver the plywood eqipment. This practical training in operation in a plywood plant should comprise the professions of the lathe operator, of the dry-operator and of the press-operator and last at least six months.

The foremen and operators of other equipment will be instructed how to operate equipment in Wau during the assembly of the plant under the guidance of fitters of the supplying company. Besides that, a practical training and instruction course should be arranged during the assembly of the plant about production technology and the servicing of equipment. This course should be attended by all workers of the future factory. The training and instruction should be given by the specialist who will be in charge of management during the running in of operations and in the starting period of production, until this position can be filled by his counterpart whom he will train.

During the assembly of the plant maintenance workers and the crew of the boiler should be already assigned to their respective jobs in order to become acquainted with the equipment. They should be chosen from among experienced workers with adequate qualification.

In the first two years of operations two expatriate experts /one for technology and the other for maintenance/ should be hired in order to control the running in of the plant and to complete the training of all personell.

For the future Sudanese technical staff for the plywood mill - and for the sawmilling and woodworking industry at large - should be trained in a professional woodworking education centre at secondary school level which could be established in Soba.

In another development the college training and education of professional staff specialized in the woodworking industry should be envisaged at Khartoum university. This study could be closely linked with the forestry or engineering curriculum by adding lectures on wood and its processing during two semesters to the extent of 5 hours and exercising to the extent of 2 hours. This training should be entrusted to an expert with educational experience and a good knowledge of African tree species. The existing woodworking industry in the Sudan would greatly benefit from this improvement in college training.

6 Economic and financial evaluation

Sales forecast

The structure of the potential market is specified in details in the chapter dealing with the marketing aspects of the project. In this summary, the calculation of sales value is made under these assumptions:

Sales /in m3/

	Ex factory Wau	Khartoum wholesale	Khartoum retail	Total
3 mm	800	500	1,200	2,500
4 mm	300	200	500	1,000
5-10 mm	200	100	200	500
15 mm	200	200	600	1,000
Total	1,500	1,000	2,500	5,000

Selling prices /in £S per m3/

	Ex factory Wau	Khartoum wholesale	Khartoum retail
3 mm	168.0	180.0	198.0
4 mm	141.0	153.0	171.0
5-10 mm	135.0	147.0	162.0
15 mm	137.0	149.0	164.0

The expected structure of quality grades and the details as to the calculation of average selling prices are given in Annex 6/A.

Sales revenue /in 1,000 £S/

	Ex factory Wau	Khartoum wholesale	Khartoum retail	Total
3 mm	134.4	90.0	237.6	462.0
4 mm	42.3	30.6	85.5	158.4
5-10 mm	27.0	14.7	32.4	74.1
15 mm	27.4	29.8	98.4	155.6
Total	231.1	165.1	453.9	850.1
Average selling price /in £S per m3/	154.1	165.1	181.6	170.0

The above indicated level of sales revenue is assumed to be reached in the 4th operating year, the amounts of sales receipts in the first three operating years to the start-up period are quoted in Annex 6/A.

Investment costs

The delivery of the plant should be contracted on a turn-key basis. While the investment cost of the production machinery and equipment are calculated as to be paid entirely in foreign currency, the construction works and the deliveries of transport equipment and furniture are planned to be fully sub-contracted to Sudanese suppliers.

Detailed specifications /with the necessary technical data and price quotations/ for the production machinery and equipment are given in Table 5 /see page 123/. Other details concerning investment costs are mentioned in Annex 6/B.

Summary of investment costs /in £S/

	Foreign currency	Local currency	Total
Production machinery and equipment	516,310	142,170	658,480
Transport and office equipment	-	61,600	61,600
Construction works	-	277,000	277,000
Preliminary expenses	22,000	92,600	114,600
T o t a l	538,310	573,370	1,111,680

Permanent working capital /in £S/

	Foreign currency	Local currency	Total
Spare parts and technical material /3 % on the cost of production machinery and 5 % on the cost of vehicles/	12,980	4,590	17,570
Production materials /1 % on the cost of production machinery/	4,330	1,100	5,430
Stock of raw material /for 3 months/		35,800	35,800
Stock of adhesives	15,000	500	15,500
Wages and salaries /approx.4 months wage bill/	-	15,000	15,000
Provision for cash	-	20,000	20,000
T o t a l	32,310	76,990	109,300

The break-down into local and foreign currency requirements is made in order to furnish data for the macro-economic evaluation of the project.

Total capital requirements /in £S/

	Foreign currency	Local currency	Total
Investment costs	538,310	573,370	1,111,680
Permanent working capital	32,310	76,990	109,300
T o t a l	570,620	650,360	1,220,980

Plan for financing

During the stay of the working team in the Sudan, the governement authorities were not prepared to specify the expected sources of financing the project. To enable a rough preliminary assessment of the impact of financial charges on the profitability of the project, a potential solution discussed with the Industrial Bank of Sudan and the Sudan Development Corporation has been adopted. It is assumed that the project should take full advantage of credit possibilities offered by the Industrial Bank of Sudan under the following conditions:

- the applicant is required to contribute at least a minimum of 1/3 of the total cost of the project,
- the maximum loan can not exceed £S 700,000,
- loans are granted for periods not less than 2 years and not exceeding 15 years; the Bank normally grants a reasonable period of grace before commencement of re-payment to permit completion of the project,
- the current rates charged by the Bank are 7.5 % on medium-term loans /2-6 years/ and 8.5 % on long-term loans /6-15 years/ for local currency and 9.5 % on foreign exchange loans.

Besides the credit from the Industrial Bank of Sudan, it is assumed the supplier of the production machinery and equipment may grant a medium-term loan covering approx. 40 % of the value of production machinery.

Summary of sources of financing

	£S	Interest	Payable in
Equity capital	400,000	-	-
Supplier's loan	150,000	9.5 %	5 years
Long-term loan /I.B.S./	400,000	8.5 %	12 years
Medium-term loan /I.B.S./	249,380	9.5 %	6 years

It is assumed that the commencement of repayment of the loans from the Industrial Bank of Sudan may be postponed as it is to be seen in the re-payment scheme /see Annex 6/C/.

The simulation of the financial position of the plant during two years of construction and 15 years of operation is shown in the cash-flow forecast /see Annex 6/D/. The replacements of the equipment will be paid from the firm's cash reserves.

Estimates of costs and profits

Operating costs

The running-in period is assumed to cover the first three years of operation. In the fourth operating year, the full capacity of 5,000 m3 has to be reached with the corresponding full level of operational costs resumed in the following table:

	£S
a/ Raw material /peeler logs/ 11,100 m3 x £S 12.90	143,190
b/ Urea formaldehyde adhesive 200 tons x £S 190.0	38,000
c/ Technological flour 36 tons x £S 100,0	3,600
d/ Phenolic foil /Tegofilm/ 600,000 m2 x £S 0.033	19,800
e/ Electrical energy 942,700 kWh x £S 0.035	32,995
f/ Water 27,000 m3 x £S 0.04	1,080
g/ Repairs and spare parts 2 % production machinery, 5 % on vehicles and 1 % on construction works	15,050
Carried forward	253,715

	⅊S
	253,715
h/ Consumption of technical materials /tools, etc./ 1.5 % on production machinery	8,130
i/ Insurance 0.2 % on buildings and machinery, 0.5 % on stock of plywood and 5 % on vehicles	7,810
j/ Wages and salaries /details are given in Table 4/	62,460
k/ Social security - obligatory /a simplified calculation of 10 % on the wage bill is assumed/ - facultative /covering risks not insured by the state social security scheme in the range of 5 % on the wage bill/	9,380
l/ Transport costs 3,500 m3 of plywood sold through Khartoum section will be transported by railway 3,500 x ⅊S 10.9	38,150
m/ Sales expenses 5 % on the value of sales in ex factory prices	38,500
n/ Plant overheads, administrative expenses, etc. 10 % on operating costs /excl.transport cost and sales expenses/	34,150
T o t a l	452,295
Contingency /approx. 5 %/	22,500
G r a n d T o t a l	474,795

Taking in consideration the lower output in the first three operating years of the running-in period, the calculation of the consistent levels in the operating costs was made in Annex 6/A.

Profits and taxation

Table 6 showing the annual operating accounts for the whole period of 15 years of operation analyses the development of sales revenues, operating and other working costs, gross profit and net profit /see page 49/.

The calculation of the net profit is made under assumption that an exemption from payment of profit tax will be granded, according to the industrial investment regulations, for the period of the first 5 years. Beginning from the 6th operating year, the normal rate of 60 % of the profit tax is planned to be delivered to the Sudanese financial authorities.

The loss of the first year covered by profits of the two successive two years indicate that liquidity problems may be faced at the beginning of operations /the financial solution can be seen in Annex 6/D/. However, starting with the fourth year of operation very massive inflows of annual net profit will contribute to the fast increase of cash reserves.

Commercial profitability of the project

The commercial profitability of the plant is naturally highly depending on the pricing policy. Though the estimates of prices have been made with the objective to enable the maximum promotion of the local market, reducing present price levels by more than 50%, the level of profit shows very reasonable margins as can be seen from the following profitability ratios based on data of costs and profits of an average year /arithmetical mean from the time series of 15 operating years/:

rate of return as ratio of	$\frac{\text{profit bef. tax and depreciation}}{\text{investment}}$	25.3 %
	$\frac{\text{profit after tax a. bef. deprec.}}{\text{investment}}$	16.6 %
pay-back period as ratio of .	$\frac{\text{investment}}{\text{profit bef. tax and depreciation}}$	4 years
	$\frac{\text{investment}}{\text{profit after tax and bef. deprec.}}$	6 years

Annual operating accounts /in LS/

Operating years	Sales receipts	Operating costs	Depreciation	Interest paid	Total expenses	Profit /loss/ before tax
1	420,100	339,150	116,410	76,749	532,309	- 112,209
2	679,900	439,390	116,410	74,391	630,191	49,709
3	772,500	470,215	116,410	68,067	654,692	117,808
4	850,100	474,795	116,410	59,404	650,609	199,491
5	850,100	474,795	116,410	49,933	641,138	208,962
6	850,100	474,795	93,610	39,589	607,994	242,106
7	850,100	474,795	93,610	31,997	600,402	249,698
8	850,100	474,795	93,610	23,693	592,098	258,002
9	850,100	474,795	93,610	21,077	589,482	260,618
10	850,100	474,795	93,610	18,610	586,644	263,456
11	850,100	474,795	93,610	15,160	583,565	266,535
12	850,100	474,795	93,610	11,819	580,224	269,876
13	850,100	474,795	93,610	8,194	576,599	273,501
14	850,100	474,795	93,610	4,261	572,666	277,434
15	850,100	474,795	93,610		568,405	281,695

SECTION 1

Table 6

Interest paid	Total expenses	Profit /loss/ before tax	Cumulative profit bef. tax	Tax on profit	Net profit	Cumulative net profit
76,749	532,309	- 112,209	- 112,209	-	- 112,209	- 112,209
74,391	630,191	49,709	- 62,500	-	49,709	- 62,500
68,067	654,692	117,808	55,308	-	117,808	55,308
59,404	650,609	199,491	254,799	-	199,491	254,799
49,933	641,138	208,962	463,761	-	208,962	463,761
39,589	607,994	242,106	705,867	145,264	96,842	560,603
31,997	600,402	249,698	955,565	149,819	99,879	660,482
23,693	592,098	258,002	1,213,567	154,801	103,201	763,683
21,077	589,482	260,618	1,474,185	156,371	104,247	867,930
18,610	586,644	263,456	1,737,641	158,074	105,382	973,312
15,160	583,565	266,535	2,004,176	159,921	106,614	1,079,926
11,819	580,224	269,876	2,274,052	161,926	107,950	1,187,876
8,194	576,599	273,501	2,547,553	164,101	109,400	1,297,276
4,261	572,666	277,434	2,825,987	166,460	110,974	1,408,250
	568,405	281,695	3,106,682	169,017	112,678	1,520,928

SECTION 2

More data concerning the profitability of the project can be found in Annex 6/E comprising, besides several more profitability ratios, the calculation of the internal rate of return and the break-even analysis. The results of these calculations emphasize still more the above stated conclusions regarding the high commercial profitability of the project, though at the same time plywood prices are being reduced very deeply below their present level.

The sensitivity analysis inquiring into the potential fluctuations of sales revenues, operating costs and investment requirements indicate the very strong positon of the projected home-produced plywood when compared with imported plywood sold on the Sudanese market. It confirms once more that changes in prices might have the most important impact on the level of profitability and demonstrates the really wide and safe limits for the future pricing policy of the plant/for more details, see Annex 6/F/.

Macro-economic evaluation of the project

The establishment of a plywood mill in Wau with an annual output of 5,000 m3 of plywood would bring the following benefits to the Sudan:

1. The annual import of plywood in the range of 2,500 m3 valued at some £S 500,000 could be stopped immediately and replaced by smaller imports of adhesive resins; the yearly net savings of foreign currency /both from import replacement and potential exports/ will fluctuate in the limits of US $ 800,000 to 1,000,000 as can be seen in Annex 6/G.

2. Domestic consumption of plywood could be almost doubled, thus helping to alleviate the existing shortage of building materials and expanding the manufacture of furniture. In places where modular construction is accepted imported coniferous sawnwood used for shutterings could be replaced by plywood and thus sawnwood imports could be reduced and additional foreign currency saved.

3. The current waste caused by using timber of peeler log quality of mahogany and other valuable tree species for inferior purpose would be largely stopped and a rational utilization of the country's timber resources encouraged.

4. Forestry in the influx area of the plywood mill would be encouraged to convert natural forests to plantations, to intensify forest management and to develop training and research activities in forestry.

5. By establishing a plywood plant in the Sudan, technical progress in the industrial development of the wood processing sector would be assured. This would be especially felt in furniture production and in the building industry.

6. The establishment and operation of a plywood plant would provide justification for infrastructure improvements and stimulate public investments /roads, electricity etc./.

7. Substantial financial returns could be expected from a well managed plywood plant, creating revenues in the form of stumpage, taxes, interest and profits.

8. In assessing the social benefits of the project, the major aspect, however, to be considered is that of employment. The direct effect of the implementation of the project will be to provide employment for the people both in the plant itself and in logging and forestry operations. Besides, the spending power generated from wages and salaries will tend to increase employment in other sectors of economy as well. At the same time, the skill of the labour force would increase by training, social benefits customary in industrial plants would improve the social standard and a higher social standing would be achieved for all the staff and workers of the factory.

An attempt to give an aggregate view of the balance between social benefits and social costs is shown in the social costs/benefits analysis /Annex 6/G/.

Another persuasive indicator of the significance of the project for the national economy of the Sudan is the high level of the value added /see Annex 6/G/.

But the establishment of a plywood plant in the Sudan is also a challenge. No false hopes should be raised by implying that this venture is going to be an easy task. Only able planning, efficient management, harmonious cooperation, and an earnest endeavour can bring the desired results.

7. Findings and Recommendations

The findings of this feasibility study can be summed up as follows:

1. There is in the Sudan a sufficient immediate market outlet for the output of a 5,000 m3 plywood plant, and once local production is started it can be safely assumed that demand will double in about five years.

2. There are sufficient timber resources in the Southern Region for the establishment of several plywood plants of this capacity, using annually 11,100 m3 of peeler logs. These could be located in Wau, in the Imatong, and in Nzara.

3. The recommended site for establishing the first plywood plant is Wau.

4. The establishment of a 5,000 m3 plywood plant in Wau is technically and economically feasible.

5. Domestic plywood production would result in cutting the present plywood price in the Sudan by more than half and yet still be highly profitable and bring important social benefits and gains to the national economy.

In order to carry out successfully this project, the following recommendations should be observed:

Recommendations to the Forestry Department:

1. An aerial survey of the timber resources around Wau should be carried out with all possible speed.

2. A forest inventory and logging plan for the influx area of the plywood plant should be prepared, possibly with multilateral or bilateral aid.

3. In order to prepare for the impending industrial development it is recommended to establish a stumpage fee for peeler logs, to examine the advisability of reducing the present girth limit, to train the forest staff in peeler log selection and to take other steps /as declaration of forest reserves, intensification of afforestation, inquiry into the possibility of softwood plantations etc./.

4. Since the establishment of a second and third plant may be soon necessary to meet demand for plywood, sawmilling capacities should be installed in the Imatong mountains and in the Azara region to promote future integration with plywood production and to enable a balanced exploitation of forests for both saw logs and peeler logs with the successive conversion of natural forests into plantations.

Recommendations to the Ministry of Industry:

5. A close institutional cooperation between the plywood mill and the Forestry Department should be established.

6. An inquiry should be made into the possibility of sliced veneer production, both from the raw material and the market point of view.

7. An effort should be made to promote the use of locally made plywood by conforming its quality to internationally accepted standards. To this end legislation should be passed to establish a national standard for Sudanese plywood.

Recommendations to the Manager of the Wau Factory:

8. Training of the three key operators /on lathe, drier and press/ should be arranged abroad for at least six months each and foremen and workers should be acquainted with equipment in the plywood mill during its installation.

9. Training, instruction and control of drivers and maintenance mechanics should be organized in order to prolong the life-time of vehicles.

10. To assure as low a cost as possible to the end users and thus promote the use of plywood in the Sudan and increase its consumption direct retailing should be organized by the factory by setting up marketing channels both in Khartoum and in Wau.

Recommendations to the Planning Commission:

11. The development of infrastructure in the Wau region should receive a high priority, especially with regard to the replacement of the ferry on the Buseri river by a bridge

and to the reconstruction of the Naga road. This would open up forests for economic logging.

12. A secondary technical school specialized in teaching woodworking subjects should be established in Soba and lectures on woodworking industry should be included in the forestry and/or civil engeneering curriculum at Khartoum University.

13. In order to speed up industrial development international assistance is required for carrying out a forest inventory with logging plan in the surroundings of Wau. Multilateral aid could be provided best by UNIDO, or even by FAO. Necessary aid could be obtained also on a bilateral basis.

III Annexes

1/A Conditions of Field Work

It should be noted that the timing of the team's visit to the Sudan, with respect to the field trips, was ill chosen. The months of July, August and September, during which the team stayed in the Sudan, are the peak of the rainy season which, in the South of the country where the forests had to be visited, is quite pronounced.

This has been apprehended by the team beforehand and Polytechna pointed out to UNIDO the inadvisability of the team's departure to the Sudan in the summer period.

Accordingly UNIDO put the question of the timing of the team's visit to the Sudan to the Government in Khartoum which requested by cable the team's arrival "early July". This request has been complied with, but the actual field work of the team was greatly hampered by its ill-timed arrival.

First, there is much rain in the South of the Sudan at this time of the year and frequent downpours hampered an inspection of the forest, indeed whole days may be lost because of lasting heavy rain.

Second, the grass of the savanna forest grows very tall in this season of the year, it often exceeds 2 m in height and consequently any view of the landscape is lost, both when travelling by car, or walking on foot in the forest. Incidetally, this circumstance is also a source of danger from wild animals since inadvertently one may bump into elephants or buffalos at close range so that they may charge.

Third, all water courses are at high water levels, the bottom land of valleys is flooded and prevent any passing through the forest, either by car or on foot.

Fourth, travelling at this time of the year is exceedingly difficult because of the bad state of roads. Roads are never in too good a shape in this part of the country, not even the main roads connecting the most important population centres; but during the rainy season they are definitely at their worst and traffic on them should be confined to an absolute minimum. In Bahr-el-Ghazal province during the rain and until six hours after the rain [illegible] roads is barred to prevent them being damaged by traffic. Flood waters cause often damage to bridges and may cut road connections for a very long time. The roads are slippery, washed out, full of deep mud holes and sometimes the car may get stuck in mud or land in the ditch. All this involves many hardships for the traveller and prevents effective work at this time of the year.

To cite an example of how difficult it is to see a forest, indeed to show that it may be sometimes impossible to reach it during the rainy season, the expert´s attempt to go to Raga may be mentioned. The forests in the Raga area have been indicated by the Director of the Forestry Department in Khartoum, Mr. [illegible], as one of the possible sites for a plywood factory and consequently every effort was made by the team-leader to see this site. After a first attempt to reach Raga failed for lack of fuel and also because time was getting short, the expert returned to Wau a second time to reach this site. It took seven days of preparations to start on the trip to Raga. Fuel was obtained by applying for help to the Commissioner of the Province. A car was provided for by the Forestry Department by ordering a five ton lorry from a logging operation 150 km distant to Wau. Finally the expedition started on its 300 km trip to Raga - only to be back in Wau the same day: the bridge over the Pongo river has collapsed and there was no possibility to cross the flooded river for at least a month. So all that could be done was to collect hearsay informations from forest staff originating from the Raga area and try to establish by cross-examination what the forest resources of Raga really are.

There is always an enormous hazard in the rainy season to be trapped somewhere in the South for days and for weeks, if not for months, in remote regions.

The trip to the Sudan was ill-timed also for another reason. The Moslem month of Ramadan falls in 1975 in most of September and early October, when all activities are reduced, if not suspended. Working hours in all offices and institutions are shorter than usual and people are exhausted by fasting.

This was especially felt during the team-leader's stay in Egypt. Out of seven days spent in Cairo, two days were taken up by arrival and departure. One day was Friday and one day Eid el Fitr. In the three remaining days work could be performed only from 9.30 to 12.30, but many institutions, including UNDP, were closed on Thursday, and some even on the other days, as a consequence of Ramadan.

