PN-AAX-929

Best available copy -- page 19 missing

PN-AAX-929 650000+1
5 1631 + 913
AHI SUK

Survey of Fuelwood Consumption in Khartoum Province Industries

By:
Abdel Salaam Ahmed
Dr. ElSheikh Elmagzoub

National Energy Administration
Ministry of Energy and Mining

April 1985

FORWARD

This report represents the culmination of the firs collaborative effort of the National Energy Administration and the Energy Research Council's Sudan Renewable Energy Project. This work has involved the integration of technology assessment and energy planning capabilities of the staffs of our 2 organizations.

We believe that this joint project has shown the great potential of this sort of inter-agency collaboration, and we hope that it marks the beginning of a long and fruitful relationship between these organizations.

ACKNOWLEDGMENTS

The authors would like to express their gratitudes towards the following:

1. Sudan Renewable Energy Project (SREP), in particular Mr. Donald Peterson, Chief of Party and Dr. Hassan Wardi and Dr. El Tayeb Idris, Energy Research Council Directors and SREP Coordinators, for financing and granting the different facilities for accomplishing this work.

2. National Energy Administration (NEA), in Particular Dr. A/Rahman Shulli, the general director, Mr. Ismail ElGizouli, the acting general director, Mr. A/Halim Ahmed El Sheikh, Renewable Energy Department Director, and Mr. Paul Cough, Consultant, for initiating this work, and those members of NEA staff who helped and contributed in carrying out the survey field work.

3. Mr. Matthew Gamser, SREP Energy Economist, for his continuous suggestions and constant advice during the writing-up stage of this report.

4. Ms. Sanaa Saad and Ms. Hawa Makawi, SREP Secretaries, for their typing services.

NEA Staff contributed in carrying out survey:

Abdel Salaam Ahmed Abdel Salaam
Abdel Halim Ahmed El Sheikh
Bakri Osman Hamed
Ahmed Abdel Gadir Abusam
Abdel Ellah Mohamed El Hassan
Abdel Azim Wida'a
Mohmed Abd Alla El Mahi
Fatma Abdel Moneim Mohmed
Mohmed El Sanosi
Igbal El Sadig
Kawther Abdel Gadir
Ezel Din Suleiman
Osama Masaad
Fath El Rahman Yousif

TABLE OF CONTENTS

Page

FORWARD
ACKNOWLEDGEMENTS
NEA STAFF CONTRIBUTED IN CARRYING OUT SURVEY
CONVERSION FACTORS
TABLE OF CONTENTS
EXECUTIVE SUMMARY..... 1

1. INTRODUCTION..... 4

2. SURVEY METHODOLOGY..... 6
   2.1 Introduction..... 6
   2.2 Bakeries..... 6
   2.3 Brick kilns..... 9
   2.4 Restaurants 12
   2.5 Sweet, Soap and Oil Industries..... 15
   2.6 Analysis..... 16

3. DESCRIPTION OF INDUSTRIES SURVEYED..... 17
   3.1 Bakeries..... 17
   3.2 Brick kilns..... 17
   3.3 Sweet, Soap and Oil Industries..... 18
   3.4 Restaurants..... 18

4. RESULTS AND DISCUSSION..... 19
   4.1 Types and Sources of Wood..... 19
   4.2 Fuelwood Consumption..... 21
   4.3 Total Cost of Production and Relative Cost of Fuelwood to Total Cost of Production..... 27
   4.4 Equivalent area of forests to meet annual fuelwood demand by industries..... 32
   4.5 Tendency for change to other sources of energy..... 34

5. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK..... 38
   5.1 Conclusions..... 38
   5.2 Recommendations for future work..... 40

PAGE

APPENDICES

Appendix 1..... 42
Preliminary Data Questionaire

Appendix 2
Main Data Questionaires..... 43
A. Traditional Bakeries Questionaire
B. Brick Kilns Questionaire
C. Restaurants Questionaire
D. Sweet, Soap and Oil Questionaire.

Appendix 3
Procedure for Determining Sample Size
of Bakeries..... 56

Appendix 4
Location of Kaminas in Khartoum Province
according to Area..... 59

REFERENCES..... 61

CONVERSION FACTORS

1 Habel	=	3.5 m		
1 Feddan	=	4,200 m^2		
1 Hectare (ha)	=	10,000 m^2		
1 Feddan	=	0.42 ha		
1 m^3 stacked sunt wood	=	440 kg		
1 Ton	=	1,000 kg	=	22.2 Kontar
1 Kontar	=	45 kg	=	100 Ib

Executive Summary

A consumption pattern survey for Khartoum Province industries annual demand from fuelwood has been carried out. The industries included in the survey were the traditional bakeries, brick kilns, restaurants, Sweet, Soap and Oil industries.