I/D List of People Contacted

In the Sudan

- Idris Ali Ahmed, Ministry of Industry, Khartoum
- Sanhuri, Ministry of Industry, Khartoum
- Amin Abu Sineina, Deputy Minister of Industry, Khartoum
- Abdel Rahman Abdel Halim Obeid, Director of Industrial Research and Consultancy Institute, Khartoum
- Kamal Osman Kalifa, Director of Forestry Department, Khartoum
- Kamal Hasan Badi, Deputy Director of Forestry Department, Juba
- Hamza Hanudi, Utilization Officer, Forestry Department, Khartoum
- Peter Mazia Kusum, Conservator of Forests, Equatoria
- Baipath Majvec Kilpou, Conservator of Forests, Bahr-el-Ghazal
- Ali Kandidu, Acting Assistant Conservator, Yambio
- Philip Adam, Forestry Department, Juba
- Valentino Lein Bulimka, Forestry Department, Juba
- David Bassiouni, Director, Regional Ministry of Agriculture, Juba
- Daniel Matthews, Director, Regional Ministry of Commerce, Industry and Supplies, Juba
- Cuor Deng Mareng, Inspector, Regional Ministry of Commerce, Industry and Supplies, Juba
- Michel Hyland, Deputy Resident Representative, UNDP, Khartoum,
- Miguel Bermeo, UNDP, Khartoum
- P.Astolfi, in charge of the UNDP sub-office in Juba
- Peter Dood, Adviser, Regional Ministry of Agriculture, Juba
- Gerard van Herhoeven, Adviser, Agricultural Training Centre, Yambio
- Kishor P.Sheth, Interfreight /Kenya/ Ltd., Juba
- J.Mueller, German Aid, Juba
- Alexander Dahia, Chief Civil Engineer, Regional Ministry of Communications, Transport and Roads
- Chappel, Road Expert, UNDP, Juba
- R.L.Mills, UNDP, Juba
- Manolis Andriotis, merchant, Maridi

Zoran, Yougoslav Energoproject, Juba

Derrick Maze, Maritime Forwardes, Juba

Michel Miama, Afforestation Officer, Wau

Anthony Tikmo, Assistant Deputy Commissioner, Wau

In Egypt

Adel A. Bahgat, General Manager, General Trading and Chemicals Co., 1/A Ramsis Str., Cairo

Stephen J.Szivos, Senior Industrial Development Field Adviser, UNDP, Cairo

Zdeněk Formánek, Commercial Section of the Czechoslovak Embassy

2/A Plywood Imports

Imports of plywood into the Sudan are not negligible neither in quantity nor in value. For the last five years the official Foreign Trade Statistics give the following figures for plywood imports:

Year	Quantity in kg	Value in LS	Unit value in LS/t
1970	273,185	25,530	93.453
1971	1,688,852	171,485	101.539
1972	1,632,077	191,169	117.132
1973	2,791,189	253,974	90.991
1974	1,118,057	302,078	270.181
Average per annum	1,500,672	188,847	125.842

However, it should be noted that imports of plywood in 1974 cannot be regarded as normal in the second half of that year. In the first six months of 1974 plywood imports reached 827,058 kg and a corresponding value of LS 219,933. The considerable drop of imports in the second half of the year was caused not by lack of demand but by a temporary shortage of foreign exchange and the need to import items having higher priority like fuel.

Also the 1970 imports seem to be entirely abnormal and should therefore be excluded from the calculation of the average. Based on the more or less normal years 1971--1974 an annual import of plywood in the range of 1,800 t would seem to be a fair average.

The bulk of plywood imports cames from China and Romania, only small quantities are supplied by India, Japan, UK, France, Federal Republic of Germany, Italy, Bulgaria, Czechoslovakia and Ethiopia.

The average weight of these plywood imports is estimated to be 720 kg per m3 /i.e. 4.8 kg per sheet 4′x 6′x 3 mm/. An average annual import of 1,800 t of plywood would therefore amount to 2,500 m3 per annum. This would be the present annual apparent consumption of plywood in the Sudan also in the opinion of plywood importers.

The standard size of imported plywood sheets is 4′ x 6′ x 3 mm. At least 90 % of all imported plywood has this dimension, and this size of plywood sheet is referred to, if no other specification is given expressis verbis. Exceptionally also plywood sheets of other size and thickness are seen in the market /e.g. sheets 4′x 7′ or sheets of 4 mm thickness/. The assertion of a Sudanese pre-investment study that 60 % of plywood used in the Sudan is of the size 4′x 8′, cannot be subscribed to /12/.

As to quality, most of the imported plywood is of class BB and CC. Plywood imported from China is usually of poor quality; Romanian beech plywood sheets are much better and sold at up to a 30 percent higher price.

2/B The Price of Plywood

The present wholesale price for a sheet of plywood in Khartoum is £S 2.60 per sheet/4´x 8´x 5 mm/ ex warehouse. The Carpenters Union - a cooperative society with 1,200 members in Khartoum also sells plywood sheets to its members at this price.

The consumer price charged by the retail dealer is at least £S 3.00 to 3.20 per sheet of plywood, but may go up as high as £S 3.75 per sheet.

In the South the consumer price is still much higher. In Juba where plywood is transported as air cargo from Khartoum at a cost of £S 0.384 per sheet the consumer prices is £S 5.75 per sheet.

All plywood imports reach the Sudan via Port Sudan. No plywood is imported via Mombasa-Juba.

The C and F price of plywood in Port Sudan is at present about US $ 300-320 per m3 according to quality and country of origin. At the present currency conversion rates this represents about £S 100. This price seems to have remained on the whole stable for the last five years, in spite of changing world trends.

To this value the following charges are added:

- customs duty 30 %,
- exchange tax 14.785 %
- surtax or additional tax 5 %
- development tax 2 %
- clearance and stamp tax 2.5 % and some other smaller items /0.715 %/ making a total of 55 %.

The transport cost from Port Sudan to Khartoum by lorry /the railway is not used/ is Pt 15 per sheet or £S 30 per ton.

The importer´s margin is 15 % and the wholesaler and retail dealer each add a margin of 10 %.

Consequently, the actual cost of plywood import can be summed up like this:

C and F price of plywood in Port Sudan	£S	100.-	/m3
Customs´duty and related charges 55 %		55.-	
	£S	155.-	/m3
Transport Port Sudan - Khartoum	£S	22.50	/m3
	£S	177.50	/m3
15 % importer´s margin		26.63	
	£S	204.13	/m3
10 % wholesaler´s margin		20.41	
	£S	224.54	/m3
10 % retail dealer´s margin		22.45	
Retail sales price	£S	246.99	/m3

or £S 1.65 per sheet.

This shows that the actual price of £S 3.- to 3.75 per sheet charged to the consumer in Khartoum is an inflated price which is about double that of the officially admitted price. In the South the overcharged price is nearly three times as high as that shown in the above calculation, taking into account £S 57.60 /m3 air freight.

This exaggerated price for plywood exists in spite the fact that the prices of all imported consumer goods are nominally controlled by the Sudanese Government /Ministry of Commerce, Pricing Control Department/. Since price control is based essentially on cost, the above price calculation is inflated by all sorts of cost items incurred by each dealer /like expenses for transport and storage, bank charges etc./ and by adding to these the margins which are in fact the gross profit.

On the other hand, the exorbitant price for plywood is possible because the present plywood imports are inadequate and do not meet the country´s demand. All dealers of plywood agree that the market could absorb easily double the present consumption without any sales promotion effort.

2/C Particle Boards and Hardboards

There is a particle board factory in North Khartoum with an annual production capacity of 6,000 m3 on a three-shift basis, but the actual output is much lower. In 1974 the output was 2,200 m3 on a two-shift basis. The raw material used is Eucalyptus camaldulensis and Eucalyptus tereticornis /50 %/, and bagasse /50 %/. The size of sheets is 4´x 8´x 6 mm, this size accounts for 96 % of the output. Only exceptionally are thicker sheets produced /they range from 8 to 25 mm/. The sheets are of poor quality. The price of a sheet /4´x 8´x 6 mm/ ex factory is £S 2.18,excise duty is £S 0.02 per sheet, the consumer price in Khartoum is £S 2.56 per sheet. Most /75 %/ of these particle boards are used in construction for ceilings etc; only about 25 percent goes into furniture production.

In order to protect this home-based particle board production no imports of particle boards are allowed into the Sudan. The import of hardboards /compressed fibreboards/ is restricted, but licences for import of hardboard are granted from time to time to the Carpenters´Union and to the May Corporation. The price of a hardboard sheet /4´x 6´x x 3.2 mm/ in the market of Khartoum is £S 2.40. Hardboards are imported mainly from Romania. No imports of hardboards /or fibreboards/ are listed in the Annual Foreign Trade Statistics for 1974, though at least 500 m3 of hardboards were imported in this year by the two agencies mentioned above. Maybe, these imports are listed under plywood imports.

2/D Imports and Production of Sawnwood

About 50,000 m3 of coniferous sawn timber is imported annually into the Sudan, consisting of redwood /Pinus silvestris/ from Sweden and the USSR and of white wood /Picea excelsa/ from Austria and Romania in equal proportions. Sudan Building Material Company and Sudan Railways are the sole importers. In 1974 the C and F price in Port Sudan was US $ 167 per m3 for white wood and US $ 250 per m3 for redwood. Customs duty and related items totalled 40 %, transport by truck to Khartoum costed £S 10-11 per m3. The importer adds a margin of 15 %, the wholesale and retail dealer each 10 %. According to this calculation the retail price should be £S 124 for white wood and £S 162 for redwood.

The actual consumer price in Khartoum is £S 162 per m3 for white wood and £S 252 per m3 for redwood. This retail price seems to be also an inflated one.

About two thirds of the sawn timber are used in furniture manufacture and one third in construction, of which about 10,000 m3 of sawn timber are for shutterings. There is a marked shortage of redwood in the market.

Little is done to meet the country's sawn timber demand from its own forest resources. There are 14 sawmills operating in the Sudan, 9 of which are located in the Southern Region. All sawmills are government owned and operated by the Forest Department. Their combined output representing some 7,000 m3 of sawn timber per annum consists almost exclusively of hardwoods. The bulk of this production are railway sleepers.

[illegible] Market survey in Egypt

Egypt has a plywood production capacity of 1[illegible],000 to 15,000 m3 per annum, but its output is very irregular because of fluctuations in the import of peeler logs. There are four plywood plants in Egypt /all of which are state owned/, three belonging to the Egyptian Woodworking Co. and one to the Nile Match Co. About half of the raw material is imported from Europe /mainly poplar and beech/, the other half of the raw material originates in African countries. There are also 2 veneer plants, whose output in 1973 was [illegible],000 m3.

It is difficult to asses plywood imports into Egypt because the data of the foreign trade statistics are not clear. Information gathered from plywood importers seem to indicate annual plywood imports in the range of 30,000 to 40,000 m3.

Plywood is imported mostly from the USSR /birch/, from Romania /beech/ and from the Far East, mainly Taiwan and Korea /lauan/.

The General Trading and Chemicals Company in Cairo, Ramses Str. 1/A /General Manager Mr. Adel A. Behgat/ is importing in 1975:

a/ from the USSR 15,000 m3 of birch plywood for the Ministry of Housing and Reconstruction of the following specification:

size 60" x 60" 90 %, other dimensions 10 %
thickness 3 mm 75 %, 4 mm 20 %, 5 mm 5 %
quality BB 25 %, BB/C 25 %, C 50 %

b/ from Romania about 500 m3 of beech plywood for the private sector through the Committee on Timber

size 5 x 5, 10 x 4, 7 x 4,
thickness 3 mm 70 %, 4 mm 20 %, 5 mm 10 %,
quality B/BB /and [illegible]/

c/ from Taiwan and Korea 6,000 m3 of plywood for the Ministry of Housing and Reconstruction of the following specification:

size 220 x 122 cm
thickness 4 mm 60 %, 5 mm 40 %

There are, beside this firm, other importers of plywood, but they are said to import less.

The C and F price in Alexandria /in US $/ is:

<u>for birch plywood /from USSR/</u>

quality	BB	C	BB/C	BB/CP	US $/m3
3 mm	231.51	178.59	226.50	244.64	
4 mm	210.87	142.88		198.24	
6 mm	201.90			194.04	
9 mm	194.04			189.80	
18 mm	187.69			181.37	

<u>for beech plywood /from Romania/</u>

3 mm quality B/BB US $ 474 /m3

STD US $ 392 /m3

These prices seem to include the premium on foreign exchange. The Company is buying plywood by tenders.

The retail price of plywood sheets in Cairo is:

Country of origin	Dimensions	Pt/sheet	LEg/m3
Italy	153 x 153 cm x 3 mm	150	256
	x 4 mm	200	214
Finland	122 x 183 cm x 4 mm	260	291
Lebanon	122 x 183 cm x 3 mm	190	284

Plywood is not used for shutterings.

Egypt's own resources /bagasse and flax shives/ are used for production of particle board.

3/A The Forests and their Utilization

Forest land with important timber resources which could represent a potential for plywood production occurs only in the South of Sudan, viz. in Equatoria and Bahr-el--Ghazal provinces. No reliable data exist as to actual volume of stock and annual yield, nor as to the distribution of forests and their species composition. No forest inventory is available and no working plans exist for any part of the forests. There is-with one exception in the Wau region - no map showing the distribution of forests, their density or tree species composition in the two provinces. Information concerning forest resources given by the Sudanese Forest Service conveys a general picture, but lacks data and figures as to possible utilization of the forests. Records of sample plots have been mostly destroyed during 17 years of hostilities in the South. Under these conditions, the best available information concerning forestry is little more than hearsay.

Libor Putna /13/ puts the approximate area of production forests in the woodland savanna with high rainfall /900 to 1800 mm/ at 164,000 square km and the estimated volume of timber at 34 million m3 which averages to about 2 m3 per ha. For the montane vegetation with a rainfall of 500 to 2000 mm he estimates the area of production forests as being 6,000 square km and the timber volume as being 16 million m3 which represents about 27 m3 per ha.

The Forest Department /Bulletin 16/ classifies 445,000 square km as productive forest land in the Sudan with an average standing volume of just over 1 m3 per ha. According to this source the montane forests extend to about 3,000 square km and contain about 30 % of the total standing volume, i.e. 16 million m3, or 53 m3 per ha.

Johannes Weck /14/ estimates that the average annual yield of plantations could be 8 to 12 m3 per ha in the humid savanna and 8 to 20 m3 per ha in the montane rain forest.

According to J.K. Jackson whose excellent Report to the Government of the Sudan on Forest Management, though written in 1960, is still considered to be the most reliable source of information on forestry in the South, the estimated potential annual yield of sawn timber in southern Sudan is as follows:

Isoberlinia doka /Vuba/	128,000 m3
Daniella oliveri /Bu/	1,250 m3
Khaya senegalensis /Dark Mahogany/	2,500 m3
Khaya grandifolia /Light Mahogany/	800 m3
Olea hochstetteri, Podocarpus milanjianus and other species of Montane forests	1,000 m3
Other species /approx./	4,000 m3
Total	137,550 m3

These figures have been quoted by Mr.Kamal Osman Kalifa, Director of the Forestry Department in Khartoum, at the time of the team's visit as the actual possibility of utilization of the forests.

Sawn timber production reached its all-time peak in 1963 with an output of 13,600 m3 sawn timber. The present installed sawmilling capacity in Equatoria and Bahr-el-Ghazal provinces would allow an annual production of almost 20,000 m3 sawn timber on a one-shift basis, corresponding to an intake capacity of about 50,000 m3 of saw logs. Actual output of sawn timber is said to be at present only about a quarter of the rated capacity, owing mainly to transport difficulties, lack of fuel, lack of spare parts, and inefficient management.

The territorial distribution of the sawmilling capacity is as follows:

Sawmills in	Capacity m3 sawn timber
Bahr-el-Ghazal	
Wau	4,000
Bisselia	1,000
Pongo Nuer	2,000
Pongo Aweil	2,000
Matiang	2,000
Subtotal	11,000

Sawmills in Equatoria	Capacity m3 sawn timber
Katire	2,000
Gilo	1,000
Nzara	2,000
Nuni	2,000
Loka /to be established in 1976/	2,000
Subtotal	9,000
Bahr-el-Ghazal	11,000
Equatoria	9,000
T o t a l	20,000

Judging from the saw logs which have been inspected during the team's visit to the South about 30 % of peeler logs are at present used for sawn timber. Sometimes peeler and veneer logs are processed even into railway sleepers! The absence of plywood production prevents the rational utilization of forest resources.

The prevailing tree species used for sawmilling and representing about 85 % of the total sawn timber output is Mahogany /both Khaya senegalensis and Khaya grandifolia/. Only the Nuni sawmill which lies in the Vuba belt processes almost exclusively Vuba /Isoberlinia doka/. A more or less important admixture of some other tree species occur in the sawmill yards which may be, according to the nature of the surrounding forest, Isoberlinia doka, Chlorophora excelsa, Terminalia superba or T. glaucescens, Afzelia africana, Daniella oliveri, Maesopsis eminii, Tectonia grandis, Cedrela toona, Cupressus lusitanica etc. Most tree species converted into sawn timber are suitable also for plywood and/or veneer production.

5/D Stumpage Recommendation

Since the Forestry Department owns and operates practically all sawmills, no stumpage is paid for saw logs. For saw logs processed in the sawmill in Asosa which is operated by the Agricultural Industrial Complex a fixed annual rate is paid as stumpage to the Forestry Department.

For commercial fellings outside of forest reserves a royalty is paid according to four different sizes of timber:

Large Kutla /big log/ with a medium diameter of 13.4" and more
Kutla /log/ " " " from 7.6 to 13.4"
Mirig /big pole/ " " " from 4.8 to 7.6"
Rasses /small pole/ " " " less than 4.8"

The royalty differs according to tree species and is /in Birr per piece of 7 feet length or more/:

Species	Large Kutla	Kutla	Mirig	Rasses
Teak /Tectona grandis/	60	60	60	60
Duraba /Pseudocedrela kotschyi/	40	35	25	25
Mahogany /Khaya grandif., K.senegalensis/	60	60	60	60
Inderab or Gambeil /Cordia abyssinica/	60	60	60	60
Bu /Daniella oliveri/	60	60	60	60
Other tree species	40	25	12	5

For pieces less than seven feet long half of above rates is charged.

Royalty differs essentially from stumpage not only in terms of money, but also as an economic tool and as to purpose. The intention of the forest law in establishing the royalty has been to prevent fellings outside of forest reserves. Royalty is not based on the cost of silviculture, but is intended as a punishment for cutting trees outside the forest reserve. This is reflected also in the high level of money levied. While royalty is a deterrent, stumpage is the equivalent of silvicultural cost and should enable normal management inside the forest reserve.

If the proposed plywood mill will operate - like the sawmills - in the organizational framework of the Forestry Department, the question of stumpage will not arise. But if it will represent a joint venture of the Ministry of Agriculture and the Ministry of Industry, even with a share of profit going to the Forestry Department, it is necessary to introduce stumpage as an element of cost into the calculation of cost for plywood. Besides that, a stumpage item would be needed, if the plywood industry were entirely separated from the Forestry Department as a private enterprise. Since up to now no stumpage fee has been fixed and levied for the forests of the Sudan, an attempt had to be made to determine a practical value for stumpage in this feasibility study.

As a basis for the computation of stumpage the actual cost of silvicultural operations in establishing and maintaining a plantation during the rotation period was taken. The rotation period was put at 80 years.

According to records from Equatoria and Bahr-el-Ghazal provinces the present cost of silvicultural operations is estimated as follows:

Ground preparation	initial	ZS	3.50	per feddan
" "	final	ZS	2.50	per feddan
Nursery stock		ZS	3.50	per feddan
Planting		ZS	3.30	per feddan
Weeding		ZS	4.00	per feddan
Firelining		ZS	3.20	per feddan
T o t a l		ZS	20.00	per feddan

Overheads are not likely to exceed 60 % of the direct cost, consequently the total cost of silvicultural operations amounts to ZS 32 per feddan, or ZS 80 per ha.

The mean annual increment of plantations /mostly teak/ connot be less than 1 m3 of logs per feddan, or 2.5 m3 per ha. Based on this safe asumption, the average stumpage for logs would be

$$\frac{80}{2.5 \text{ m3} \times 80 \text{ years}} = \text{ZS } 0{,}40 \text{ per m3}$$

It is now assumed:

1. that the stumpage for peeler logs should be twice that of saw logs
2. that the occurrence of peeler logs is on the average half of that of saw logs.

Under these two assumptions the stumpage for saw logs is ZS 0.30 per m3 and for peeler logs ZS 0.60 per m3, since 1/3 m3 x 0.60 ZS + 2/3 m3 x 0.30 ZS = 0.40 ZS/m3.

The stumpage paid for the production of 1 m3 plywood will be accordingly ZS 1.33 per m3 plywood /2.22 m3 logs x x ZS 0.60 /m3 log/.

3/C Evaluation of Timber Resources

Imatong mountains

The forests of the Imatong mountains are generally considered to be the most promising source of timber in the Sudan. They consist mainly of montane rain forest which should be termed perhaps better as "cloud forest". They occur mostly at altitudes between 1700-2700 m /the highest point being Mt. Kenyati 3187 m/. They contain the second largest forest reserve in the Sudan with an area of 282,270 feddans /115 000 ha/. This area is composed of hilly broken country of varying slopes with a few sheer rock outcrops; there is little flat land.

This appraisal is concerned only with the Imatong forest reserve though montane forests can be found also in the Lolibai mountains to the South, reaching to the Uganda border, the Lomariti mountains in the East, and the Acholi mountains in the North East. All these ranges contain the greater part of the montane forest found within the Sudan.

The Imatong forest reserve is composed of two distinctive kinds of forests: the montane forest above 1500 m which covers about 75 % of the area, and the lower lying foothill forest limited to about 25 % of the surface. About 13 % of the area is estimated to be non-forest land. According to a crude estimate, in the montane forest 10 % of the forest land may be logged over or cleared for shifting cultivation, and another 10 % may consist of protection forest; in the foothill forest, 20 % of forest land may be logged over or cleared and another 20 % are or should be declared a nature reserve. Consequently, the area of production forests is calculated as follows:

Imatong Forest Reserve, total area	115,000 ha
Less 13 % of non-forest land	- 15,000 ha
Forest land	100,000 ha

Forest land		100,000 ha
A/ Montane forest 75 %		75,000 ha
Logged over or cleared 10 %	7,500 ha	
Protection forest 10 %	7,500 ha	15,000 ha
Montane production forest		60,000 ha
B/ Foothill forest 25 %		25,000 ha
Logged over or cleared 20 %	5,000 ha	
Nature reserves 20 %	5,000 ha	10,000 ha
Foothill production forest		15,000 ha
Total production forest		75,000 ha
Annual felling area for 30 years		2,500 ha

There are 8 forest rangers in the Imatong Forest Reserve, consequently the annual felling area for a forest ranger would amount on the average to 312.5 ha which is feasible. The total annual felling area in the Montane forest would be 2,000 ha and in the foothill forest 500 ha.

As far as can be judged from the short visit to the montane forest, there occur about 25 big trees per ha with an average volume of 1 m3 per tree, totalling 25 m3 per ha. This would be consistent with the Draper report /15/ which indicates a volume of 15 to 50 m3 of saw logs per ha from the natural forest.

The main tree species occurring in the montane forest are Olea hochstetteri and Podocarpus milanjianus which may represent 75 % of the total felling volume. Besides them a number of other hardwoods occur such as Syzigium guineense, Pygeum africanum, Ocotea viridis, Fagara macrophylla, Polyscias fulva, etc. It is estimated that at least 80 % of the volume is represented by tree species suitable for plywood production.

The stem quality of the trees is, unfortunately, mostly not favorable for plywood production. The sample seen on four walks into the forest would not yield even 10 % of peeler logs. But this field inspection may not have conveyed a true picture of the untouched natural forest and from what has been said by the local forest staff and read in various reports about the Imatong forests it may be expected that an outturn of 20 % of peeler logs would be a safe assumption.

Consequently, the calculated volume of peeler logs is put at /0.80 x 0.20 =/ 16 % of the total volume, i.e. at /25 m3 per ha x 0.16 =/ 4 m3 per ha. This would amount for the annual felling area of 2,000 ha to 8,000 m3 of peeler logs per annum from the montane forest.