For each industry, a separate survey methodology was developed and statistical techniques were used for selecting samples to be surveyed and analysing data generated.

A summary of the main survey results is shown in the following table and the enclosed pie graph.

Type of industry	Fuelwood consumed 1984	Fuelwood cost (LS)	% age of Total prod-uction cost	% Willing accept new energy source
Bakeries	66,700	8,883,960	9	88
Brick kilns	100,980	11,208,500	17	82
Restaurants	7,530	1,002,600	6	26
Sweet	2,710	330,550	11	100
Soap	1,580	192,500	3	100
Oil	2,110	257,400	3.5	100
TOTALS	181,610	21,875,510		

The 1984 estimate of annual industrial fuelwood consumption in Khartoum Province is about 2.6 times of that estimated by NEA in 1980 (174,000 tons versus 68,000 tons).

About 22 million Sudanese pounds have been spent on using fuelwood energy in Khartoum industries for the year 1984. This significant amount of money could be reduced if other cheap sources of energy is used and/or efficient measures for utilising fuelwood are taken.

However, it was found that the relative cost of fuelwood to total cost of production in most of these industries is less than 10%. Therefore, the owners of these industries have low incentives for accepting any costly major technical modifications for energy conservation.

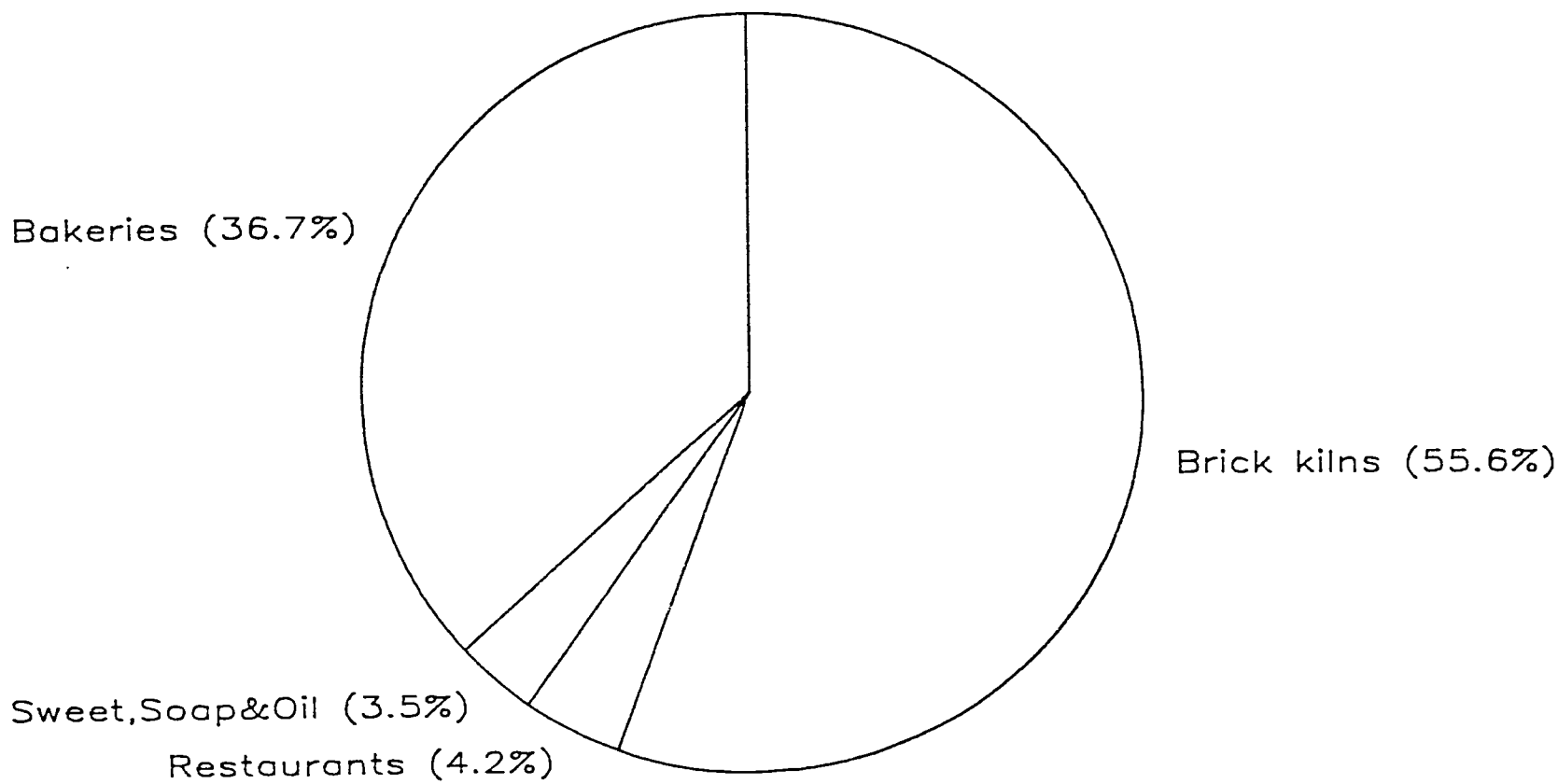
As brick kilns consume more than half of the total consumption of fuelwood and the relative cost of fuelwood to the total cost of production averages 17%, this industry is considered as the best canditate for initiating any technology development work.