In the foothill forest Khaya grandifolia is the prevailing tree species representing about two thirds of the standing volume. The other species are Chlorophora excelsa, Entandophragma angolense, Measopsis eminii, Chrysophyllum albidum, Celtis zenkeri, Cola cordifolia etc.

J.K. Jackson puts the standing volume in the Talanga forest which is part of the foothill forests and which was also visited by the team at 13.5 m3 per ha out of which mahogany represents 9 m3 per ha, but he adds that an increase of yield could be allowed if a wider range of tree species could be utilized /1/.

In our opinion it is safe to assume a standing volume of at least 18 m3 per ha as an average for the foothill forest. About three quarters of the tree species may be suitable for plywood production and most of the trees being of outstanding shape an outturn of two thirds in peeler logs could be expected. Accordingly, the quantity of peeler logs is put at /18 m3 x 3/4 x 2/3 =/ 9 m3 per ha on the average which gives for the 500 ha of the annual felling area a total of 4,500 m3 of peeler logs.

The Imatong Forest Reserve could thus yield annually:

from the montane forest	8,000 m3 of peeler logs
from the foothill forest	4,500 m3 of peeler logs
T o t a l	12,500 m3 of peeler logs

or 5 m3 of peeler logs per ha.

If all the saw logs could be processed as well, fellings could produce

	saw logs	peeler logs	total
from the montane forest	42,000 m3	8,000 m3	50,000 m3
from the foothill forest	4,500 m3	4,500 m3	9,000 m3
from the whole reserve	46,500 m3	12,500 m3	59,000 m3
in proportion	79 %	21	100 %

But the sawmilling capacity consists at present only of two small sawmills in Katire and Gilo with an intake capacity of about 6,000 m3 per annum. According to the Imatong Forestry Project drawn up by the IBRD in July 1973 as the first part of an integrated development programme a new sawmill at Itibol should be constructed with an annual roundwood input of 9,000 m3. Together with the existing sawmill in Katire this would allow the processing of some 13,000 m3 of saw logs per annum.

For the time being fellings should be limited to a selection of trees containing peeler logs in the range of at least 18,000 m3 roundwood per annum since it is estimated that even selective fellings of peeler logs would produce about 30 % of saw logs:

Total fellings	18,000 m3	100 %
Peeler logs	12,600 m3	70 %
Saw logs	5,400 m3	30 %

Felling of trees is done in the Imatongs - as indeed everywhere in the South - by hand. There are power saws kept in the store, but they are not used for lack of know-how.

The cost involved in logging operations is estimated as follows.

The daily wages of forest workers are 30 Pt, the average output in felling and crosscutting in the Imatongs is 0.4 m3 per man-day. The unit cost is therefore 75 Pt per m3.

The Imatong Forest Reserve has the approximate shape of a square of 33 x 33 km. Katire lies in the middle of the northern edge of this square. Maximum transportation distance from the forest to Katire would be around 40 km, the average distance would not exceed 30 km.

The density of the road network should be planned so as to keep the total sum of skidding cost and road construction cost at its minimum. For skidding a crawler tractor, preferably a D6 Caterpillar with logging arch should be used. Since the country is hilly and skidding cost relatively high, the skidding distance should not exceed 600 m and be kept at 300 m as an average. This would require about 8 m of hauling roads per ha.

The soil in the Imatong mountains is mostly deep clay loam, but plenty of rock can be found. Road construction cost is estimated at ZS 1200 per km. This would amount to ZS 9.60 per ha or ZS 1.92 per m3, of peeler log. Road maintenance is included in this sum.

Skidding cost would amount to ZS 2.50 per m3, and hauling cost, according to current rates of contractors, to Pt 18 per m3, and km, or ZS 5.40 per m3 for the average hauling distance.

For saw logs the hauling cost would be the same as for peeler logs. But if no plywood production would be started, the hauling distance for saw logs would be only about 15 km instead of 30 km, so the hauling cost would be reduced by ZS 2.70 per m3. Since for each m3 of saw logs /30 % / 2.33 m3 of peeler logs /70 %/ occur, the difference in hauling cost should be charged against this quantity of peeler logs, consequently /2.70 : 2.33 =/ ZS 1.16 per m3 of peeler log.

The total cost of one m3 of peeler log at the factory yard in Katire would, accordingly, consist of

stumpage for peeler logs	ZS	0.60 /m3
felling and crosscutting	ZS	0.75 "
skidding, 300 m, ZS 5 per hour, 2 m3 per hour	ZS	2.50 "
hauling, 30 km, Pt 18 per m3 and km	ZS	5.40 "
road construction	ZS	1.92 "
increased cost of saw log hauling	ZS	1.16 "
Total cost of peeler log at factory yard	ZS	12.[illegible] /m3

This cost may be regarded as a favourable one from the financial viewpoint, but from the silvicultural viewpoint the situation is less satisfactory. The main drawback is that the saw log volume remains for the greatest part unutilized in the forest, consequently the exploitation of the forest cannot be followed by subsequent conversion of the natural forest into plantations. It should be noted that there are coniferous plantations /Cupressus lusitanica and some pine species/ in the Imatongs which do extremely well, and large-scale planting of fast-growing coniferous species at short rotations should be the aim of forestry operations in the Imatongs.

The IBRD Imatong Forestry Project referred to above envisages the annual establishment of 350 ha of plantations around Gilo. If this afforestation programme could be carried out in each of the 8 Forest Ranger Districts of the Imatong Forest Reserve, all the area logged over could be currently converted to softwood plantations.

This would, of course, require a very large increase of the existing sawmilling capacity. Since the Katire sawmill could process even in its present state without any reconstruction all incoming saw logs from the foothill forest, it would be necessary to install at Itibol and preferably at two or three other sites in the montane forest a number of sawmills with a total intake capacity of 42 000 m3 of roundwood. Such an increase of the sawmilling capacity would allow, together with large-scale charcoal production, and perhaps even with a chipboard plant, the complete utilization of the natural forest and its subsequent conversion to softwood plantations.

In the opinion of the consultent it would be worthwhile to examine such an optimum solution in the light of forest inventory results from the Imatong Forest Reserve.

Loka - Nuni area

This area lies on the eastern edge of the long Vuba belt which extends from here to the north west as far as

Aweil and Raga for some 800 km. The prevailing tree species are Isoberlinia doka /Vuba/, Afzelia africana /Pai/ and Daniella oliveri /Bu/ occuring as an admixture.

The only sawmill in this region is in Nuni, with an annual intake capacity of about 2,500 m3 roundwood. Two other sawmills with a similar total capacity shall be installed in the Loka area in 1976 financed from German bilateral aid.

Plywood production in this region could be based only on Vuba as the main tree species. Now, while Vuba as a tree species in itself is suitable for plywood production, the particular size and quality of Vuba timber in this region seems to be of little value for this purpose. Both the log yard at Nuni sawmill and the surrounding forest have been inspected and the impression was gained that it would be hardly feasible to supply the necessary raw material under existing conditions. The average volume of a log of Vuba is estimated to be only 0.3 m3 and not more than 10 % of the logs in the sawmill yard could be used for peeling.

Also from what has been seen in the forest the conclusion was drawn that the inspected stands could not provide peeler logs in sufficient quantity to warrant the establishment of a plywood mill in this area.

Consequently the idea to choose this region as a potential site for a plywood mill was abandoned.

This does not mean, of course, that a plywood mill could not be installed in the Vuba belt in some other place where Vuba stands are said to be of exceedingly good size and quality. But no such place has actually been seen by the expert.

Nzara area

Little is known about the forests and timber resources of the Nzara-Yambio region, therefore not much can be said about them. It seems to be certain that there are two kinds of forest in this region: the gallery forest and the savanna forest. Both kinds of forest were visited and a personal impression gained of them. Besides information about the [illegible] was obtained from Mr. [illegible], Commissioner of Forests of [illegible], and from several forest rangers.

It appears that the belt of forest land stretches along the border between Sudan and Zaire and along the road from Yambio to Nzara and farther in the direction to Tumbura. Not much forest land is left to the north east of this road, but the forest belt to the south west of the road seems to be dense and [illegible] uninhabited. The forest is said to improve both in growth and density towards the border.

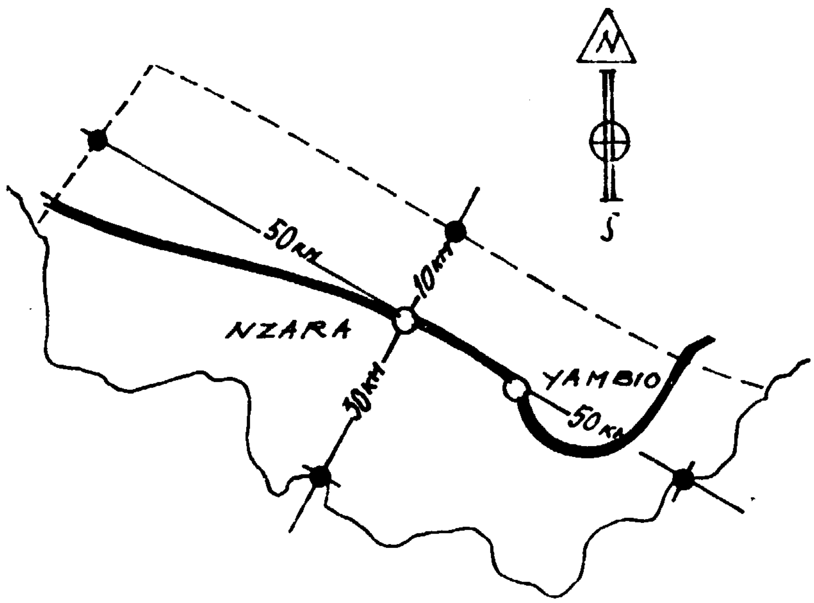
The only sawmill in this region is in Nzara operated by the Agricultural Industrial Complex. The transport distance of logs from the forest to the sawmill is said to be 5-11 km. Mostly mahogany and Chlorophora are used. The annual intake [illegible] roundwood. About half of [illegible] used for [illegible] [illegible] attached to the sawmill.

The small sawmill [illegible] in this region does not allow the utilization of both saw logs and peeler logs occurring in the forest. Instead of that only trees containing peeler logs could be taken out of the forest. Even so besides peeler logs about [illegible] % of the volume felled would represent saw logs.

If Nzara would be chosen as the site of a plywood mill, logging operations could extend as far as the Sudan-Zaire border which is only 30 km distant as the crow flies; but in the opposite direction, to the northeast, only a belt of about 10 km width is forested, farther away the savanna woodland does not contain timber. In the direction to the southeast and northwest, i.e. towards Yambio and Tumbura, forests up to 50 km [illegible] in each direction could be utilized.

Consequently, the influx area of the plywood mill would comprise a rectangle of /30 + 10/ x /50 + 50/ km, representing a surface of 4,000 square km. Maximum transportation distance could reach 60 km. but the average distance is not likely to exceed 40 km /see map/.

SITE IN NZARA
1 : 1,000,000



Consequently, the intake area of the plywood mill would comprise a rectangle of /30 + 10/ x /50 + 50/ km, representing a surface of 4,000 square km. Maximum transportation distance could reach 60 km, but the average distance is not likely to exceed 40 km.

The forest cover of this area is estimated by the responsible forest authorities at 50 to 70 %. To be on the safe side, let us assume a 50 % forest cover which corresponds to a forest surface of 200,000 ha. Of this about 5 % or 10,000 ha are gallery forests and 95 % or 190,000 ha savanna forests. Distributed over 30 years, the annual felling area is 6,666 ha.

The average width of a gallery forest is from 50 to 100 m. This would imply a total length of 1,333 km of water courses and a distance of about 3 km between them, which would be consistent with the configuration of land. The main species of the gallery forest is mahogany /Khaya grandifolia/ which attains a very big size. The average volume of a mahogany tree could well be 3 m3 and most of it could be used for peeling and even for veneer. In small numbers also other big-sized tree species occur, mainly Chlorophora excelsa and Albizzia zygia. Stocking is dense, about 10 big trees grow per ha with a utilisable peeler log volume of about 15 m3 per ha. This would represent for the total area of gallery forests some 150,000 m3 of peeler logs, mostly mahogany, which distributed ower 30 years would amount to 5,000 m3 of peeler logs per annum.

The savanna forest is composed mainly of Chlorophora and Terminalia. Chlorophora excelsa grows usually in clusters of 5 to 10 trees at distances of 10 to 20 m, then another cluster occurs several hundred meters farther off. The trees are very tall and of exceedingly good shape. One tree may occur on the average per 2 ha with a peeler log of 1.8 m^3 per tree, or 0.9 m3 per ha.

The other main species is Terminalia /T.glaucescens and T. superba/ which is of much smaller size and less good shape. On the average, three trees may occur per ha, each of a log volume of 0.5 m3 per tree and 20 % peeler quality. This would amount to 0.3 m3 of peeler logs per ha.

Consequently, the savanna forest could yield:

Chlorophora	0.90 m3 of peeler logs per ha
Terminalia	0.30 m3 of peeler logs per ha
T o t a l	1.20 m3 of peeler logs per ha

The total amount of peeler logs would be, therefore: /190,000 ha x 1.20 m3 per ha =/228,000 m3 which distributed over 30 years would amount to 7,600 m3 of peeler logs per annum.

The annual supply of peeler logs for the plywood mill would consist of:

timber from gallery forests	5,000 m3 of peeler logs per annum
timber from savanna forests	7,600 m3 of peeler logs per annum
Total supply	12,600 m3 of peeler logs per annum

Trees felled for peeler logs would contain, of course, also a certain amount of saw logs. It may be assumed that on the average trees selected for peeling would contain 30 % of saw logs. Consequently, total fellings for both the plywood mill and the sawmill in Nzara should be in the order of 18,000 m3 of logs per annum which would result in:

70 % of peeler logs	12,600 m3 per annum
30 % of saw logs	5,400 m3 per annum
100 %	18,000 m3 per annum

Thus, fellings for the plywood mill would supply, at the same time, also the saw logs for the sawmill.

Felling is done in the Nzara region - like elsewhere in Equatoria - by workers paid a daily wage of Pt 30. Average daily output is 0.5 m3 per man. Consequently, cost of felling amounts to Pt 60 per m3. This would include also crosscutting.

For the extraction of logs to the roadside a D5 Caterpillar should be used for a maximum distance of 1 km, on the average for a distance of 500 m. This would require a road density of 5 m per ha. Under these conditions, skidding cost would amount to about £S 2 per m3 /cost of tractor £S 4 per hour, skidding output 2 m3 per hour/.

The ground in this region is very suitable for road construction, the earth cover is shallow, consisting of coarse sand with excellent drainage and based on iron-stone. Slopes are gentle. Road construction cost would amount to £S 800 per km, or £S 4 per ha. This entire cost should be charged against peeler logs, since the collection of saw logs would not require such an extensive road network. The quantity of peeler logs being on the average 1.89 m3 per ha /i.e. 12,600 m3 : 6,666 ha/, road construction cost would be £S 2.12 per m3 of peeler log.

Hauling is done usually be contractors. The current rate is 18 Pt per m3 and km, which amounts for an average hauling distance of 40 km to £S 7.20 per m3 of peeler logs. This includes also loading and unloading and stacking in the factory yard.

The same amount of cost would apply for the hauling of saw logs. But the actual hauling cost for saw logs, if no plywood mill would be established, would not exceed £S 1.80 per m3 since hauling distance would be on the average 10 km. So the difference £S 5.40 /= 7.20 - 1.80/ per m3 should be charged to plywood production. If saw logs represent 30 % and peeler logs 70 % of the fellings, this difference would amount to £S 2.3[illegible] /= 5.40 : 2.33/ per m3 of peeler log.

The total cost involved in supplying peeler logs in the Nzara area is estimated accordingly as follows:

	in £S per m3
stumpage for peeler logs	[illegible]
felling and crosscutting	0.60
skidding, 500 m, £S 6 per hour, 3 m3	[illegible]
hauling, 40 km, Pt 18 per m3 and km	7.20
road construction, 5 m per ha, £S [illegible] per km	[illegible]
increased cost of saw log hauling	[illegible]
Total cost of peeler logs at factory yard	[illegible]

This would be, from the financial viewpoint, an acceptable result, but it should be borne in mind that the exploitation of the natural forest is unsatisfactory, since only the cream of timber resources is utilized and no silvicultural improvement is achieved. This situation could be remedied by a substantial increase of the sawmilling capacity at Nzara which would allow, at least partially, the full utilization of existing timber resources, both for plywood and sawnwood production, and the subsequent conversion of the natural forest to [illegible] plantations, or, even better, to plantations of [illegible] softwood [illegible].

Wau - Raga area

The forest area between Wau and Raga was photographed and evaluated by the Inventory Section of the Forestry Department in 1963. As a result a map is available showing the Vuba belt and savanna rich in large-crowned trees.

In the Vuba belt there were 20.5 trees per ha with a volume of 8.66 m3 per ha, corresponding to an average tree volume of 0.43 m3 which would seem to be of sufficient size for containing peeler logs of a diameter of around 35 cm.

In the savanna there were on a surface of 320 square km
24,000 mahogany trees with a volume of 40,000 m3, or 1.67 m3/tree
14,000 Afzelia trees with a volume of 30,000 m3, or 2.01 m3/tree
3,000 Daniella trees with a volume of 6,000 m3, or 2.00 m3/tree.

This amounts to an average stocking of 2.4 m3 per ha.

An aerial reconnaissance which had been undertaken with a survey plane revealed that there were more than tree times as much Vuba and mahogany, Afzelia africana and Daniella oliveri in the areas south of Deim Zubeir and east of the area investigated. These areas have been photographed at the end of January 1963. The statement was made then by M.S.S.Gassouma, Forest Inventory Officer.

However Gassouma's report was questioned by a committee which visited the area in December 1963, reporting: "It cannot by assumed /indeed our visit showed the contrary/ that sufficient merchantable timber can be found where the photos reveal "dense" forest".

Not much more is known about this forest since that time. But it is a fact that there are 5 sawmills established in the area to the north and west of Wau with an important sawmilling capacity, as has been already indicated. In the opinion of the Conservator of Forests in Wau, Mr. Saipath, the supply of logs for all these sawmills is well established for the future, and could be even increased, though it may be necessary to transfer one or two sawmills to other sites nearer to the timber resources in the near future. Furthermore, it is urgently required to build a bridge across the Bousseri river, replacing the ferry operating there now, in order to start timber exploitation also to the south of the river.

With regard to this situation, the best solution for starting plywood production in Bahr-el-Ghazal province seems to be to increase sawmilling to the full capacity of the existing sawmills in Wau, Besselia, Pongo Nuer, Pongo Aweil and Matiang and to add an extra 43 % to the felling volume for supplying peeler logs to the plywood plant, assuming a 30 % outturn of peeler logs from the volume of felled timber. The plywood mill whould be situated in this case in the centre of the area for the delivery of peeler logs which lies practically in Wau itself.

Consequently, the timber supply for the plywood mill could be best provided in this manner:

Sawmill	Total fellings 100 %	Peeler logs 30 %	Saw logs 70 %	Distance in km from Wau
	Thousands of cubic meters			
Wau	14,3	4,3	10,0	-
Besselia	3,6	1,1	2,5	35
Pongo Nuer	7,9	2,4	5,5	85
Pongo Aweil	7,8	2,3	5,5	90
Matiang	7,8	2,3	5,5	150
T o t a l	41,4	12,4	29,0	

Accordingly, fellings in the range of 41,400 m3 per annum could provide 29,000 m3 of saw logs for the existing five sawmills and, at the same time, around 12,400 m3 of peeler logs for the plywood mill.

The transportation of peeler logs to the site of the plywood mill in Wau would be done from the sawmills in Besselia and Pongo Nuer by lorries on the Raga road, and from the sawmills Pongo Aweil /which is only 8 km from Mundit railway station/ and Matiang /which is next to the railway station in Aweil/ by train. The cost of transportation would be:

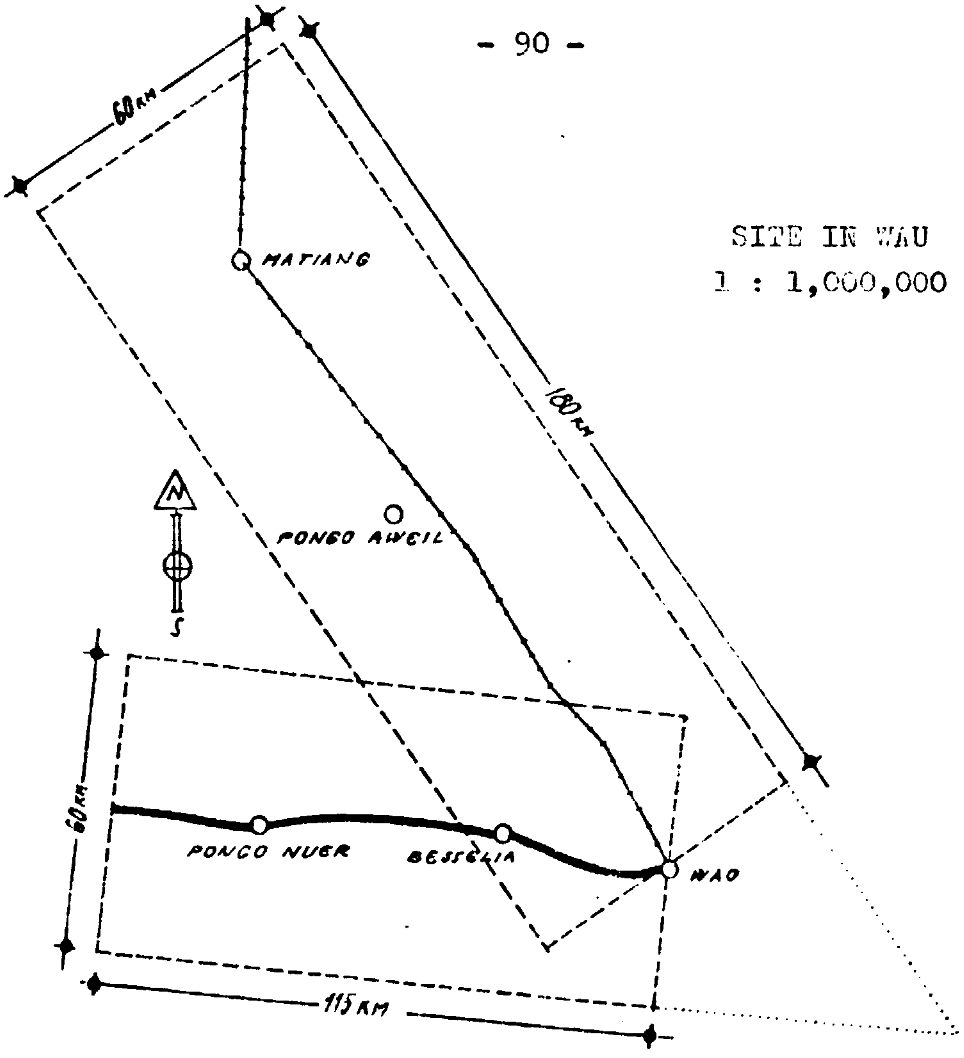
To Wau from	Volume	Distance	Unit cost	ZS per annum
Bosselia	1,100 m3	35 km	Pt 7.5 /m3/km	2,888
Pongo Nuer	2,400 m3	85 km	Pt 7.5 /m3/km	15,300
Pongo Aweil	2,300 m3	8 km	Pt 7.5 /m3/km	
		90 km	ZS 1.57 /m3	4,991
Matiang	2,300 m3	150 km	ZS 1.87 /m3	4,301
Wau	4,300 m3			
Loading and unloading	12,400 m3		Pt 25 /m3	3,100
				30,580

or ZS 2.47 per m3 of peeler log.

It is estimated that fellings in the order of 41,400 m3 of logs per annum could be made for at least 15 years along a 60 km wide strip stretching 180 km to the north of Wau along the road and railway to Aweil, and 115 km to the west of Wau along the road to Raga, i.e. 30 km behind Matiang and Pongo Nuer.

These two strips cover an area of 17,000 square km /i.e. 60 x 180 + 60 x 115/ of which at least one third should be covered by forest representing approximately 600,000 ha of untouched forest land. It is further estimated that there is on the average at least one big tree of mahogany, Afzelia or Daniella with a breast height girth of 45 or more inches /36 cm diameter or more/ and an average log volume of 1.6 m3 per 2 feddans which amounts to 2 m3 log volume per ha. The total stocking on the two strips would equal accordingly 1,200,000 m3 of logs. If this supply should last 30 years the annual fellings would be 40,000 m3 of logs, out of which some 12,000 m3 would represent peeler logs. The supply of raw material for plywood production in Wau may be considered safe on this basis.

The maximum distance of log transport from the two mentioned strips to the five sawmill sites would practically not exceed 50 km and the average distance would be around 30 km /see map/.



SITE IN WAU
1 : 1,000,000

The ground on all this territory is either level or very moderately undulated, with very shallow and permeable sandy soil and the underlying ironstone plate which protrudes often to the surface and makes an excellent hard surface for transportation.

In order to keep skidding cost at a reasonable level, maximum skidding distance should not exceed 1 km and average skidding distance should be around 500 m. This would enable keeping skidding cost at about £S 0.75 per m3 on the average, when using a 85 h.p. wheel tractor and logging arch, but would require a density of hauling roads of about 5 m per ha.

Since annual fellings amount to 40,000 m3 of logs on an area of 20,000 ha, an annual road construction programme of

100 km hauling roads should be tackled. The cost of road construction can be estimated at LS 400 /km or LS 2 /ha. With 2 m3 of logs felled per ha this amounts to LS 1.00 per m3.

The hauling of logs is done usually be contractors, the latest bids in Bahr-el-Ghazal province indicate a price of Pt 18 per m3 and km. For the average hauling distance of 30 km the hauling cost is estimated at LS 5.40 per m3. This sum includes loading, unloading and stacking of timber, at the factory yard.

Felling and crosscutting of trees is done in Bahr-el-Ghazal provicne on a piece work basis. The forest workers are prid LS 0.015 per cubic foot which is equal to Pt 53 per m3.

The final cost of peeler logs at the rill yard is therefore composed of the following items:

	LS/m3
stumpage for peeler logs	0.60
felling and crosscutting	0.53
skidding, 500 m, LS 1.50 per hour, 2 m3 per hour	0.57
hauling, 30 km, Pt 18 per m3 and km	5.40
road construction, 5 m per ha, 400 LS per km	1.00
delivery from sawmills to plywood mill in Wau	2.47
Total cost of peeler log at factory yard	LS 10.75 per m3

This may be regarded as a very satisfactory result from the economic viewpoint, caused by the integration of the plywood plant with existing sawmilling capacities. But what is still more important from the viewpoint of feasibility is the bright outlook for longstanding utilization of the vast timber resources which lie to the west of the two mentioned strips and especially in the Kuru - Deim Zubeir - Raga area and behind it to the south up to the border of the Central African Republic.

As has been already mentioned in the introduction, it has not been possible to the forest economics expert to visit these forests inspite of all efforts undertaken to reach this region. But discussions with forestry staff originating in this region revealed the existence of important timber resources both of the gallery and savanna type with mahogany, Afzelia, Daniella, Isoberlinia and Terminalia as the prevailing tree species. The size of these trees seems to be by no means inferior to the trees around Wau and the density of the forest increases, and tree growth improves, in the direction to the border. The surface of forest land involved may be in the range of 5,000 square km or more, with very little or no population at all.

At present, this region is untouched by any development, and it would be very difficult to establish an industrial plant here for lack of infrastructure. The road from Wau via Kuru and Deim Zubeir to Raga is notorious for its desolate state and should be entirely reconstructed. This could involve expenses in the range of up to one million pounds /or about LS 3,000 per km/, but no projects for any road improvement are planned or even contemplated at present.

However, this situation may change in 15 years' time and once a good road, suitable for heavy traffic, is built between Wau and Raga as an infrastructure development, access to the whole region will be gained and timber extraction could be started with corresponding installation of sawmills and also of a plywood industry.

But at present conditions for the establishment of a plywood mill exist only in and around Wau. A great advantage of Wau is the railway connection with Khartoum and the entire North of the country. The only improvement of the existing infrastructure which is urgently needed is the construction of a bridge across the Busseri river. This could involve a cost of about LS 750,000 and should be accomplished as part of the road improvement from Juba via Maridi-Yambio-Tumbura to Wau, which is under consideration.

3/D Forest Inventory Recommendations

The title of the project should be Forest Inventory with Logging Plan. The project should cover an estimated surface of 400,000 ha of forest land in Bahr-el-Ghazal province around Wau, Besselia, Tongo Nyer, Tongo Aweil and Matiang, and prepare a logging plan for 10 years. Besides that, assistance should be given in the testing of interesting tree species as to their suitability for the production of plywood and sliced veneer. The staff of the project should consist of

	Assignment Project Area	Assignment Khartoum
1 Project Manager and Forest Management Expert	12 months	5 months
1 Inventory Officer	12 months	3 months
3 Field Inventory Assistant Officers each 12 months	36 months	3 months
1 Consultant for Photogrammetry	6 months	1 month
1 Consultant for road network and logging	4 months	2 months
T o t a l	70 months	14 months

Sudanese staff provided by Sudanese Government should include at least 7 counterparts, 4 forest rangers, 4 forest guards, 12 drivers and assistant drivers, 32 unskilled labourers.

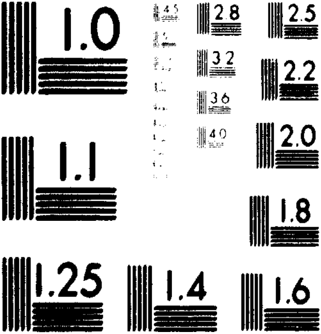
Sampling on 0.5 % of the forest land should be carried out.

Equipment required: 1 survey plane for 30 days, 4 landrovers and 2 light lorries, radio transmission and receiving equipment, camping equipment, calculators and typewriters.

Estimated total cost: US $ 450,000.

Financing could be from bilateral or multilateral sources.

81.12.03



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

3/E Suitability of Tree Species for Veneer and Plywood

according to

Tag Eldin Hussein Masrour	African Timbers /15/
Botanical species /Sudanese name/	
Suitable:	
Acacia albeberrima	suitable
Albizzia aylmeri /Sereira/	"
Albizzia lebbeck	"
Albizzia zygia /Albizia sohaul/	"
Boswellia papyrifera /Cafal/	"
Ceiba pentandra	"
Chlorophora excelsa	"
Cordia africana /Inderab/	"
Cupressus lusitanica	"
Daniella oliveri /Du/	"
Eucalyptus camaldulensis	"
Eucalyptus tereticornis	"
Isoberlinia doka /Tuba/	not tested
Khaya grandifolia /Mahogany tari/	suitable
Khaya senegalensis /Mahogany afl/	"
Mitragyne stipulosa /Mitragyne/	"
Olea hochstetteri /Zaytun/	"
Podocarpus milanjianus /Podo/	"
Pseudocedrela kotschyi /Duruba/	"
Sclerocarya birrea /Homoid/	"
Syzygium guineense /Kuji/	"
Tectona grandis /Teak/	"
Terminalia ssp. /Derut/	"
Terminalia superba	"
Could be used:	
Acacia albida /Haraz/	not tested
Afzelia africana /Tei/	suitable

3/I Testing of Sudanese Tree Species in Czechoslovakia

At the beginning of 1973 the State Forest Products Research Institute in Bratislava received from Lignoprojekt 5 samples of wood species grown in the Sudan. The samples were delivered in the form of small, rectangular, sawn pieces 200 x 110 x 15 - 22 mm with a moisture content of about 7 %.

The botanical names of the five species were:

1. Pseudocedrela Kotschi
2. Cordia africana
3. Vuba isoberlinia
4. Boswellia papyrifera
5. Khaya senegalensis

The purpose of the delivery was to get at least a general idea on the possibility of utilization of these species for the production of veneer and plywood. In spite of the fact that the dimensions of the samples were too small to perform the routine laboratory investigations, a new laboratory approach was developed which made it possible to peel a couple of veneers from each piece of wood.

<u>Peeling procedure</u>

The samples were converted into veneer on a laboratory rotary cutter. The preparation of the samples for cutting was based on soaking in water at 20 °C for 20 hours with an gradual increase of temperature to 40 °C during the following 24 hours. Immediately before cutting the pieces were steeped in water at a temperature of 80 °C for 4 hours.

The nominal thickness of the experimental veneers was established at 1.5 mm and 0.8 mm. The cutting procedure was conducted under the following settings:

The horizontal distance between the edge of the knife and the nose-bar was 0.7 mm for the nominal thickness of 0.8 mm and 1.45 mm for the nominal thickness of 1.5 mm. During the cutting the compression of the veneer of 1.5 mm was 12 % and that of the 0.8 mm veneer 9 %. The setting of the clearance angle was [illegible] and that of the sharpness angle [illegible].

Due to the small amount of material which was available for the tests, all specimens were cut in one single process, so that the [illegible] could not be differentiated [illegible].

This [illegible] correction [illegible] cannot be [illegible] species from the technological point of view.

The basic results established by the experiments are given in the following table:

Species	Density of oven-dry wood	Resulting thickness of wet veneer in mm for nominal thickness of 1.[illegible] mm	of 1.5 mm	Average moisture content during [illegible] in [illegible]
Isoberl[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cordia [illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] was [illegible] and that [illegible] was extremely unfavorable [illegible] process.

Nevertheless the quality of the peeled veneer was in general [illegible].

The quality of the veneer obtained from [illegible] to 1 and [illegible] 5 /Isoberlinia doka [illegible] considered to be the best. The veneers of these species [illegible] cutting checks, their surface is smooth and it seems that they could be used for decorative purposes as well as for [illegible] of plywood.

[illegible] showed [illegible] of cutting checks. [illegible], however [illegible] were [illegible] [illegible].

wood could be used for decorative purposes and also for the production of plywood, provided, of course, that further investigations confirm the preliminary results.

Sample No 3 /Vuba/ presented no difficulties in peeling. The veneers were free from cutting checks. The texture of the veneers is very attractive, the only handicap is the rough structure of the surface due to the deep pores. Some difficulties would arise in the finishing and gluing operations. Deep glue penetration and a high consumption of resins and fillers is to be expected.

Sample No 4 /Boswellia/ caused no troubles in cutting. The wood is very light, capable of absorbing a large amount of water by soaking in a very short time. It is obvious that this wood is not resistant to fungal attack. After soaking in water the light grey turns black which is an indication of mould attack. The mould on the small specimens could not be identified and there was no possibility to investigate this problem further.

The low resistance to mould attack does not necessarily mean that the mecanical properties of the wood are affected. Apparently the veneers could be siutable for the production of plywood and could be used probably as the inner plies and cores. The veneers are smooth enough and quite free from cutting checks. There is little hope that these veneers could be used for decorative purposes.

Veneer Drying

After cutting, the veneers were soaked in warm water to raise the moisture content as high as possible.

The specimens filled with water created the most unfavorable conditions for drying. The drying took place in a laboratory air-impact conveyor dryer at the temperature of 140°C and at an air velocity of 13 m/min. Sample No 1 was not submitted to the drying process because of the lack of sufficient material.

The results are shown in the following table:

Sample No:	Botanical Name	Thickness	Original	Moisture content % After 2 min. of drying	After 4 min. of drying
2	Cordia	0.8	164	6.0	0.3
3	Vuba	0.8	91	1.2	0.1
4	Boswellia	0.8	172	4.7	0.2
5	Khaya	1.5	74	6.8	0.7

The table shows that the specimens were dried up to the moisture content less than 7 % in less than 2 minutes without any damage by severe splits. Thy only exeption was sample No 1, where some splits occurred. Those splits could be eliminated by proper hydrothermal preparation and by improved cutting conditions.

The specimens soaked in water were discolored to a certain extent so that they lost the natural, original color. It is hoped that this discoloration may be avoided provided the presoaking of the veneers had not taken place in the process before drying.

General Conclusions

The amount of experimental material which was available for the tests was too small to allow definitive conclusions. Nevertheless, according to the results of the preliminary, improvised laboratory tests, there are no indications that the species concerned were not suitable for the manufacture of veneers. The results are in no way discouraging in any respect and there are optimistic indications that further research on a more adequate scale would solve the various utilization problems for the species under review.

3/G Aerial Survey Recommendations

The aerial survey should comprise about 17,000 square km of land on both sides along the road from Wau to Aweil and 30 km behind Aweil, and along the road from Wau to Pongo Nuer and 30 km behind Pongo Nuer. The width of the strip photographed should be 60 km.

The scale of the photographs taken should be 1:30,000, this would enable the drawing of maps in the scale of 1:25,000. Longitudinal overlapping should be 60 %, transversal overlapping 30 %.

The size of the photographs taken should be 18 x 18 cm, or 23 x 23 cm. For the 18 x 18 cm size a camera with a 200 mm focal length, for the 23 x 23 cm size a camera with a 150 mm focal distance should be used.

In order to facilitate identification of tree species from aerial photographs spectro-zonal photographic material should be used, if available. Else black and white photographs would do, too.

4/A Distances and Freight Rates

Distances involved are

a/ by road

Katire - Juba	180 km
Nzara - Juba	522 km
Nzara - Wau	477 km
Juba - Wau	846 km
Juba - Mombasa	1,638 km

These distances are quoted from Michelin's map of North-East - Africa, N° 154, it being borne in mind that according to Michelin in Africa distances rarely can be given with absolute accuracy.

b/ by rail

Wau - Khartoum	1,498 km
Wau - Port Sudan	2,285 km
Wau - Wadi Halfa	2,407 km
Khartoum - Port Sudan	787 km
Khartoum - Wadi Halfa	909 km
Khartoum - Kosti	383 km

These distances are taken from the Transport Statistical Bulletin 1974, p.20.

c/ on the Nile

Juba - Kosti	1,436 km
Juba - Khartoum	1,660 km

These distances are quoted from the Transport Statistical Bulletin 1974, for the Kosti-Khartoum section road distance according to the Michelin map being added.

The freight rates /in £S/m3/ are at present as follows:

a/ by road	for logs	for plywood
from Katire to Juba	11.48	8.27
from Nzara to Juba	23.49	16.91
from Nzara to Wau	21.47	15.46
from Juba to Wau	-	27.41
from Juba to Mombasa	-	28.80

These rates are calculated according to the official tariff established by the Commissioner in Equatoria province

/Pt 7 per ton/mile/ and in Bahr-el-Ghazal province /Pt 12 per ton/mile/, for transportation of goods on main roads. For the transportation from Katire to Juba this rate applies only as far as Torit /135 km from Juba/; for the road from Katire to Torit /45 km/ the maintenance of which is the responsibility of the Forestry Department, the rate of Pt 12 per ton/km was applied. The road connection from Nzara to Wau cannot be used economically at the present conditions because the existing ferry on the Bousseri river offers slow service and a low weight limitation. Freight rate to Mombasa is given according to charges for transport made by Interfreight /Kenya/ Ltd.

b/ by rail	in £S/m3 for logs	for plywood
from Wau to Khartoum	14.168	10.519
from Wau to Port Sudan	-	15.127
from Wau to Wadi Halfa	-	16.855
from Khartoum to Port Sudan	-	5.551
from Khartoum to Wadi Halfa	-	7.279
from Kosti to Khartoum	4.728	-

The freight rates quoted above are valid since 1 July 1975. They are based on the assumption that 30 m3 of plywood /21.6 ton/ or 20 m3 of logs /16 ton/ could be loaded on a 30 ton waggon.

c/ on the Nile /For a full barge 100 ton or 500 ton both for logs and plywood/

	in £S/ton
from Juba to Kosti	17.100
from Juba to Khartoum	21.700

The River Transport Corporation is authorized to transport goods only to and from Kosti. Direct transport on the Nile to or from Khartoum requires special authorization by Sudan Railways.

The loading space of a 500 tons barge is 500 m3. It is estimated that on such a barge 333 m3 of logs or 500 m3 of plywood could be loaded. Transportation cost in £S/m3 would therefore be:

	for logs £S/m3	for plywood £S/m3
from Juba to Kosti	25.676	17.100
from Juba to Khartoum	32.583	21.700

d/ by sea

For plywood	in US $/m3 from Port Sudan		from Mombasa	
to Jedda	26.33	/19.50/	31.73	/23.50/
to Alexandria	48.26	/35.75/	53.33	/39.50/
to Hamburg	82.62	/61.20/	88.16	/65.30/

These freight rates apply for 1 t or 1 m3 whichever is more /weight for volume basis/ and include the Suez surcharge /2.5 %/, bunker surcharge /8.5 %/, the currency adjustment factor /10 %/ levied on the basic rates and surcharges, and finally, the congestion surcharge which varies from port to port. The basic rate is given in parenthesis.

for machinery	in US $/ton or m3 to Port Sudan	to Mombasa
from Hamburg	144.94	170.94

The basic freight rate is US $ 118.70 to Port Sudan and US $ 140 to Mombasa. To it are added 2.5 % Suez surcharge, 8.5 % bunker surcharge, and finally on the total the 10 % currency adjustment factor. The freight rate includes loading and unloading costs. A heavy lift charge of US $ 25.90 is made for every piece exceeding 6 tons, for pieces over 15 tons weight the charge is US $ 73.20 + US $ 3.50 per each additional ton or a part thereof. The freight rate applies to 1 t or 1 m3 whichever is more.

Installed crane lifting capacity in Port Sudan is 15 tons, heavier pieces can only be unloaded by ship's crane.

For the export of plywood to Egypt there is theoretically an alternative way of transportation from Wadi Halfa on the Nile to Assuan and from there eventually by train to Cairo. The freight rate on the Nile from Wadi Hlafa to Assuan charged by the Nile Navigation Company is £S 5 /ton. But there are no facilities at Wadi Halfa, no port, no arrangement for the handling of goods, consequently no commodities pass on this transportation line in either direction. For the time being, this transport system would require a vividly uneconomic amount of unloading and reloading from train to steamer and from steamer to train and must consequently be ruled out until facilities in Wadi Halfa improve.

Handling charges for plywood in Port Sudan would be £S 1 /ton /Pt 60 /ton for unloading from railway and stacking, Pt 25 /ton for loading on boat, Pt 15 /ton miscellanous/, or Pt 72 /m3. Handling charges in Mombasa should be about the same. For machinery handling charges would amount to £S 2 /ton, for heavy items up to £S 3 /ton.

The handling charges on the Nile and railway for logs or plywood, including loading and unloading, would be about Pt 40 /m3.

5/A Sliced veneer

All tree species intended for plywood production are suitable also for the production of sliced veneer. Especially suited for sliced veneer is teak, and teak plantations in the South will yield in the future an important supply of veneer logs. For the time being, tree species listed in Annex 3/E as suitable for veneer should be used.

Since the utilization of the most valuable species and of logs of the best quality and largest diameter for the production of sliced veneer sheets, in connection with the establishement of a plywood mill in Wau, seems to be viable, a short technical and economical evaluation of such a project is added. Veneer production could be considered also for other sites in the South beside Wau, or even in the particle board factory in Khartoum with transport of veneer logs to Khartoum, preferably on the Nile. This would require, of course, further study which is outside the scope of the present contract.

For the site in Wau the following targets of veneer production are recommended:

Output: 2,000,000 square m of veneer per annum
Thickness of veneer sheets: 0.7 mm
Timber consumption: 1.3 m3 per 1,000 m2 of veneer
Annual timber consumption: 2,000 m3
Daily timber consumption: 9.5 m3

Necessary new equipment

The integration of veneer production with plywood production has important advantages since most of the equipment installed in the plywood plant, like the drier, the equipment for crosscutting, the mobile crane, veneer knife grinder, chain saw grinder, hog, steam boiler etc. can be used in common with the plywood plant.

Additional machinery and equipment necessary for veneer production would comprise the following items:

E q u i p m e n t	Power input in KW	Price in £S
Horizontal veneer slicer with accessories /length of knife 2,700 mm/	70	40,000
Band saw	50	30,000
Clipper for transversal clipping of veneer /length of knife 1,350 mm/	3	4,000
Clipper for longitudinal clipping of veneer /length of knife 3,700 mm/	6	10,000
Hoist to the veneer slicer	5	1,500
2 trucks with trailers for logs and waste	1	1,500
T o t a l	135	87,000

Construction investment

In order to produce the intended amount of sliced veneer the recommended hall of the plywood mill should be extended by 6 m on the left side. The steaming vats should be shifted by the same distance. This means that the area of the hall will increase by 900 m2 which represents a cost of £S 45,000.

To the recommended steaming vats two steaming vats of 6 x 3 x 3 m dimensions should be added /i.e. one 12 long steaming vat divided into two parts with independent lids/.

Cost £S 2,500

Other necessary construction, e.g. levelling and preparation of site and log yard, road construction, warehouses, administrative building, hygienic facilities, garages, boiler house etc., are in common with the plywood plant.

Labour force

The production of sliced venner requires:

Skilled workers	13
Semi-skilled workers	15
Unskilled workers	8
Management and business administration	4
Total personell	40

Electric power

Annual consumption of electric power is 400 MWh.

Water

The requirements are:

Industrial water in m3 per annum	1,650
Water for sanitary purposes and for drinking in m3 per annum	1,300
Total water consumption in m3 per annum	2,950

Heat requirement

Steaming of logs in Gcal per annum	390
Veneer drying in Gcal per annum	1,000
Total heat requirement in Gcal per annum	1,390

Investment costs /in ZS/

a/ Production machinery and equipment	
Price of [illegible]	[illegible],000
Exchange, development and additional tax, clearing, insurance and transport to site / [illegible] % /	[illegible],210
Value of machinery at site	10[illegible],[illegible]10
Engineering, assembly and installation /10 %/	10,820
Value of erected machinery	119,030
Contingency /10 %/	11,900
Total investment cost	130,930
b/ Construction works	
Operational building	45,000
Steaming pit	2,500
Design work /6 %/	2,850
Total	50,350
Contingency /5 %/	2,520
	52,870

Summary /LS/

	investment cost	depreciation
production machinery and equipment	130,930	13,090
construction works	52,870	2,640
permanent working capital	32,500	
T o t a l	216,300	15,730

Operating costs /LS/

Only the most important items are specified, minor items are included in "other expenses". The price of raw material is calculated almost double that in the plywood project; the average wages are increased by 15 % as compared with plywood production.