The area of forests needed to provide sustained supply of sunt fuelwood to Khartoum Province industries is calculated as 230,000 feddans (assuming 20 years rotation). At present, only 38% of this demand is supplied from reserved managed forests situated mainly in the Central and Eastern Regions. The rest of the supply is obtained from rapidly diminishing natural forests located outside Khartoum Province.

The existing types of traditional bakeries were briefly described and a general layout of a brick kiln is presented. The different usages of fuelwood energy in Sweet, Soap and Oil industries are discussed and the most common types of fuelwood stoves utilised in restaurants are described.

Industry share of fuel wood consumption

[1984]



1. INTRODUCTION

1.1 Objectives:

The idea of determining wood fuels consumption in industries in Khartoum Province was initiated by the National Energy Administration (NEA) and it was then discussed in the Technical Committee meetings for the Sudan Renewable Energy Project (SREP). A proposal for undertaking this study was prepared by NEA and submitted to SREP on the 23rd of August 1984. This first proposal listed five objectives for this study and could be summarised as follows:

1) Up date the future industrial wood fuel demand;

2) Future energy investments;

3) Options and measures to take for efficient use of wood fuel;

4) Potential impacts of changes in the energy pricing policy on woodfuel demand;

5) Environmental impacts of using wood fuels.

The proposal also suggested a three month duration for carrying out this study.

A joint meeting between SREP and NEA was held later and discussed the proposal submitted by NEA. SREP staff accepted to finance this study and expressed that one of their objectives in doing this was to help NEA build up its data base on the usage of different fuels and to develop and test different survey methodologies which could be applied to any energy consuming sector. Some modifications recommended by the SREP technical committee were made. It was agreed at the meeting that the main emphasis of the work would be on data collection. Finally NEA and SREP approved that the following three points were to be the main objectives of this study:

1) Determination of the magnitude of wood fuel consumption and supply sources in the different indutry sectors of Khartoum Province so as to judge the impact of these sectors on the present and future stock of trees.

2) Determination of the receptivity of business people who run operations in these sectors to alternative sources of energy and to provide a base of information for further technical evaluation of combustion methods and system design improvements.

3) Estimation of wood fuel cost relative to other costs in each industry.

1.2 Background:

Fuel wood in Sudan is mainly used in household sector, especially in rural areas. The second big user is the industries and services sector. It was estimated in 1980 (1) that the household sector consumed about $7.88 10^6$ tons of firewood. Nearly 85% of this amount is utilised in rural areas. The household sector in Khartoum Province uses only about 2% of the total amount. The industries and services sector in Sudan consumes about 222950 tons, about 30% of this in Khartoum Province.

The major users of wood in Khartoum Province industries are the traditional industries which include bakeries, brick kilns, soap, sweet and oil factories and restaurants. Separate survey methodologies were developed for obtaining the total consumption of wood for each individual industry and these are presented in Chapter 2.

A general description of how wood fuel is being used in each of the above industries is shown in Chapter 3. The results of the survey are presented and discussed in Chapter 4. Chapter 5 is devoted to the conclusions and the recommendations for future work.

2. SURVEY METHODOLOGY

2.1 INTRODUCTION:

To get preliminary stage information about bakeries, brick kilns and restaurants utilising fuelwood or other fuels, the following councils were visited through the liaison on commissioner's office.

1. Khartoum, Khartoum North and Omdurman town councils;

2. District Councils.

The type of information gathered from these councils include the number and location of each of the above industries in the Province. The designed questionaire for this purpose is shown in appendix 1.