	LS
a/ Raw material	
2,600 m3 x 22.0	57,200
b/ Electrical energy	
400,000 x 0.035	14,000
c/ Repairs, consumption of technical materials	
3.5 % on production machinery +	
1.0 % on construction works	5,110
d/ wages	20,240
e/ social security	3,040
f/ overheads, administrative and other	
expenses /20 % on a-e/	19,920
T o t a l	119,510
Contingency /5 %/	5,980
Total operating costs	125,390

Sales

As the major part of the output is assumed to be exported, the calculation of sales revenues is based on average prices CIF North European port:

selling price 0.30 - 0.50 US $ per m^2.

In the calculation, the average price is taken into consideration; under these assumptions, the sales revenues will amount to:

0.40 US $ per m2 = 0.133 £S per m2

0.133 £S x 2,000,000 = 266,000 £S

Profitability

Investment cost		£S 215,300
Sales revenues		266,000
Annual expenses:		
- operating costs	125,390	
- depreciation	15,730	
- transport costs	40,000	181,120

The transport costs are based on experience from several projects in West Africa.

Profit before tax	84,880
Net profit	33,950
Net profit + depreciation	49,680

Pay-back period as ratio of

Investment/net profit + depreciation - 4.4 years

i.e. 30 % higher when compared with the profitability of plywood production.

5/B The Production Process of Plywood

In the following production flow chart the different steps of production are demonstrated between the input of raw materials and the output of the finished product.

Plywood Production Flow

(1)

Log Transport /Lorry/
Unloading /Mobile Crane/
Transport / " " /
Storage /Log Yard/
Transport /Mobile Crane/

(2)

Steaming /Vats/
Cross-cutting /Chain Saw/
Transport /Truck/

(3)

Pieces of Veneer — Peeling — Veneer sheets

Clipping
Storage
Transport

Peeling
Storege
Unreeling
Clipping
Transport
Storage

(4)

Drying
Sorting
Transport /High Lift Truck/

(5)

Trimming
Jointing
Transport

Repair
Transport

(6)

Storage
Glue spreading
[illegible]
Transport

Pressing
Transport
Storage

(8)

Sizing
Transport

Repair

(9)

Sanding
Transport
[illegible]

Repair

Transport
Packing
Storage
Loading of plywood

1. Log storage

Logs delivered from the forest at the factory yard should be sorted in classes according to diameter /by increments of 10 cm/ and then stored on wooden supports. Logs thus sorted can by loaded directly into the steaming vats.

A log supply of about 2,800 m3 should be stored at the beginning of the rainy season, when a three months supply is necessary to compensate for transport restriction during the summer months. The minimum log supply is 500 m3 which represents a fortnight's supply and is sufficient to make up for irregulaties of delivery during continuous logging operations.

Sprinkling of logs is not required since the storing of logs will not exceed three months and tropical hardwoods are slow to develop cracks in the climate of Wau, if shaded from insolation. No serious danger from attack by insects or fungi during the storage of logs at the factory yard is anticipated /see page /.

Log transport in the factory yard and filling of steaming vats will be done by a mobile crane of 16 tons lifting capacity. No stabilization of the yard surface is required for the movement of the crane. Its lifting capacity permits the carrying of a 6 tons load at a distance of 8 m which is important for the filling and emptying of steaming vats. A bridge crane which is currently used in large plywood plants is too expensive to be installed for the planned small production capacity /since it costs some £S 120,000/, whereas a mobile crane is fully adequate for this task.

2. Steaming and cross-cutting

In order to plastify the roundwood and to improve peeling conditions at the peeling lathe the steaming of logs in necessary. It should be done by the indirect method in four steaming vats. The following steaming cycle is envisaged:

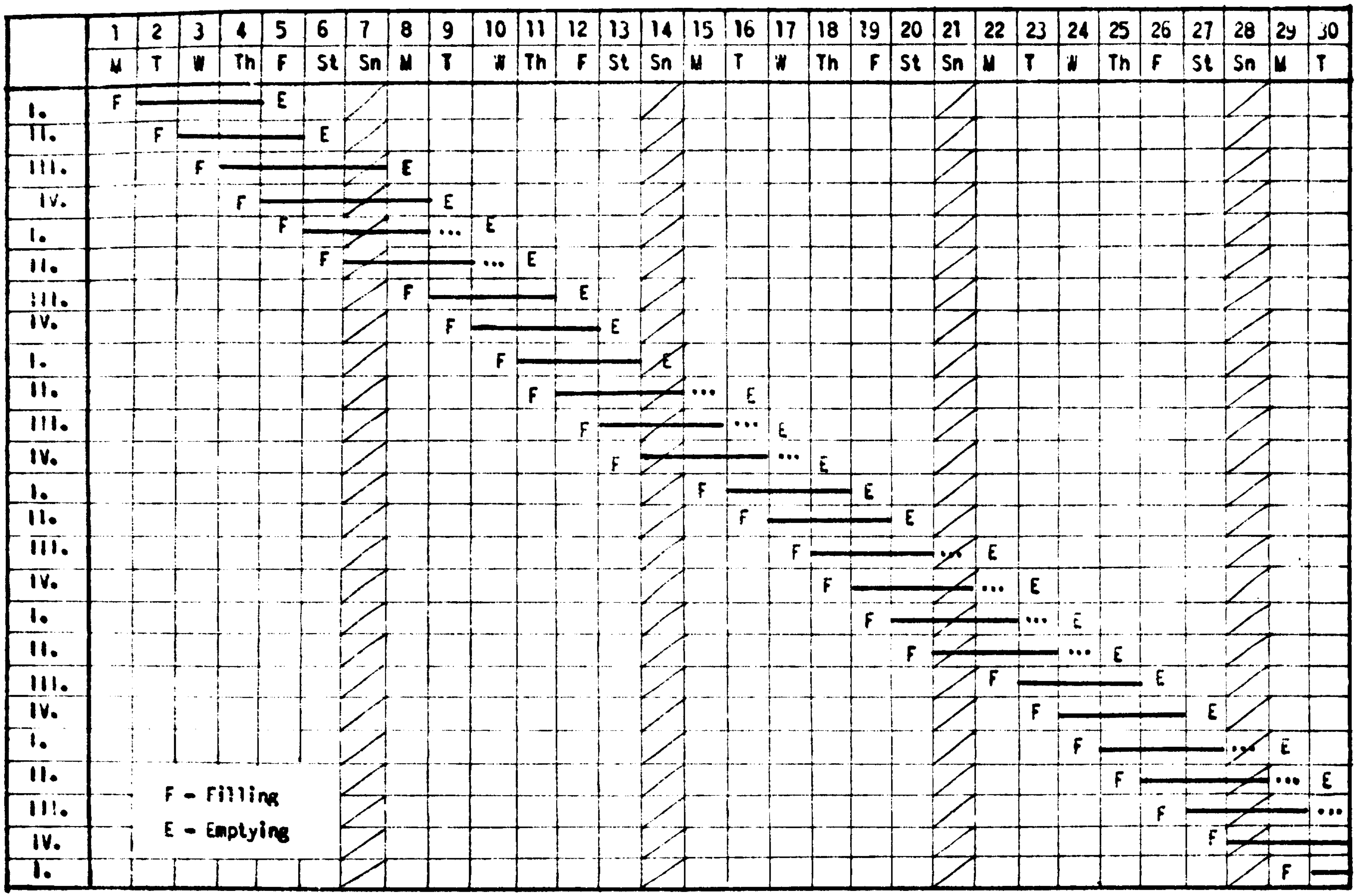
Filling of steaming vat	4 hours
Emptying of steaming vat	8 hours
Heating to a temperature of 85 to 90°C	8 hours
Steaming at this temperature	40 hours
Conditioning, and cooling off	12 hours
Total	72 hours

The steaming cycle is shown on Chart 2 /see the following page/.

For the steaming of 40.4 m3 four steaming vats are necessary, accounting for loss of time. Chart N° 2 shows the cycles of the heating schedule. The steaming vat should be filled the day it is emptied.

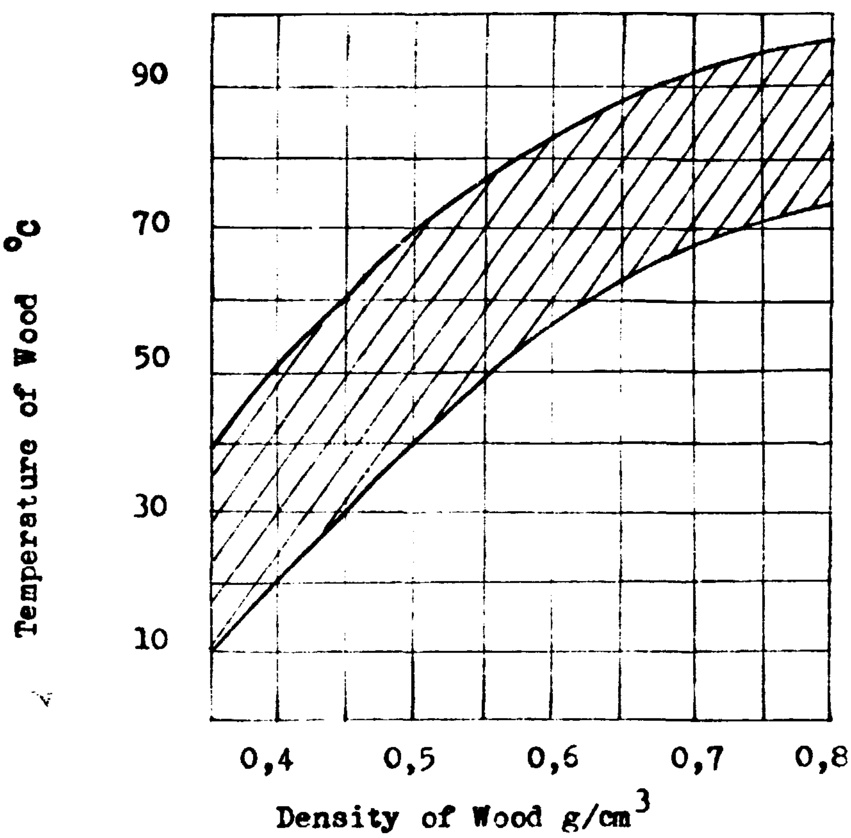
The Steaming cycle

Chart 2



The temperature to which peeler logs must be heated is determined from Chart 3.

Chart 3



The steamed logs shall be lifted by the mobile crane for handling on the landing where they shall be crosscut by a power saw into required lengths /i.e. 1.30, 1.90 and 2.30 m/. Waste comprising bark, trimmings and saw dust shall be transferred by carriage to the waste hog. Debarking shall be done by hand after steaming. Debarked logs shall be pushed on a rail carriage to the depot in front of the peeling machine from where a monorail with electric hoist shall feed them into the peeling machine.

3. Peeling and veneer clipping

The logs are placed between the chuck spindles /marking of the centres of the logs should be done with a template/. A centering device is not recommended being too expensive. Veneer shall be peeled into thicknesses of 1.2, 2.0 and 3.0 mm. From this range of thicknesses plywood of almost any thickness can be composed, as is shown in Table 1 /see the following page/.

Veneer of 1.2 mm thickness shall be peeled off from the outer part of logs in the whole knot-free zone. From the inner part of logs of poorer quality veneer of 2.0 and 3.0 mm thickness shall be peeled for core.

After fixing the log into the double /retracting/ chucks of the peeling lathe the log is rounded off into a cylindrical form. Pieces of veneer which are shorter than the log length and cannot be utilized represent a waste and are removed to the waste hog and used as fuel. Veneer peeled in log length and having a width of at least 15 cm is transferred by hand to mechanical clippers where it is clipped on both sides and piled on a pallet. Having got the log into cylindrical shape a continuous veneer sheet appears and is reeled by hand onto a bobbin. From there it is moved to an interim store in front of the clippers. The interim store should have three storeys in order to separate 1.2 mm veneer from 2.0 and 3.0 mm veneer. The third storey serves the purpose of returning empty bobbins. The veneer belt is reeled off by hand and cut into required dimensions leaving excess size for shrinking. The veneer is then stocked on the pallet and together with it transferred to the drier for drying. Having finished the peeling of the log the cylindrical core is taken out of the peeling lathe and carried away to the framesaw to be converted into small dimension stock.

The whole production process from the handling of logs up to the drier can be also organized as a continuous line using a debarker and an automatic crosscutting device, from where the logs could be transported before the peeling machine and fed into it by means of a fastening and centering device.

Plywood structure

Table 1

Number of layers		3				5					7				
Rated thickness	mm	3	4	5	6	6	8	9	10	12	8	9	10	12	15
Face veneer	mm	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2
Core	mm										1,2	1,2	1,2	2,0	2,0
Core	mm					1,2	2,0	2,0	3,0	3,0	1,2	1,2	2,0	2,0	3,0
Centre	mm	1,2	2,0	3,0	4,0	2,0	2,0	3,0	2,0	4,0	1,2	2,0	2,0	2,0	3,0
Core	mm					1,2	2,0	2,0	3,0	3,0	1,2	1,2	2,0	2,0	3,0
Core	mm										1,2	1,2	1,2	2,0	2,0
Face veneer	mm	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2
Total thickness	mm	3,6	4,4	5,4	6,4	6,8	8,4	9,4	10,4	12,4	8,4	9,2	10,8	12,4	15,4
Compressing	%							5							
Sanding	%	9,9	9,7	6,9	6,8	6,8	4,0	3,0	3,0	2,4	4,0	3,0	2,4	2,0	1,5
Actual thickness	mm	3,1	3,8	4,8	5,7	6,0	7,7	8,7	9,6	11,5	7,7	8,5	10,0	11,5	14,7
Permissible tolerance	mm			+ 0,2				+ 0,4					+ 0,4		
according to ISO	mm			- 0,5				- 0,6					- 0,7		

The outcoming continuous sheet could be automatically reeled and transferred to the drier by another automatic device for reeling-off the veneer. In this case the clipping of the veneer should be performed behind the drier. The whole line would require only 6 men and its capacity would be about 10,000 m3 per shift. Such a line is very sophisticated and complicated to operate and maintain, it requires a lot of conveyers, spare parts and is very expensive. For the intended capacity and conditions prevailing in the Sudan this line would be utterly unsuitable.

Capacity of peeling lathe

The peeling lathe, operating 275 working days a year, should peel 3.9 m3 of moist veneer per hour. The average performance of a peeling lathe, taking into account loss of time, for log lengths of 130 and 230 cm and a veneer thickness of 1.2, 2.0 and 3.0 mm and supposing an average log diameter of 50 cm /which would represent the average log diameter in the Sudan/ is 4.5 m3 per hour.

4. Veneer drying and sorting

Veneer shall be dried in a jet drier with a belt conveyor with impact air circulation. Veneer shall be dried to a final humidity of 6 % for furniture plywood glued with urea-formaldehyde glue and to a final humidity of 8 - 10 % for WBP plywood glued with phenol formaldehyde foils.

The dried veneer is sorted behind the drier according to quality and size. It will be necessary to establish quality standards of sorting after running in the plant. Sheets requiring surface repair shall be transferred to the plugging machine and sheets with edge cracks to the tables for manual repairing. Each type is piled on a separete pallet. Once the pallet is loaded the veneer is carried, as the case may be, either for repair, or to the press, while undersized pieces are taken to the trimmer and jointer.

5. Veneer jointing, treatment and repair

Undersized pieces of veneer are taken in the trimmer where glue is spread on the edges and then the pieces are matched in the jointer into an endless belt which is again cut into suitable sizes. Of the total amount of dry veneer about 30 % will be undersized which represents 7.4 m3 per day. The capacity of the trimmer being 2.5 m3 per hour, one machine is sufficient.

Pieces of veneer spread with glue are matched in the transverse jointer. Since veneer of all lengths /125, 185 and 225 cm/ is to be matched, the working width of the jointer should be 230 cm. The feed of the machine is 7 m/min. At an average veneer length of 178 cm and thickness of 2.0 mm the performance of the jointer in 420 minutes /with a utilization capacity of 0.8/ would be 7 m3.

End cracks in whole sheets shall be mendied manually on tables. Surface defects /knots, decay/ shall be removed on the veneer plugging machine.

6. Spreading of glue

The urea-formaldehyde glue /prepared from glue containing the $ZnCl_2$ hardener, non-edible flour, and water/ shall be spread by the glue spreader at a rate of 180 to 200 g/m2. Daily output averages 18 m3 of plywood. With regard to the structure of production 2,050 sheets of veneer should be spread over with glue per day. The capacity of the glue spreader is about 2,500 sheets per shift.

The glue is put on both sides of the core /in three layer plywood/ or cores /in plywood with more layers/ and then the assembling is made by hand. The assembled pieces are moved on pallets to the press.

WBP plywood shall be glued with phenol formaldehyde foils, consequently no spreading of glue is necessary.

7. The pressing of plywood

It is made in the heated press. The press shall be filled by hand from a hydraulic lifting table. The plywood for furniture in pressed at a temperature of platens of 105 to 110°C and at a pressure of 18 kp/cm2. For WBP plywood the temperature should be 140 to 150 °C. The pressing cycle in seconds for various plywood thickness is as follows:

	3 and 4 mm	6 mm	15 mm
Filling of press	60	60	60
Closing of press	30	30	30
Pressing	180	270	480
Opening and emptying	60	60	60
Total time in seconds	330	420	630

Press capacity

Annually 3,571 hours are required for pressing this amount of plywood at the given cycle. A one-shift operation /275 days x 7 hours = 1,925 hours/ covers only 54 % of the required capacity with a press in 15 openings. Consequently the press must be operated in two shifts.

The manual filling of a press with a larger number of openings is not feasible. In this case an automatic filling and emptying device and a cold pre-press are required, but this would substantially increase the price of the pressing equipment. Therefore, the press shall be filled from the lifting table.

8. Sizing of panels

This is made on the double sizing saw. Its capacity, at a feeding speed of 20 m/min, average plywood thickness of 4 mm, size 122 x 183 cm, 0.8 utilization of working time,and a 4.2 m distance between the step motion of the belt, is about 3,0 m3 per hour.

The first sizing saw cuts along the face grain, the second one transversally to it. The waste from the sizing saws shall be transported manually to the waste hog.

Repair of defective plywood shall be made by hand. Repaired plywood shall be pressed in the second shift using the free capacity of the press.

9. Sanding

Sanding of plywood shall be done only on 3, 4 and 6 mm thick plywood sheets in as far the plywood quality suits furniture production and exports. Plywood of lowest quality shall be used for containers, this shall not be sanded. WBP plywood intended for construction shall also not be sanded. The performance of the three drum sander is higher than the expected production, consequently the sander shall operate only during one shift. Since there is only one sander the sheets must be returned for sanding the other side.

A high fork lift truck shall be used for the transport of finished plywood into the store and from the store to the vehicle used for external transport. It shall also be used to transfer dry veneer.

In Table 2 and 3 /see the following pages/ the movement of material and the waste arising from various operations in the production process are given for an annual outpt of 5,000 m3 of plywood manufactured in one shift numbering 275 and 300 working days, respectively. Waste and losses are calculated from the timber volume. Both a 45 % and a 50 % rate of utilization are considered, but Chart 4 /see page 125/ shows only the 45 % rate of utilization.

The possible plant layout is shown in Chart 5 /see page 126 /. The layout may be, of course, altered by the deliverer of the machinery.

The manpower specification is given in Table 4 /see page 122 / and equipment requirements are listed in Table 5 /see page 123 /.

Table 2

Movement of Material

Rate of utilization 45 %

Output: 5,000 m3 plywood per annum

Log consumption: 11,100 m3 per annum,
2.22 m3 per m3 of plywood

Item	Output in %	Waste in %	Volume in m3 275 working days	Volume in m3 300 working days	Total waste losses
Logs into steaming vats	100				
per day			40.4	37.0	
per hour			5.8	5.3	
Handling loss		7			
per day			2.8	2.6	
per year					777
Peeling machine processes	93				
per day			37.6	34.4	
per hour			5.4	4.9	
Wet non utilizable waste		14			
per day			5.7	5.2	
per year					1,554
Cores		12			
per day			4.8	4.4	
per year					1,332
Output of wet veneer	67				
per day			27.1	24.8	
per hour			3.9	3.5	
Losses due to shrinking		6			
per day			2.5	2.2	
per year					666
Output of dry veneer	67				
per day			24.6	22.6	
per hour			3.5	3.2	
Waste from dry veneer		8			
per day			3.2	3.0	
per year					888
Volume processed in the press	53				
per day			21.4	19.6	
per hour			3.0	2.8	
Losses in pressing, trimming and sanding		8			
per day			3.2	3.0	
per year					888
Finished plywood	45				
per day			18.2	16.6	
per hour			2.6	2.4	

Table 3

Movement of Material

Rate of utilization 50 %

Output: 5,000 m3 plywood per annum

Log consumption: 10,000 m3 per annum
2.00 m3 per m3 plywood

Item	Output in %	Waste in %	Volume in m3 275 working days	Volume in m3 300 working days	Total waste losses
Logs into steaming vats	100				
per day			36.5	33.3	
per hour			5.2	4.8	
Handling loss		6			
per day			2.2	2.0	
per year					600
Peeling machine processes	94				
per day			34.3	31.3	
per hour			4.9	4.5	
Wet non utilizable waste		14			
per day			5.1	4.7	
per year					1,400
Cores		12			
per day			4.4	4.0	
per year					1,200
Output of wet veneer	68				
per day			24.8	22.6	
per hour			3.5	3.2	
Losses due to shrinking		6			
per day			2.2	2.0	
per year					600
Output of dry veneer	62				
per day			22.6	20.6	
per hour			3.2	2.9	
Waste from dry veneer		6			
per day			2.2	2.0	
per year					600
Volume processed in the press	56				
per day			20.4	18.6	
per hour			2.9	2.7	
Losses in pressing, trimming sanding		6			
per day			2.2	2.2	
per year					600
Finished plywood	50				
per day			18.2	16.6	
per hour			2.6	2.4	

Table 4

Manning table

	Number	Per person	Annual salaries or wages /LS/
A - WAU			
General manager	1		3,600
Technical manager	1		3,000
Plant engineer	1		1,800
Assistant plant engineer	2	900	1,800
Administration manager	1		1,800
Senior accountant	1		1,200
Accountants	2	600	1,200
Senior clerks	2	600	1,200
Junior clerks	3	400	1,200
Secretaries	2	360	720
Typists	2	300	600
Office boys, watchmen	5	180	900
Chief mechanic	1		700
Production supervisors	3	560	1,680
Storekeepers	2	560	1,120
Foremen	8	480	3,840
Skilled workers	30	400	12,000
Semi-skilled workers	24	300	7,200
Unskilled workers	30	200	8,000
Drivers	2	240	480
Total	123		54,040
B - KHARTOUM			
Sales manager	1		2,400
Senior clerk	1		960
Accountant	1		960
Junior clerks	2	400	800
Secretary	1		400
Typist	1		360
Driver	1		300
Storekeeper	1		600
Unskilled workers	3	280	840
Watchmen, messenger	4	200	800
Total	16		8,420
Grandtotal	139		62,460

Table 5

Equipment Requirements

Equipment	Power demand in KW	Heat consumer Kcal/h	Price LS
A. Log yard			
1. Storage			
1 mobile crane 16 t	-	-	25,500
2 chain saws	6	-	2,000
Sub-Total	6	-	27,500
B. Production line			
2. Steaming and cross-cutting			
Equipment for steaming vats /2 pumps, steam distribution, covers/	6	400,000	8,000
Equipment for crosscutting	-	-	500
2 truck for logs and waste with rail	-	-	550
3. Peeling and veneer clipping			
1 monorail with electric hoist	5	-	1,500
1 veneer lathe	75		45,000
1 reeling equipment, hand-operated, with bobbin magazin	-		2,000
1 truck for undersized pieces of veneer	-	-	200
2 veneer clippers	10		7,000
4. Veneer drying and sorting			
1 veneer drier	120	1,400,000	58,000
5. Veneer jointing, treatment and repair			
1 veneer trimmer	20	-	16,000
1 veneer jointer with clipper	11	130,000	28,000
1 veneer plugging machine	7	-	5,300
6. Glue spreading			
1 glue spreader	5	-	4,000
1 glue mixer	2	-	1,000
1 glue storage complete	4	-	1,650
Carried forward	265	1,930,000	177,700

Table 5 cont'd

Equipment	Power demand in KW	Heat consumer Kcal/h	Price LS
	265	1,930,000	177,700
7. Pressing			
1 hydraulic hot press in 15 openings	50	700,000	45,000
1 hydraulic sinking table for loading	3	-	1,400
8. Sizing			
1 plywood sizing saw	20	-	10,000
9. Sanding			
1 three - drum sander	50	-	16,000
Sub-Total	388	2,630,000	250,100
C. General services and installations			
1 veneer knife grinder	5	-	9,500
1 circular saw grinder	2	-	1,000
1 chain saw grinder	2	-	200
1 waste hog and blower	24	-	3,900
1 steam boiler complete 12 atp	5	-	90,000
Exhaust plant	36	-	11,500
Equipment for producing and distribution of compression air /6 atp/	30		3,400
Equipment for heat distribution	-	-	4,000
Installation of electromotors light	-	-	9,000
Lab.equipment /lab.hydraul. press, glue bond testing machine, lab.drier/	10	-	6,500
High lift truck	-	-	6,000
Maintenance equipment			10,000
Sub-Total	114	-	155,000
Sub-Total A	6	-	27,500
Sub-Total B	388	2,630,000	250,100
Sub-Total C	114	-	155,000
Grand-Total	508	2,630,000	432,600

Chart 4

Sankey's Chart of Utilization

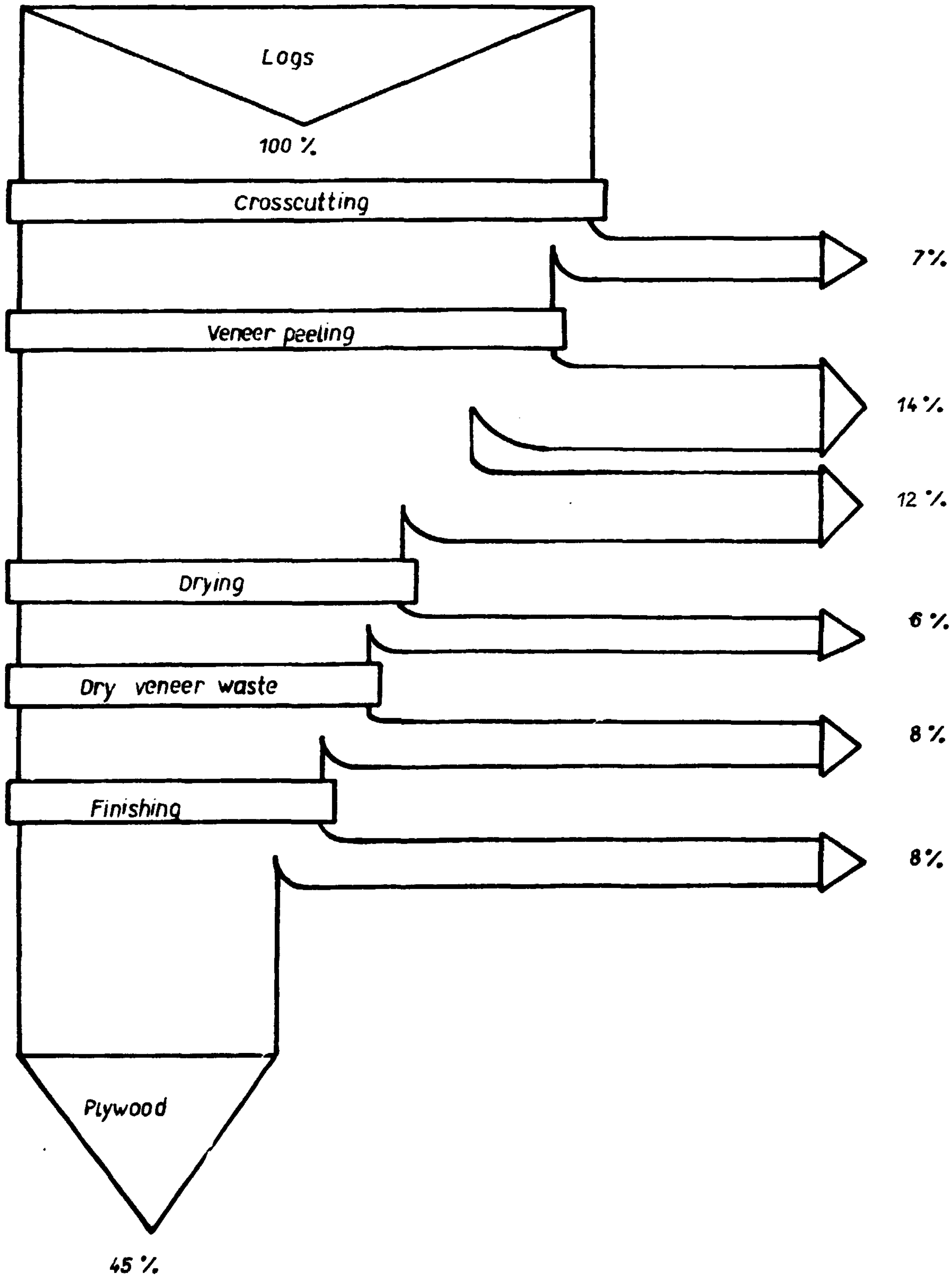
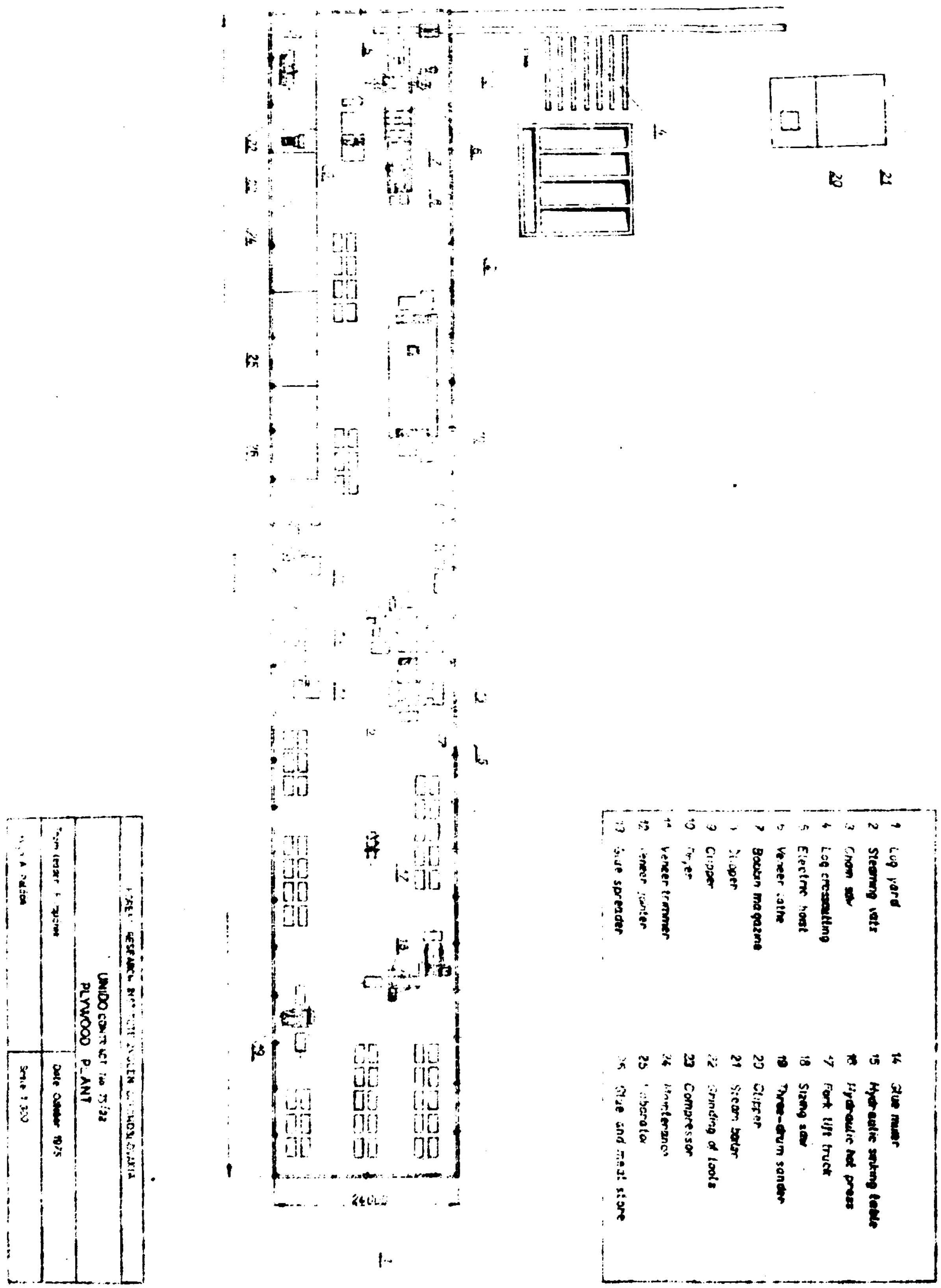


Chart 5


1 Log yard
2 Steaming vats
3 Chain saw
4 Log crosscutting
5 Electric hoist
6 Veneer lathe
7 Bobbin magazine
8 Clipper
9 Clipper
10 Dryer
11 Veneer trimmer
12 Veneer jointer
13 Glue spreader
14 Glue mixer
15 Hydraulic sinking table
16 Hydraulic hot press
17 Fork lift truck
18 Sizing saw
19 Three-drum sander
20 Chipper
21 Steam boiler
22 Grinding of tools
23 Compressor
24 Maintenance
25 Laboratory
26 Glue and meal store
FOREST RESEARCH INSTITUTE ZVOLEN CZECHOSLOVAKIA
UNIDO CONTRACT No 75/32
PLYWOOD PLANT
Date October 1975
24000

5/C Material and Energy Consumption

Waste

At the expected 45 % rate of utilization of logs the following amount of wood waste will be available at the plywood plant and should be disposed of:

Operation	Quantity of waste from logs in %	in m3/day	in m3/year
Handling of logs	7	2.8	777
Peeling /wet undersized pieces/	14	5.7	1,554
Cores	12	4.8	1,332
Waste from dry veneer	8	3.2	888
Trimming of plywood sheets	5	2.0	550
		18.5	5,101

In this survey only utiliseable wood waste is listed. Not mentioned are losses caused by shrinking and pressing. The utilisation of wood waste for the production of particle boards or fibreboards is not feasible because of the small amount of waste which is best used by burning for energy production.

Glue consumption

Plywood intended for furniture production shall be glued with urea-formaldehyde glue. The powder glue /which is used also in the particle board production in Khartoum/ is made to contain 64 % of dry substance /7 weight parts of glue powder and 4 weight parts of water at a temperature of 40 °C/. For glue prepared in this way the following recipe can be used:

55 % of glue
20 % of non edible flour
25 % of water.

It is recommended to order from the producer a glue which contains already the $ZnCl_2$ hardener. In this case the preparation of the hardener, and also its transport costs, are eliminated. If glue without hardener would be purchased, to the total amount of gluing matter 10 % of a hardener /15 % of NH_4Cl, 30 % of urea, 55 % of water/ should be added. The total spread of gluing matter is 180 to 200 g/m2.

For the intended production programme the requirement of glue powder shall be as follows:

cm	mm	m3	pieces/m3	kg/m3
122 x 220	3	1,300	124	52
122 x 183	3	1,200	150	52
122 x 220	4	700	93	38,5
122 x 183	4	300	112	38,5
122 x 220	6	500	62	63

Annual glue consumption is 200,000 kg. Average consumption of glue per m3 plywood is 50 kg.

Flour consumption is 9 kg per m3 of plywood. Total annual consumption of flour shall be 36,000 kg.

Glue requirements for waterproof plywood intended for construction:

Dimensions 120 x 183 cm - 15 mm - 31 pieces/m3.

Total annual consumption of tegofoils is 600,000 m2.

Heat energy

The distribution of heat energy consumption by the various appliences is given in the following survey.

	kcal/h	t/h	t/day	Gcal/year	t/year
Steaming vats	400,000	0.8	19.2	2,640	5,280
Veneer drier	1,400,000	2.8	22.4	3,080	6,160
Veneer jointer	130,000	0.3	2.4	286	660
Press	700,000	1.4	22.4	3,080	6,160
T o t a l	2,630,000	5.3	66.4	9,086	18,260

Heat requirements per m3 plywood: $\frac{9,086}{5,000}$ = 1.8 Gcal/m3

The necessary amount of heat energy of about 2.6 Gcal/h shall be supplied by a steam boiler operating at a pressure of 12 atmospheres. The condensated steam shall be returned to the boiler. Wood waste shall be used as fuel. It shall be shortened by a circular saw, fragmented by a waste hog and burnt in a stoker.

The consumption of 2.6 Gcal/h refers to the first shift, in the second shift consumption shall be 1.1 Gcal/h and in the third shift 0.4 Gcal/h.

Fuel consumption

The caloric power of wood waste is assessed at 2,500 kcal/kg. The boiler´s efficiency being 0.75 fuel consumption shall be:

in the first shift:

$$Q = \frac{2{,}630{,}000}{2{,}500 \times 0.75} = 1{,}402 \text{ kg/h} \times 8 = 11{,}216 \text{ kg}$$

in the second shift:

$$Q = \frac{1{,}100{,}000}{2{,}500 \times 0.75} = 586 \text{ kg/h} \times 8 = 4{,}688 \text{ kg}$$

in the third shift:

$$Q = \frac{400{,}000}{2{,}500 \times 0.75} = 288 \text{ kg/h} \times 8 = 2{,}304 \text{ kg}$$

Fuel requirement per day 18,208 kg

In the plywood plant a daily amount of 20,350 kg of wood waste is expected to be available. From this amount only 13,970 kg shall be burnt. The cores, /i.e. the cylinders remaining after the peeling process representing 5.8 m3 /6,380 kg/ per day/ shall be transferred to the Wau Training Sawmill and there converted on a small frame saw into small dimension stock, thus obtaining 3.5 m3 f sawnwood a day.

The remaining requirement for fuel shall be met by the Wau Training sawmill where 12,000 kg of wood waste will be available from the planned sawmill output.

Electric energy

Consumption of electric energy shall be as follows:

	Installed kw	Used kwh	kwh/D I.shift	II.shift	Total	kwh/year
Equipment	508	356	2,848	552	3,400	935,000
Light	14	7	-	28	28	7,700
T o t a l	522	363	2,848	580	3,428	942,700

The consumption of electric energy per m3 of plywood is 188 kwh/m3.

The required electric energy shall be supplied by the power plant in Wau. The Wau Training Sawmill has a stand-by generator with a capacity of 208 KW which is at present unused.

Should the power plant in Wau be unable to supply electricity for want of installed capacity, a consumer's power plant could be installed at the plywood mill /to the 208 KW Diesel generator mentioned above another 500 KW Diesel generator could be bought which would supply electricity to the plywood plant including sliced veneer production/. In this case the price of electricity produced would not exceed the price charged by the power plant in Wau which is that taken into account in the cost calculation /see Annex 5/E./

In the second shift the power consumption shall be limited to requirements for preparing and spreading of glue, for operating the press and for lighting.

Water consumption

The water consumption for industrial purpose is computed as follows:

Steaming vats 1 m3/h x 24 h	24 m3/day
Preparation of glue 1 m3/h x 16 h	16 m3/day
Washing of the glue spreader	1.5 m3/day
Boiler 2 m3/h x 24 h	48 m3/day
T o t a l	89.5 m3/day

Annual water consumption for industrial use is 24,612 m3.

Water consumption for sanitary purposes and for drinking:

100 l per person per day about		2,500 m3
Total water consumption		27,112 m3

Water consumption per m3 of plywood: 5.4 m3

Spare parts and supplies for repair and maintenance.

A list of spare parts which are necessary for one year's operation is given hereunder. Included also are spare parts and material for maintenance which shall be specified as to type and quantity by the supplier of equipment.

Type	Quantity
Peeler knives	15
Clipper knives	9
Cutters for the waste hog	30
Pressure-bar for peeling lathe	3
Pressure-bar for clipper	2
Circular saw blades for sizing device and waste crosscut saw	50
Abrasive paper	500 m2
Saw chains	10
Conveyer for the drier /life-time 2-3 years/	1
Screws of the support of the peeler	1
Nut of feeding spindle	1
Electric motors	2
Lubricants and hydraulic oil	700 kg
Lubricating grease	300 kg

Further spare parts and material which will be specified by the supplier of machines comprises: steel rope for the mobile crane, bearings, valves, V-belts, construction material etc.

5/I Calling for Tenders

Production programme:

Annual output: 5,000 m3 of plywood

Number of working days: 275

Plywood assortments:

3 mm thick plywood
size 122 x 220 cm - 1,300 m3
size 122 x 183 cm - 1,200 m3

4 mm thick plywood
size 122 x 220 cm - 700 m3
size 122 x 183 cm - 300 m3

6 mm thick plywood
size 122 x 220 cm - 500 m3

15 mm thick plywood - waterproof
size 122 x 183 cm - 1,000 m3

1. Storage

Mobile crane of 15 tons lifting power, with ability to lower and lift a load of 6 tons at a distance of 8 m into or from a depth of 3 m, operating on Diesel oil. The mobile crane shall be used for unloading logs from lorries, for storing logs in the log yard, for the transfer of logs into the steaming vats, and for moving the steamed logs to the cross-cutting device.

2. Steaming and cross-cutting

Feed piping for steam reduced to 1.3 atmosphere into four steaming vats dimensioned 12 x 3 x 3 m, and drain piping to the boiler house, including heating calorifers in the steaming vats.

Two pumps for pumping water

Covers for the steaming vats made from stainless steal with polystyrene insulation

Two electric chain saws /one as a reserve/ able to cross-cut logs of a diameter of up to 120 cm.

3. Peeling and veneer clipping

The peeling lathe

Requirements concerning the peeling lathe

The peeling lathe should be able to process logs of a length between 130 and 230 cm. These dimensions limit the maximum and mimimum length of the peeled log without using a prolonging spindle /such machines are already offered in the market/. With regard to potential log diameter, especially with mahogany, the cross-transverse motion of the support should enable peeling of logs up to a diameter of 120 cm.

The number of spindle revolutions need not to exceed 150 per minute, since the reeling is done by hand and the cutting speed will be sufficient even at low revolutions, with respect to the expected size of logs. The range of thickness required extends from 0.5 to 6.0 mm. The Ward Leonard device for the regulation of revolutions is not recommended /being rather expensive/, a three-pole commutation electric motor for changing the spindle revolution in correspondance with the diminishing log diameter will be sufficient. The machine should be equipped with double /retracting/ chucks, the diameter of the outer spindle measuring at least 26 cm and of the inner one at least 13 cm. The machine shall be equipped with a casette which permits the installation of the knife in exact position with respect to the spindle axis after sharpening. In order to prevent the bending of the log at the end of peeling a backup roll should be added to the machine.

Reeling equipment with bobbin magazine

The reeling equipment is placed on rails behind the peeling lathe so that it can be moved away when undersized pieces of veneer leave the peeler. The length of the bobbin is 2,300 mm.

The full bobbin is moved into the bobbin magazine from where it glides automatically to the clipper.

The bobbin magazine is made of iron, with two storeys for full bobbins and the third one /inclined towards the peeling lathe/ for returning the empty bobbins. The diameter of the empty bobbin is 0.2 m, the diameter of the full bobbin is 0.6 m. Ten bobbins are necessary /for each storey/.

Clipper for the veneer belt

- Length of the knife in mm	2,400
- Speed of the feeding conveyer in m per min.	0 - 60
- Speed of the removing conveyer in m per min.	30
- Compressed air drive in kg/cm2	6
- Possibility of clipping both automatically by photo-electric cell and by hand	

Clipper for undersized pieces of veneer

Instead of feeding and removing conveyers:benches or rollers. No photo-electric cell for clipping is required. Length of knife, as given before.

4. Veneer drying and sorting

Requirements concerning drier

The drier should dry 27 m3 of moist veneer or 24.6 m3 of dry veneer per day. The initial humidity of veneer being 80 % and the final one 6 %, 13,986 kg of water should be evaporated per day. This represents 1,998 kg of water per hour, based on one 7 hour shift. With a working width of 2.8 m a belt length of 55.3 m is required, consequently a three storey veneer drier 20 m long /excluding the cooling-off zone/ is necessary. The drier will be heated by steam at a pressure of 12 atmospheres.

Technical requirements:

- Width of belt in mm	2,400
- Length of heated zone in mm	3 x 20,000
- Length of cooling-off zone in mm	3,000
- Pressure in atmospheres	12
- Average output of dry veneer in m3/hour	3.0

- Behind the drier a transversal rubber conveyer for sorting veneer sheets shall be installed.