For sweet, soap and oil industries, the following government agencies were contacted to get the recorded preliminary data:

1. Customs Department.
2. General Sugar Corporation.
3. Ministry of Industry.

To obtain the data and informations for facilitating the fulfillment of the objectives of this study, a separate questionaire was developed for each kind of industry (Appendix 2). Also for each industry a separate method for surveying was adhered to. It is described briefly in the following sections.

2.2 BAKERIES:

Bakeries could be classified into two classes according to the type of fuel they were using : a) fire wood, b) gas oil and electric bakeries (Automatic bakeries). Table (2.1) shows the type and number of bakeries in Khartoum Province.

Table (2.1) Type and number of bakeries in Khartoum Province (1984)

Type of Bakery	Number
Fire Wood	645
Automatic	120
Total	765

To stick to the objectives of this study only those bakeries using wood, which are commonly called traditional bakeries, were surveyed. The total number of bakeries in the Province was stratified on the basis of two criteria: i) in which town the bakery exists and ii) in which area of town the bakery is located.

i) Town: Khartoum
Khartoum North
Omdurman

ii) Location: Mid-Town (Area 1)
Outskirts (Area 2)
Villages (Area 3)

Mid-Town areas are defined in this text as those urban areas which are situated around the city center. The outskirts are semi-urban areas which are relatively new extensions in each town when compared to the buildings of area 1 (built after 1960). They form the outer borders for each town and the inner boundaries for villages. Area 3 are rural areas which constitute all villages within the Province.

According to this stratification, the total number of bakeries is distributed as shown in table (2.2)

Table(2.2)Distribution of traditional bakeries in Khartoum Province according to their town and location

Area / Town	1	2	3	Total
Khartoum	78	56	27	161
Khartoum-North	87	92	173	352
Omdurman	52	42	38	132
Total	217	190	238	645

To get the total amount of wood consumed per day per bakery, stratified random sampling method was used. The main three strata in each town were taken as areas 1,2 and 3. Before doing this, a preliminary pilot survey was done to determine the size of the sample and test the set questionaire. The results of this pilot survey in sixteen bakeries gave the amount of wood consumed/day in kontars as follows:

area 1 : 2,4,2,2,2,1.25,4,4
area 2 : 6,5,6,5,4
area 3 : 4,4,6

The variation on the estimate for each strata was calculated on the basis of stratified random sampling and the sample size to be surveyed was determined as in appendix 3. The sample size distribution of bakeries according to location in town is shown in table(2.3).

Table(2.3)The sample size and distribution of bakeries according to town and location

Area / Town	1	2	3	Total
Khartoum	6	4	2	12
Khartoum-North	7	7	13	27
Omdurman	4	4	3	11
Total	17	15	18	50

The sample size of bakeries in each area was selected randomly and the questionaire designed for bakeries was then applied.

Some bakeries utilise wood in making pastry and the distribution of such bakeries in the three main towns of the Province is shown in table (2.4).

Table (2.4) Distribution of bakeries making pastry in Khartoum Province.

Town	No. of Bakeries
Khartoum	52
Khartoum-North	32
Omdurman	84
Total	132

A sample of 9 pastry making bakeries was selected randomly from the whole Province to be surveyed. Therefore nine questionaires were filled so that an average consumption of wood per bakery making pastry could be obtained.

2.3 Brick Kilns :

The preliminary stage informations about the number of locations of brick kilns (Kaminas) in the Khartoum Province was obtained from the district councils. However, when the field survey started for the selected samples of the brick kilns, it was discovered that only licenced brick kilns were recorded in the district councils. Therefore it was decided to do actual counting in the field to get the exact number of brick kilns in the Province.

To accomplish this job to a reasonable accuracy, Khartoum Province is divided into the four following areas:

1. Eastern Nile Area (Khartoum North)
2. Western Nile Area (Omdurman)
3. Eastern Blue Nile Area (Khartoum North)
4. Western Blue Nile Area (Khartoum).

Each of the above areas was surveyed separately.

1.Eastern Nile Area:

Brick kilns in this area are situated in several locations mainly in the Halfaia, Shambat and Kadaro areas. Halfaia area extends for a distance of 4 Km along the river Nile bank. The total number of Kaminas in this area is about 80. Each Kamina occupies an area of 4 habels. Habel is a special terminology used for measuring distances along the river bank and equals to 3.5 m. The Kaminas in this area have a density of 2-3 firing places. The firing place (Kosha) is a fixed place for building kilns of green bricks ready to be fired. Each firing place has 1-2 preparation tables (Tarabiza) for making the green bricks. The number of bricks per kiln is about 10,000. Kaminas in this area are a bit far from the nile and that is why under ground water was used. In Shambat area the number of Kaminas is about 15 and the total number of firing places is about 25. The Kadaro area has about 60 firing place. To conclude, the Eastern Nile area has got a total of 287 firing place and the number of questionaires filled were 14.