5. Veneer jointing, treatment and repair

Trimmer

- Operating length in mm	2,400
- Height of bundle before pressing in mm	300
- Feed rate in m per min.	12

Transverse jointer

- Operating width in mm	2,300
- Feed rate in m per min.	9
- Required output in m3 per day	7

- The jointer is equipped with a clipper.

Veneer plugging machine

Surface defects shall be removed on the veneer plugging machine.

- Diameter of the plug puncheon in cm	15

6. Spreading of glue

The glue spreader should have a daily output /in two shifts/ of about 2,100 sheets.

The glue will be prepared directly on the glue spreader, on which a glue mixer is fastened; from there the glue is pumped to the glue spreader.

The capacity is about 1,000 kg of glue mix in two shifts.

7. Pressing of plywood

Requirements concerning the press:

- Pressing plates in mm	2,600/1,300
- Number of openings	15
- Day light of opening in mm	70
- Greatest total pressure in kp/cm2	1,050
- Highest specific pressure in kp/cm2	25
- Hydraulic fluid: water + 5 % of emulsion gease	
- Length of input side in mm	2,300
- Closing speed in mm per sec.	100

- Heating: by steam
- Pressing plates equipped with metal cauls.

Filling of the press and closing from the upper opening.

8. Sizing of panels

First sizing saw:	
- Maximum edging width in mm	1,400
- Minimum edging width in mm	1,000
Second sizing saw:	
- Maximum edging width in mm	2,400
- Minimum edging width in mm	1,700
Feeding speed in m per min.	20

9. Sanding

Three-drum sander:	
- Operating width in mm	2,050

General services and installations

Veneer knife grinder:	
- Disk diameter in mm	3,200
Circular saw grinder:	
- universal	
Waste hog and blower:	
- Hog width in mm	430
- Height in mm	120
- Feeding speed in m per min.	12
- Output in m3 per hour	3
Steam boiler:	
- Capacity in Gcal per hour	5
- Pressure in atmospheres	12

The whole equipment is composed of

- the conveyer, means of transport and bunker
- the furnace
- the boiler with armature
- the device for fume cleaning and chimney
- the control panel
- the feeding pump
- the device for water conditioning.

The output of the steam boiler would cover also requirements for possible production of sliced veneer.

Maintenance equipment:

- Electric hand drilling machine
- Electric pillar drilling machine
- Universal grinder
- Shaping machine
- Tin shears
- Welding apparatus
- Universal lathe
- Universal milling cutter
- Hack saw
- Saw set pliers
- Diverse grinding disks, 15 pieces
- Locksmith´s equipment
- Electrical outfit

Modern equipment of this type is available in the maintenance working shop of the Wau Training Sawmill.

Laboratory equipment

Hydraulic press:

- dimensions of platens in mm	300 x 300
- specific pressure in kp per cm2	25
- Day light in mm	200
- Electric heating	

Glue bond testing machine:

- total strenght in tons	0.5

Laboratory drier

- with a thermostat up to 200 °C

Laboratory scales

Höpler viscosimeter

Laboratory table

Laboratory glass

Electric moisture-content indicator for veneer

Other auxiliary equipment will be produced locally:

- 10 work tables
- 50 pallets for veneer and plywood to be transferred by high lift trucks.

Firms delivering machinery and equipment for plywood plants:

<u>Siempelkamp</u> - Maschinenfabrik
Krefeld 1
Deutsche Bundesrepublik /West Germany/

<u>Hildebrand</u> - Maschinenbau Grub H 7446
Oberboihingen
Deutsche Bundesrepublik /West Germany/

<u>RFR</u> - Vereinigte Furnier - und Sperrholz - Maschinenfabriken
Hamburg 33
Wiesendamm 30
Deutsche Bundesrepublik /West Germany/

<u>C.Müller-Forst</u> - Maschinenfabrik und Eisengiesserei
bei Holzminden an der Weser
Deutsche Bundesrepublik /West Germany/

<u>Angelo Cremona and Figlio</u> - Monza
Viale Lombardia 275
Italia /Italy/

<u>Lahden Rautoteollisuus</u> - Lahti
Suomi - /Finland/

<u>Coe Manufacturing Co.</u> - Painesville
Ohio - USA

5/E Cost of electricity produced by consumer´s power plant

If the plywood plant in Wau generates its own electricity, this would not increase the cost of electric power above the current rate charged by the plant in Wau /i.e. £S 0.035 per KWh/ as is shown by the cash-flow forecast presented below. The following assumptions were made in this calculation:

		£S
Investment cost of consumer´s power plant including installation in Wau		35,000
Permanent working capital		5,000
Annual operating costs:		
fuel 290,000 liter x £S 0.09	26,100	
wages etc.	1,750	27,850

Internal revenue: 942,700 KWh/annum x 3.5 Pt/KWh = = 33,000

Interest on loans: 9.5 %

Cash-flow forecast /in LS/
for consumer's power plant in Wau

	Constr.	1	2	3	4	5
A. Sources of cash						
1. Loans	40,000					
2. Internal revenue		33,000	33,000	33,000	33,000	33,000
B. Uses of cash	40,000					
1. Fixed capital expenditure	35,000					
2. Permanent working capital	5,000					
3. Operating costs	-	27,850	27,850	27,850	27,850	27,850
4. Debt service						
4.1 Interest on loans		3,800	3,672	3,531	3,378	3,209
4.2 Repayment of loans		1,350	1,478	1,619	1,772	1,941
C. Surplus/Deficit						

SECTION 1

2	3	4	5	6	7	8	9	10	11
33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
27,850	27,850	27,850	27,850	27,850	27,850	27,850	27,850	27,850	27,850
3,672	3,531	3,378	3,209	3,025	2,823	2,602	2,360	2,095	1,805
1,478	1,619	1,772	1,941	2,125	2,327	2,548	2,790	3,055	3,345

SECTION 2

8	9	10	11	12	13	14	15
33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
27,850	27,850	27,850	27,850	27,850	27,850	27,850	27,850
2,602	2,360	2,095	1,805	1,487	1,139	758	340
2,548	2,790	3,055	3,345	3,663	4,011	4,392	3,584
							+ 1,226

SECTION 3

6/A Pricing of the output and receipts and costs during the start-up period

Selling prices

The calculation of the average selling prices is based on the following assumptions:

a/ it is expected that under normal conditions /beginning from the third operating year/ the structure of quality grades should be:

- for interior plywood /thicknesses from 3 to 10 mm/:

quality BB /and better/	20 %
quality BB/C	50 %
quality C	30 %

- for exterior plywood only two quality grades will be produced:

quality BB	50 %
quality BB/C	50 %

b/ the transport and sales expenses will be positively influenced by the fact that the bulk of the output will be distributed through the firm's own selling bureau in Khartoum; this will allow to bring the wholesale and retail margins to relatively low levels when compared with the present situation of imported plywood.

The summary of the planned ex factory prices is given in the following table:

Prices ex factory Wau /in £S per m3/

	Quality BB	BB/C	C	Average price
3 mm	192.0	172.0	146.0	168.0
4 mm	161.0	144.0	[illegible]	141.0
5 mm	157.0	140.0	119.0	137.0
6 mm	155.0	137.0	[illegible]	135.0
8 mm	152.0	136.0	[illegible]	[illegible]
10 mm	151.0	135.0	115.0	[illegible]
15 mm /ext.grade/	145.0	130.0	-	137.0

Based on the average ex factory prices indicated in the preceeding table, the wholesale and retail prices are calculated in the following way /in LS per m3/:

	Ex factory Wau	Khartoum wholesale	Khartoum retail
3 mm	168.0	180.0	198.0
4 mm	141.0	153.0	171.0
5 mm	137.0	149.0	164.0
6 mm	135.0	147.0	162.0
8 mm	133.0	145.0	160.0
10 mm	132.0	144.0	159.0
15 mm	137.0	149.0	164.0

Note: in the calculation of the sales receipts, the 6 mm plywood is taken as representing the whole group from 5 to 10 mm /considering the relatively small volume of this group, such a simplification cannot affect the exactness of the calculation/.

Sales and costs during the start-up period

Sales /in m3/

	Operating year		
	1	2	3
Ex factory Wau	200	650	1,050
Khartoum wholesale	400	900	950
Khartoum retail	1,900	2,450	2,500
T o t a l	2,500	4,000	4,500

Selling prices /in LS per m3/

	Operating year		
	1	2	3
Ex factory Wau	143.3	149.5	154.1
Khartoum wholesale	155.3	161.5	165.1
Khartoum retail	173.3	178.5	181.6

Note: it is assumed that during the first two years the output may be of lower quality /1st year: BB/C-50 %, C-50 %; 2 nd year: BB-10 %, BB/C-50 %, C-40 %/

Sales revenue /in 1,000 £S/

	Operating year 1	2	3
Ex factory Wau	28.7	97.2	161.8
Khartoum wholesale	62.1	145.4	156.8
Khartoum retail	329.3	437.3	453.9
T o t a l	420.1	679.9	772.5

Operating costs during the running-in period
/as a percentage of the final amount/

	operating years 1	2	3
Level of output	50	80	95
Sales through Khartoum /as percentage of total Kh.sales/	66	96	99
Raw materials	58	85	98
Power, water	65	87	100
Spare parts, technical materials	60	85	100
Wages and salaries x/	90	95	100
Sales expenses	70	90	100
Transport costs	66	96	99
Overheads, administrative expenses, insurance	80	90	100

x/Note: expatriate staff - 100 %

During the first two operating years, the wage bill is to be increased to pay the salaries of two expatriate experts; their salaries, incl. allowances are assumed to be £S 700 and £S 600 per month, the annual expence being £S 15,600 /40 % of this amount to be paid in foreign currency/.

Summary of operating costs during the running-in period /in LS/

	operating years 1	2	3
Raw material	83,050	121,710	140,330
Urea adhesive	22,040	32,300	37,240
Technological flour	2,090	3,060	3,530
Phenolic foil	11,480	16,830	19,400
Electrical energy	21,450	28,710	32,995
Water	700	940	1,080
Repairs and spare parts	9,030	12,790	15,050
Consumption of technical material	4,880	6,910	8,130
Insurance	6,250	7,030	7,810
Wages and salaries	71,810	74,940	62,460
Social security	10,770	11,240	9,380
Transport costs	25,180	36,620	37,770
Sales expenses	25,950	34,650	38,500
Plant overheads	27,320	30,740	34,150
T o t a l	323,000	418,470	447,825
Contingency /5 %/	16,150	20,920	22,390
G r a n d T o t a l	339,150	439,390	470,215

6/B Investment costs

Production machinery and equipment

As stated in chapter 6.2, the delivery of the plant will be carried out on a turn-key basis. It is, however, not excluded that minor items of equipment might be sub-contracted to local suppliers /the value of potential local deliveries is estimated not to exceed approx. 3 % of the total value of production machinery and equipment/. As the details of such a sub-contract could not be satisfactorily specified in this initial phase of the project, the investment costs of the machinery and equipment are calculated under the assumption that the total sum has to be paid for entirely in foreign currency.

According to the Sudanese industrial investment regulations, it can be reasonably assumed that all machinery and equipment may be granted the full exemption of custom duties.

The straight line of depreciation will be used. The write-off period will be 10 years for the production machinery and equipment and 5 years for the handling equipment.

Two replacements or repairs of investment character are planned to be carried out in the 7th and 11th operating years /the amount of investment requirement being 20 %, resp. 50 % of the initial cost of the machinery and equipment/. The prices are assumed to be constant. The handling equipment is planned to be replaced every 6th year.

Calculation of the value of erected machinery /in £S/

	Foreign currency	Local currency	Total
Price CF Port Sudan:			
a/ log yard equipment	27,500	-	27,500
b/ production line	264,700	-	264,700
c/ general installations and services	140,400	-	140,400
Total CF Port Sudan	432,600		432,600
Insurance /1.0 %/	-	4,330	4,330
Price CIF Port Sudan	432,600	4,330	436,930

	Foreign currency	Local currency	Total
Price CIF Port Sudan	432,600	4,330	436,930
Exchange tax /14,875 %/	-	64,350	64,350
Development tax /2 %/	-	8,650	8,650
Additional tax /5 %/	-	21,630	21,630
Clearing, insurance, transport to site /2.5 %/	-	10,820	10,820
Value of machinery at site	432,600	109,780	542,380
Engineering, supervision / 3 % /	4,330	8,650	12,980
Assembly and installation /10 %/	32,440	10,820	43,260
Value of erected machinery	469,370	129,250	598,620
Contingency and inflation allowance /10 %/	46,940	12,920	59,860
T o t a l	516,310	142,170	658,480

Construction works

Owing to the climatic conditions in Wau, the economic life of constructions is assumed to be 20 years. No replacements are planned during the 15 years' period included in the cash-flow forecast.

A/ Factory at Wau	£S
1. Levelling and preparation of the site, incl. log yard 20,000 m2; 0.5 £S/m2	10,000
2. Roads on the site 1,000 m2; 2.5 £S/m2	2,500
3. Operational building, incl. foundations for heavy machinery 2,400 m2; 50 £S/m2	120,000
4. Warehouses for plywood, spare parts, materials 1,200 m2; 30 £S/m2	36,000
5. Administration building 200 m2; 35 £S/m2	7,000
Carried forward	175,500

	LS
	175,500
6. Garage, workshops for vehicles	
100 m2; 20 LS/m2	2,000
7. Concrete drainage /apron/ around	
operational building and warehouses	
350 m; 8 LS/m	2,800
8. Canteen, first-aid center, social services	
300 m2; 35 LS/m2	10,500
9. Perimeter fence, incl. entrance area	
600 m; 5 LS/m	3,000
10. Boiler house	
150 m2; 40 LS/m2	6,000
11. Steaming pits	2,400
12. Steam supply	500
13. Water and sewage installation	2,000
14. Fire protection	5,000
T o t a l	209,700

B/ <u>Housing at Wau</u>

1. 2 residential houses for managers	20,000
2. Guesthouse	8,000
T o t a l	28,000

C/ <u>Warehouse and sales section at Khartoum</u>

1. Land, incl. levelling	750
500 m2; 1.5 LS/m2	
2. Warehouse	
200 m2; 40 LS/m2	8,000
3. Administration building	
50 m2; 30 LS/m2	1,500
4. Garage	
40 m2; 15 LS/m2	600
5. Perimeter fence	
70 m; 5 LS/m2	350
T o t a l	11,200

Summary	£S
A/ Factory at Wau	209,700
B/ Housing at Wau	28,000
C/ Warehouse and sales section at Khartoum	11,200
D/ Design work /6 % on A - C/	14,930
E/ Contingency /approx.5 % on A-D/	13,170
T o t a l	277,000

Transport, office and housing equipment

Price estimates for transport, housing and office equipment are considered as paid for in local currency. Even if partially imported, all these items are available on the local market and no exemptions from custom duties are expected to be granted.

The service life of the vehicles is assumed to be 4 years, the write-off period for the office and housing furniture will be 10 years. It is planned to replace the vehicles every 5th year and the furniture in the 11th operating year /the replacement being made under the condition of constant prices/.

Equipment to be purchased includes:	£S
1. 1 lorry 10 T/Wau/	10,000
2. 1 lorry 6 T /Khartoum/	6,000
3. Landrover /Wau/	5,000
4. Medium-price car /Khartoum/	5,000
5. Office furniture and equipment	10,000
6. Furniture and equipment for residential houses	12,000
7. Furniture and equipment for the canteen and first-aid center	8,000
T o t a l	56,000
Contingency /10 %/	5,600
T o t a l	61,600

Preliminary /development/ expenses

The assessment is based on experiences with similar industrial projects and discussions in the Sudanese consultancy institutes and firms. The write-off period will be 5 years.

	Foreign currency /LS/	Local currency /LS/	Total /LS/
1. Cost of establishing the company	-	2,000	2,000
2. Tendering and commissioning services, technical assistance	9,000	9,000	18,000
3. Wages and salaries during construction	1,000	32,600	33,600
4. Training of technical and managerial personnel	12,000	4,000	16,000
5. Interest on capital during construction x/	-	45,000	45,000
Total	22,000	92,600	114,600

x/
Note: according to the timing of construction and installation works, interest on capital during construction is assumed to be 60 % of the sum of interest paid in the first operating year

Schedule of depreciation

	Investment cost /LS/	Depreciation rate /%/	Annual depreciation /LS/
Production machinery and equipment	623,830	10	62,380
Handling equipment	34,650	20	6,930
Construction works	277,000	5	13,850
Vehicles	28,600	25	7,150
Furniture	33,000	10	3,300
Preliminary expenses	114,600	20	22,920
Total			116,530

Note: Beginning from the 6th operating year, the sum of annual depreciation will decrease to LS 93,610. The replacements of machinery and equipment will not affect the amount of depreciation.

6/C Calculation of annual repayments of loans

As can be seen in the cash-flow forecast, the operational loss in the first operating year has a very negative impact on the financial situation of the plant. To improve the liquidity in the first two years, the following measures in the financing schedule are proposed:

a/ to postpone the repayment of principal of the medium-term and long-term loans from the Industrial Bank of Sudan for the first, resp. the first two years,

b/ to use the system of repayment in equal annual instalments.

All data concerning the debt service are given in table 7 on the following page.

Loan	Amount /in £S/	Rate	Period		Operating year 1	2	3	4	5	6
Supplier's credit	150,000	9.5 %	5 years	Princ.	24,814	27,712	29,754	32,581	35,679	
				Int.	14,249	11,391	9,309	6,482	3,384	
				Instal.	39,063	39,063	39,063	39,063	39,063	
Long-term loan I.B.S.	400,000	8.5 %	12 years	Princ.	-	-	20,459	22,198	24,085	26,133
				Int.	34,000	34,000	34,000	32,261	30,374	28,326
				Instal.	34,000	34,000	54,459	54,459	54,459	54,459
Medium-term loan I.B.S.	300,000	9.5 %	6 years	Princ.	-	39,375	43,117	47,214	51,700	56,612
				Int.	28,500	28,500	24,758	20,661	16,175	11,263
				Instal.	28,500	67,875	67,875	67,875	67,875	67,875
Aggregate repayment of principal					24,814	66,547	93,330	101,993	111,464	82,745
Aggregate interest					76,749	74,391	68,067	59,404	49,933	39,589
Aggregate annual instalment					101,563	140,938	161,397	161,397	161,397	122,334

SECTION 1

Table 7

...ng year 3	4	5	6	7	8	9	10	11	12	13	14
29,754	32,581	35,679									
9,309	6,482	3,384									
39,063	39,063	39,063									
20,459	22,198	24,085	26,133	28,355	30,766	33,382	36,220	39,299	42,640	46,265	50,198
34,000	32,261	30,374	28,326	26,104	23,693	21,077	18,239	15,610	11,819	8,194	4,261
54,459	54,459	54,459	54,459	54,459	54,459	54,459	54,459	54,459	54,459	54,459	54,459
43,117	47,214	51,700	56,612	61,982							
24,758	20,661	16,175	11,263	5,893							
67,875	67,875	67,875	67,875	67,875							
93,330	101,993	111,464	82,745	90,337	30,766	33,382	36,220	39,299	42,640	46,265	50,198
68,067	59,404	49,933	39,589	31,997	23,693	21,077	18,239	15,610	11,819	8,194	4,261
161,397	161,397	161,397	122,334	122,334	54,459	54,459	54,459	54,459	54,459	54,459	54,459

SECTION 2

6/D Cash-flow forecast /in IS/

	Construction 1	Construction 2	Operating years 1	Operating years 2	Operating years 3	Operating years 4
A. Sources of cash	260,000	990,000	420,100	679,900	772,500	850,100
1. Financial resources, total	260,000	990,000				
1.1 Loans		850,000				
1.2 Equity	260,000	140,000				
2. Sales revenue			420,100	679,900	772,500	850,100
B. Uses of cash	253,800	952,180	455,713	580,328	631,612	636,192
1. Fixed capital expenditure	253,800	857,880				
1.1 Construction works	110,800	166,200				
1.2 Machinery and equipment	108,000	612,080				
1.3 Preliminary expenses	35,000	79,600				
2. Permanent working capital		94,300	15,000			
3. Operating costs			339,150	439,390	470,215	474,795
4. Debt service			101,563	140,938	161,397	161,397
4.1 Interest on loans			76,749	74,391	68,067	59,404
4.2 Repayment of loans			24,814	66,547	93,330	101,993
5. Tax on profit						
C. Surplus /Deficit of cash /A-B/	6,200	37,820	- 35,613	99,572	140,888	213,908
Surplus/Deficit accumulated		44,020	8,407	107,979	248,867	462,775

SECTION 1

3	4	5	6	7	8	9	10	11	12
,500	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,1
,500	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,1
1,612	636,192	664,792	777,043	871,714	684,055	714,225	687,328	1,068,740	691,1
		28,600	34,650	124,766		28,600		379,565	
		28,600	34,650	124,766		28,600		379,565	
,215	474,795	474,795	474,795	474,795	474,795	474,795	474,795	474,795	474,7
1,397	161,397	161,397	122,334	122,334	54,459	54,459	54,459	54,459	54,4
,067	59,404	49,933	39,589	31,997	23,693	21,077	18,239	15,160	11,8
,330	101,993	111,464	82,745	90,337	30,766	33,382	36,220	39,299	42,6
			145,264	149,819	154,801	156,371	158,074	159,921	161,
,688	13,908	185,308	73,057	- 21,614	166,045	135,875	162,772	-218,640	158,
,867	462,775	648,083	721,140	699,526	865,571	1,001,446	1,164,218	945,578	1,104,

SECTION 2

[illegible]	9	10	11	12	13	14	15	Terminal value
,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	
0,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	
4,055	714,225	687,328	1,068,740	691,180	721,955	695,714	643,812	
	28,600		379,565		28,600			218,311
	28,600		379,565		28,600			218,311
								109,300
4,795	474,795	474,795	474,795	474,795	474,795	474,795	474,795	
,459	54,459	54,459	54,459	54,459	54,459	54,459		
,693	21,077	18,239	15,160	11,819	8,194	4,261		
,766	33,382	36,220	39,299	42,640	46,265	50,198		
,801	156,371	158,074	159,921	161,926	164,101	166,460	169,017	
,045	135,875	162,772	-218,640	158,920	128,145	154,386	206,288	327,611
,571	1,001,446	1,164,218	945,578	1,104,498	1,232,643	1,387,029	1,593,317	1,920,928

SECTION 3

6/E Calculations of the commercial profitability of the project

The commercial profitability is calculated on the assumption that the present level of plywood price in the Sudan will be cut by more than half. This means that there remains a very broad margin to raise the commercial profitability of the project - if it should be desirable - as will be shown by the sensitivity analysis examples.

The calculations of the commercial profitability are based on two basic data:

- cost and profits of an "average" year /arithmatical mean/
- cost and profits of the 8th operating year /mediane/

as can be seen from the following table /in LS/:

Total capital investment: 1,220,980

Forecast operational accounts:

	average year	8th year
Sales	804,913	850,100
Expenses:		
- operating costs	463,086	474,795
- depreciation	101,210	93,610
- interest paid	33,505	23,693
- total	597,801	592,098
Tax on profit	105,717	154,801
Profit:		
- before tax and depreciation	308,322	351,612
- before tax	207,112	258,002
- after tax /net profit/	101,395	103,201
- after tax and before depreciation	202,605	196,811

Return on investment as ratio of:

		average year	8th year
ROI_1	$\frac{\text{profit before tax and depreciation}}{\text{investment}}$	25.3 %	28.8 %
ROI_2	$\frac{\text{profit before tax}}{\text{investment}}$	17.0 %	21.1 %
ROI_3	$\frac{\text{profit after tax and bef. deprec.}}{\text{investment}}$	16.6 %	16.1 %
ROI_4	$\frac{\text{net profit}}{\text{investment}}$	8.3 %	8.5 %

Pay-back period as ratio of:

PBP_1	$\frac{\text{investment}}{\text{profit before tax and deprec.}}$	4.0 years	3.5 years
PBP_2	$\frac{\text{investment}}{\text{profit after tax and before deprec.}}$	6.0 years	6.2 years

Commercial profitability as ratio of sales and profit:

RP_1	$\frac{\text{profit before tax}}{\text{sales revenues}}$	25.7 %	30.3 %
RP_2	$\frac{\text{net profit}}{\text{sales revenues}}$	12.6 %	12.1 %

Break-even analysis

The break-even point /BEP/where revenues and costs, incl. depreciation and tax on profit, are equal will be calculated using the formula:

$$BEP\ /in\ \%/ = \frac{FC + 0.3\ SVC}{SR - VC - 0.7\ SVC} \times 100$$

where: FC - fixed costs
SVC - semi-variable costs
VC - variable costs
SR - sales revenues

The calculations are based on the presumed data for the 8th operating year /in LS/:

sales			850,100
variable costs:	raw material	143,190	
	adhesives	61,400	
	water,energy	34,075	
	transport costs	38,150	
	contingency	13,770	290,585
fixed costs:	depreciation	93,610	
	interest paid	23,693	
	insurance	7,810	
	overheads	34,150	
	contingency	2,090	
	tax on profit	154,801	316,154
semi-variable costs:	remaining operating costs, incl. contingency		140,160

$$BEP = \frac{316,154 + 42,048}{850,100 - 290,585 - 98,112} \times 100 = \underline{77.6\ \%}$$

Cost /Benefit Analysis /in LS/

	Construction 1	Construction 2	Operating years 1	Operating years 2	3	4
B. Benefits						
Loans		850,000				
Sales revenues			420,100	679,900	772,500	850,10
Total		850,000	420,100	679,900	772,500	850,10
C. Costs						
Fixed capital expenditure	253,800	857,880				
Permanent working capital		94,300	15,000			
Operating costs			339,150	439,390	470,215	474,79
Debt service			101,563	140,938	161,397	161,39
Tax on profit						
Total	253,800	952,180	455,713	580,328	631,612	636,19
B - C	-253,800	-102,180	-35,613	99,572	140,888	213,90
B - C accumulated		-355,980	-391,593	-292,021	-151,133	62,77
Net present value /12 %/	-253,800	-91,247	-28,384	70,895	89,605	121,286
NPV 12 % accumulated		-345,047	-373,431	-302,536	-212,931	-91,645
Net present value /25 %/	-253,800	-81,744	-22,792	50,981	57,764	70,162
NPV 25 % accumulated		-335,544	-358,336	-307,355	-249,591	-179,42

Internal rate of return is calculated using the formula:

$$IRR = P_1 + \frac{a}{a - b} / P_2 - P_1 /$$

$$IRR = 12 + \frac{298,758}{298,758 + 48,734} /25 - 12/ = 12 + 0.8598.13$$

$IRR = 23.2\ \%$

SECTION 1

3	4	5	6	7	8	9	10	11	12
772,500	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,1
772,500	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	850,1
		28,600	34,650	124,766		28,600		379,565	
470,215	474,795	474,795	474,795	474,795	474,795	474,795	474,795	474,795	474,7
161,397	161,397	161,397	122,334	122,334	54,459	54,459	54,459	54,459	54,
			145,264	149,819	154,801	156,371	158,074	159,921	161,9
631,612	636,192	664,792	777,043	871,714	684,055	714,225	687,328	1,068,740	691,1
140,888	213,908	185,308	73,057	-21,614	166,045	135,875	162,772	-218,640	158,9
-151,133	62,775	248,083	321,140	299,526	465,571	601,446	764,218	545,578	704,4
89,605	121,286	93,951	33,022	-8,732	59,942	43,752	46,716	-56,190	36,3
212,931	-91,645	2,306	35,328	26,596	86,538	130,290	177,006	120,816	157,2
57,764	70,162	48,551	15,342	-3,631	22,250	14,539	13,998	-15,086	8,7
-249,591	-179,429	-130,878	-115,536	-119,167	-96,917	-82,378	-68,380	-83,466	-74,7

SECTION 2

8	9	10	11	12	13	14	15	Terminal value
0,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	
0,100	850,100	850,100	850,100	850,100	850,100	850,100	850,100	
	28,600		379,565		28,600			218,311
								109,300
4,795	474,795	474,795	474,795	474,795	474,795	474,795	474,795	
4,459	54,459	54,459	54,459	54,459	54,459	54,459		
4,801	156,371	158,074	159,921	161,926	164,101	166,460	169,017	
,055	714,225	687,328	1,068,740	691,180	721,955	695,714	643,812	327,611
6,045	135,875	162,772	-218,640	158,920	128,145	154,386	206,288	327,611
5,571	601,446	764,218	545,578	704,498	832,643	987,029	1,193,317	1,520,928
9,942	43,752	46,716	-56,190	36,393	26,270	28,253	33,625	53,401
86,538	130,290	177,006	120,816	157,209	183,479	211,732	245,357	298,758
22,250	14,539	13,998	-15,086	8,741	5,638	5,404	5,776	9,173
6,917	-82,378	-68,380	-83,466	-74,725	-69,087	-63,683	-57,907	-48,734

SECTION 3

6/F Sensitivity analysis

Several simple examples showing the impact of the potential future market and costing development indicate the very strong position - in terms of profitability - of the domestic production of plywood /considering the wide price margin when compared with the imports of plywood to the Sudan/.

The sensitivity analysis is based on the date of the 8th year of operation /the mediane member of the time series of 15 years taken into account in the study/. The results can be summerized in the following conclusions:

- the selling price exercises the greatest influence on the return on investment of the project as can be seen mainly in the last column of the table: the increase of sales revenues by 9.7 % is sufficient enough to compensate the aggregate impact of increases both of investment and operating costs;
- the increase of investment costs has the relatively lowest impact on the return on investment /if no additional effect on interest on loans is assumed/,
- if the sales revenues were increased by 20 %, the return on investment /as ratio of gross profit to investment/ would climb up to 35.1 % with prices remaining only about 50 % of the present price level on the Sudanese market!

[illegible] analysis examples /in [illegible]/

	Basic data	Sales revenues increased by 20 %	Sales revenues cut by 10 %	Oper[illegible] inc[illegible]
Total capital investment	1,220,980	1,220,980	1,220,980	1,2[illegible]
Sales revenues	[illegible]50,100	1,020,120	765,090	[illegible]
Expenses, total	592,098	592,098	592,098	[illegible]
of which: operating costs	474,795	474,795	474,795	5[illegible]
depreciation	[illegible],610	[illegible],610	90,610	
interest [illegible]	[illegible]	[illegible]	[illegible],693	
Profit before tax	[illegible]	[illegible]	172,992	[illegible]
Tax on profit	[illegible]	[illegible]	[illegible],795	1[illegible]
Profit after tax and before depreciation	196,811	264,919	162,807	[illegible]
Net profit	[illegible],201	171,[illegible]	69,197	[illegible]
Return on investment as ratio:				
- profit before tax /investment	21.1 %	35.1 %	14.2 %	
- profit after tax and before depreciation /investment	16.1 %	21.7 %	13.3 %	[illegible]
- net profit /investment	8.5 %	14.0 %	5.7 %	
Pay-back period as ratio of:				
- investment / profit after tax and before depreciation	6.2 years	4.[illegible] years	7.5 years	
Ratio of profitability as percentage of:				
- net profit / sales revenues	12.1 %	16.8 %	9.0 %	

[illegible]les revenues increased by [illegible] %	Sales revenues cut by 10 %	Operating costs increased by 10 %	Investment cost increased by 10 %	Sales revenues increased to compensate the increase in investment and operating costs by 10 % /to retain the basic ROI/
1,220,980	1,220,980	1,220,980	1,343,080	1,343,080
1,020,120	765,090	850,100	850,100	932,728
592,098	592,098	639,578	601,459	648,938
474,795	474,795	522,275	474,795	522,275
[illegible],310	93,610	93,[illegible]10	102,971	102,971
[illegible],693	[illegible],693	23,693	23,693	23,693
4[illegible],[illegible]	172,992	210,522	248,641	283,790
15[illegible],[illegible]19	10[illegible],795	126,31[illegible]	149,185	170,274
264,919	162,807	177,819	202,427	216,487
171,109	69,197	84,209	99,456	113,516
35.1 %	14.2 %	17.2 %	18.5 %	21.1 %
21.7 %	13.3 %	14.6 %	15.1 %	16.1 %
14.0 %	5.7 %	6.9 %	7.4 %	8.5 %
[illegible] years	7.5 years	6.9 years	6.6 years	6.2 years
16.8 %	9.0 %	9.9 %	11.7 %	12.2 %

SECTION 2

6/G Macro-economic evaluation

Value added

For the calculation of the value added /from the macro-economic point of view/ the following items are taken into consideration /in ЉS/:

	operating year 4th	operating year 8th
raw material /90 %/, including contingency	135,315	135,315
wages and salaries, including social security and contingency	75,432	75,432
interest paid	59,404	23,693
profit before tax	199,491	258,002
total value added	469,642	492,442

$$\text{Ratio of value added} = \frac{\text{value added}}{\text{sales}} \times 100$$

$$RVA_4 = \frac{469,642}{850,100} \times 100 = \underline{55.2\ \%}$$

$$RVA_8 = \frac{492,442}{850,100} \times 100 = \underline{57.9\ \%}$$

Social costs/benefits analysis

For the assessment of the national economic profitability of the project a somewhat simplified method /as compared with UNIDO's Guidelines/ was used.

Since the conclusions are commented in Chapter 6, in this Annex only short remarks to the methodology are added:

- the output was evaluated in world prices - 250 US $ per m3
- for the calculation of social opportunity costs the following premiums were used: foreign exchange + 0.5; unskilled labour - 1.0
- in the component "unskilled labour" the semi-skilled labour trained in the project is included
- the social discount rate is lying between 5 % and 6 %.

Components of investment costs /in £S/

	Foreign exchange	Domestic materials	Unskilled labour
Production machinery and equipment	516,310	136,760	5,410
Transport and office equipment	26,400	35,200	
Construction works	13,850	180,050	83,100
Preliminary expenses 1/	22,000	38,000	9,600
T o t a l	578,560	390,010	98,110

1/ Interests on capital during construction are excluded

Components of working capital /in £S/

	Foreign exchange	Domestic materials	Unskilled labour
Total 2/	35,890	54,590	18,820

2/ The proportions of each component in the cost of raw material and wages are calculated on the same basis as in operating costs.

Operating costs /broken-down into components/ in LS

	Foreign exchange 1	2	3	4-15	Domestic [illegible] 1	2	3
a/ Raw material	8,305	12,170	14,030	14.320	41,525	60,860	70,[illegible]
b/ Urea adhesive	16,530	24,225	27,930	28,500	5,510	8,075	9,[illegible]
c/ Technological flour					2,090	3,060	3,[illegible]
d/ Phenolic foil	8,610	12,625	14,500	14,850	2,870	4,205	4,[illegible]
e/ Electrical energy					21,450	28,710	32,[illegible]
f/ Water					700	940	1,[illegible]
g/ Repairs and spare parts	6,770	9,680	11,440	11,440	2,260	3,110	3,[illegible]
h/ Consumption of technical materials	3,660	5,180	6,100	6,100	1,220	1,730	2,[illegible]
i/ Insurance					6,250	7,030	7,[illegible]
j/ Wages and salaries					40,990	42,270	43,[illegible]
Expatriate staff	6,240	6,240			9,360	9,360	
k/ Social security					10,770	11,240	9,[illegible]
l/ Transport costs					23,920	34,790	35,[illegible]
m/ Sales expenses	1,350	1,730	1,925	1,925	22,905	29,455	32,[illegible]
n/ Plant overheads and administrative expenses	1,365	1,535	1,710	1,710	23,225	26,135	29,[illegible]
Total	52,830	73,385	77,685	78,845	215,045	270,970	286,[illegible]
Contingency /approx.5 %/	2,640	3,670	3,880	3,910	10,750	13,550	14,[illegible]
Total operating costs	55,470	77,055	81,565	82,755	225,795	284,520	300,[illegible]

SECTION 1

in LS

exchange 3	4-15	Domestic materials 1	2	3	4-15	Unskilled labour 1	2	3	4-15
14,030	14,320	41,525	60,860	70,170	71,590	33,220	48,680	56,130	57,280
27,930	28,500	5,510	8,075	9,310	9,500				
		2,090	3,060	3,530	3,600				
14,500	14,850	2,870	4,205	4,850	4,950				
		21,450	28,710	32,995	32,995				
		700	940	1,080	1,080				
11,440	11,440	2,260	3,110	3,610	3,610				
6,100	6,100	1,220	1,730	2,030	2,030				
		6,250	7,030	7,810	7,810				
		40,990	42,270	43,940	43,940	15,220	17,070	18,520	18,520
		9,360	9,360						
		10,770	11,240	9,380	9,380				
		23,920	34,790	35,880	36,240	1,260	1,830	1,890	1,910
1,925	1,925	22,905	29,455	32,725	32,725	2,695	3,465	3,850	3,850
1,710	1,710	23,225	26,135	29,025	29,025	2,730	3,070	3,415	3,415
77,685	78,845	215,045	270,970	286,335	288,475	55,125	74,115	83,805	84,975
3,880	3,910	10,750	13,550	14,320	14,380	2,760	3,700	4,190	4,210
81,565	82,755	225,795	284,520	300,655	302,855	57,885	77,815	87,995	89,185

SECTION 2

Resources flows /in LS/

		Construction 1	Construction 2	Operating year 1	Operating year 2	Operating year 3
1. Supplier's loan: foreign exchange			150,000			
2. Output: foreign exchange				197,920	330,000	3[illegible]
3. Construction and replacement costs:						
3.1 Foreign exchange:	construction works	5,540	8,310			
	machinery and equipment	81,430	461,280			
	preliminary expenses	14,000	8,000			
3.2 Domestic materials:	construction works	72,020	108,030			
	machinery and equipment	25,920	146,040			
	preliminary expenses	21,000	17,000			
3.3 Unskilled labour:	construction works	33,240	49,860			
	machinery and equipment	650	4,760			
	preliminary expenses		9,600			
4. Permanent working capital:						
	foreign exchange		35,890			
	domestic materials		47,120	7,470		
	unskilled labour		11,290	7,530		
5. Operating costs:	foreign exchange			55,470	77,055	[illegible]
	domestic materials			225,795	284,520	30[illegible]
	unskilled labour			57,885	77,815	[illegible]
6. Debt service /supplier's loan/:						
	foreign exchange			39,063	39,063	3[illegible]
7. Scrap value and permanent working capital						
7.1 Scrap value:	domestic materials					
7.2 Permanent working capital:						
	foreign exchange					
	domestic materials					
	unskilled labour					

SECTION 1

Operating years										
1	2	3	4	5	6	7	8	9	10	
197,920	330,000	375,000	416,670	416,670	416,670	416,670	416,670	416,670	416,670	416
				12,300	20,790	94,074		12,300		286
				16,300	13,860	29,944		16,300		91
						748				2
7,470										
7,530										
55,470	77,055	81,565	82,755	82,755	82,755	82,755	82,755	82,755	82,755	8
225,795	284,520	300,655	302,855	302,855	302,855	302,855	302,855	302,855	302,855	302
57,885	77,815	87,995	89,185	89,185	89,185	89,185	89,185	89,185	89,185	89
39,063	39,063	39,063	39,063	39,063						

SECTION 2

7	8	9	10	11	12	13	14	15	Terminal value
6,670	416,670	416,670	416,670	416,670	416,670	416,670	416,670	416,670	
4,074		12,300		286,192		12,300			
9,944		16,300		91,096		16,300			
748				2,277					
2,755	82,755	82,755	82,755	82,755	82,755	82,755	82,755	82,755	
02,855	302,855	302,855	302,855	302,855	302,855	302,855	302,855	302,855	
9,185	89,185	89,185	89,185	89,185	89,185	89,185	89,185	89,185	
									218,311
									35,890
									54,590
									18,820

SECTION 3

Social costs/benefits analysis /in LS/

		Construction 1	Construction 2	1	2	3
B/	Social benefits, total		225,000	296,880	495,000	562,500
	Supplier's credit		225,000			
	Output			296,880	495,000	562,500
	Working capital and scrap value					
C/	Social costs, total	270,395	1,088,410	355,533	439,166	462,066
	Construction and replacement costs	270,395	987,455			
	Permanent working capital		100,955	7,470		
	Operating costs			309,000	400,103	423,003
	Debt service /supplier's credit/			39,063	39,063	39,063
B-C	Social net benefits	-270,395	-863,410	-58,653	55,834	100,434
	Social net benefits accumulated		-1,133,805	-1,192,458	-1,136,624	-1,036,190
	Present value of social net benefits /5 %/	-270,395	-821,966	-53,198	48,421	82,657
	Present value of SNB accumulated	-270,395	-1,092,361	-1,145,559	-1,097,138	-1,014,481

SECTION 1

Operating years

1	2	3	4	5	6	7	8	9	
6,880	495,000	562,500	625,005	625,005	625,005	625,005	625,005	625,005	625,
96,880	495,000	562,500	625,005	625,005	625,005	625,005	625,005	625,005	625,
55,533	439,166	462,066	466,051	500,801	472,033	598,043	426,988	461,738	426
				34,750	45,045	171,055		34,750	
7,470									
09,000	400,103	423,003	426,988	426,988	426,988	426,988	426,988	426,988	426
39,063	39,063	39,063	39,063	39,063					
58,653	55,834	100,434	158,954	124,204	152,972	26,962	198,017	163,267	19
92,458	-1,136,624	-1,036,190	-877,236	-753,032	-600,060	-573,098	-375,081	-211,814	-1
53,198	48,421	82,657	124,620	92,656	108,763	18,253	127,721	100,246	11
45,559	-1,097,138	-1,014,481	-889,861	-797,205	-688,442	-670,189	-542,468	-442,222	-32

SECTION 2

7	8	9	10	11	12	13	14	15
5,005	625,005	625,005	625,005	625,005	625,005	625,005	625,005	951,741
25,005	625,005	625,005	625,005	625,005	625,005	625,005	625,005	625,005 326,736
98,043	426,988	461,738	426,988	947,372	426,988	461,738	426,988	426,988
71,055		34,750		520,384		34,750		
26,988	426,988	426,988	426,988	426,988	426,988	426,988	426,988	426,988
6,962	198,017	163,267	198,017	-322,367	198,017	163,267	198,017	524,753
73,098	-375,081	-211,814	-13,797	-336,164	-138,147	+25,120	+233,137	+747,890
8,253	127,721	100,246	115,840	-179,558	104,949	82,450	95,246	240,337
70,189	-542,468	-442,222	-326,382	-505,940	-400,991	-318,541	-223,295	+17,043

SECTION 3

Flows of foreign currency /in US $/

	Construction 1	Construction 2	1	2	3	
A/ Outflow of foreign currency, total	302,910	1,540,440	283,599	348,354	361,884	
1. Outflow of capital, total	302,910	1,540,440	117,189	117,189	117,189	
Construction works	16,620	24,930				
Machinery and equipment	244,290	1,383,840				
Preliminary expenses	42,000	24,000				
Permanent working capital		107,670				
Debt service /supplier's credit/			117,189	117,189	117,189	
2. Current outflow, total			166,410	231,165	244,695	
Adhesives			75,420	110,550	127,440	
Spares, technical materials			31,290	44,580	52,620	
Expatriate staff			18,720	18,720		
Raw material			24,915	36,510	42,090	
Other expenses incl.contingency			16,065	20,805	22,545	
B/ Inflow or savings of foreign currency, total		450,000	593,760	990,000	1,125,000	1,
Supplier's credit		450,000				
Substitution of imports /or exports/			593,760	990,000	1,125,000	1,
Permanent working capital /terminal value/						
C/ Net savings of foreign currency	-302,910	-1,090,440	310,161	641,646	763,116	
Net savings of foreign currency accumulated		-1,393,350	-1,083,189	-441,543	321,573	1,

SECTION 1

	Operating years									
	1	2	3	4	5	6	7	8	9	
[illegible]0	283,599	348,354	361,884	365,454	402,354	310,635	530,487	248,265	265,165	
40	117,189	117,189	117,189	117,189	154,089	62,370	282,222		36,900	
[illegible]0										
[illegible]0					36,900	62,370	282,222		36,900	
00										
70										
	117,189	117,189	117,189	117,189	117,189					
	166,410	231,165	244,695	248,265	248,265	248,265	246,265	248,265	248,265	
	75,420	110,550	127,440	130,050	130,050	130,050	130,050	130,050	130,050	
	31,290	44,580	52,620	52,620	52,620	52,620	52,620	52,620	52,620	
	18,720	18,720								
	24,915	36,510	42,090	42,960	42,960	42,960	42,960	42,960	42,960	
	16,065	20,805	22,545	22,635	22,635	22,635	22,635	22,635	22,635	
00	593,760	990,000	1,125,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1.
00	593,760	990,000	1,125,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1.
	310,161	641,646	763,116	884,546	847,646	939,365	719,513	1,001,735	964,835	1.
	-1,083,189	-441,543	321,573	1,206,119	2,053,765	2,993,130	3,712,643	4,714,378	5,679,213	6.

SECTION 2

8	9	10	11	12	13	14	15
248,265	285,165	248,265	1,106,841	248,265	285,165	248,265	248,265
	36,900		858,576		36,900		
	36,900		858,576		36,900		
248,265	248,265	248,265	248,265	248,265	248,265	248,265	248,265
130,050	130,050	130,050	130,050	130,050	130,050	130,050	130,050
52,620	52,620	52,620	52,620	52,620	52,620	52,620	52,620
42,960	42,960	42,960	42,960	42,960	42,960	42,960	42,960
22,635	22,635	22,635	22,635	22,635	22,635	22,635	22,635
1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,357,670
1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
							107,670
1,001,735	964,835	1,001,735	143,159	1,001,735	964,835	1,001,735	1,109,405
4,714,378	5,679,213	6,680,948	6,824,107	7,825,842	8,790,677	9,792,412	10,901,817

SECTION 3

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