2.Western Nile Area:

There are about 40 firing places in this area and mainly concentrated in Elgamaier and Hitana regions. Production usually stops completely in the rainy seasons while in the other seasons an average of one kiln is fired per firing place per month. A total number of 6 questionaires have been made on random basis.

3. Eastern Blue Nile Area:

As far as the number of firing places is concerned,this is the densest area for Kamina. It includes about 2085 firing places in total; mainly located in a span of 20 Km extending from Hilat Koko to Elgirif Karkog.

Kaminas in this area are quite close to each other and each one takes an area of 6 habels. On average one kiln was fired/firing place/month. Number of bricks per kiln is 120,000. About 75% of the Kamina owners operate them for about 9 month/year.

Other Kaminas in this area are located in Hedaiba, ElSheriek, Soba Sharg, El Ailafon, Elasylat, Elbagir and Omdom. These locations comprise about 84 firing places in total. To conclude, the number of Kaminas and firing places in this section is 1050 and 2085 respectively and the number of questionaires filled were about 20.

4. Western Blue Nile Area:

The main three locations of brick kilns in this area are on Elgiraif Garb, Hegirat and Tuti Island. In Elgiraif Garb, Kaminas are found to be alternating with gardens. The total distance along the Blue Nile bank for all brick kilns in this location is approximately 6 Km including about 140 Kaminas and 150 firing places. i.e. almost about one firing place/Kamina. The capacity of one kiln is 120,000 bricks. The length of one Kamina is about 5 habels (17.5 m). In Hegirat area a total of 135 Kaminas were found (23 in kilo 10, 40 in Soba, 15 in Butri and 57 in Buri). In Tuti Island a total of 12 Kaminas are found most of them are concentrated on the Southern part of the island.

The total number of Kaminas and firing places in this section is about 120 and 400 respectively and also about 20 questionaires were filled.

Table (2.5) Number of Kaminas, firing places and questionaires filled in Khartoum Province

Area	Number of Kaminas	Number of firing places (Kosha)	Number of Questionaires
Eastern Blue Nile	1053	2085	20
Western Blue Nile	120	400	20
Western Nile	18	40	6
Eastern Nile	130	287	14
Total	1318	2812	60

Appendix (4) gives more information about the location of Kaminas in each of the four areas mentioned above.

2.4 Restaurants:

Names and location of registered restaurants which utilise fuelwood (mainly for fish frying) were obtained from the District Councils' official records. Their total number in the whole Province was recorded to be 140. However, there were plenty of restaurants which were operating in an illegal maner. Illegal or unlicenced restaurants are defined in this text as those fish frying places which operte near groceries and shops situated on the main streets and the densely populated areas. The main common kind of stoves in these restaurants is the traditional three stone fire.

The procedure taken for estimating such kind of restaurants was as follows:

i) Selecting, using stratified random sampling, about 30% of the total number of councils;

ii) Undertaking the job of actual counting of all unlicenced restaurants in those selected councils;

iii) Calculating the total number of unlicenced restaurants by estimating first an average number of restaurants per Council in each area of town.

Before applying this procedure the distribution of councils according to town and area in the Province was noted. Table (2.5) shows this distribution.

Table (2.5):

Distribution of councils according to twon and location in the Province.

Town	Area			Total
	1	2	3	
Khartoum-North	5	3	6	14
Omdurman	10	3	3	16
Khartoum	11	4	1	16
Total	26	10	10	46

The sample size of the 30% from all councils (about 14 in number) was made according to the weight of councils in each area of the Province as shown in table (2.6).

Table (2.6) Sample distribution of councils according to town and location in the Province.

Town	Area			Total
	1	2	3	
Khartoum-North	1	1	2	4
Omdurman	3	1	1	5
Khartoum	3	1	1	5
Total	7	3	4	14

Table (2.7) shows the results of calculating the number of unlicenced restaurants in the Province.

Table (2.7) Number of unlicenced restaurants in the Province.

Area	Average No. of restaurants/Council	Number of District Councils	No. of unlicenced restaurants
1	6	14	84
2	8	16	128
3	0	16	0
Total	14	46	212

In the whole Province, about 17% of the total number of restaurants were selected randomly and their owners were asked to help in filling the set questionaires.

Table (2.8) Number of restaurants and questionaires filled in the Province.

Type of restaurant	No. of restaurants	No. of questionaires
Licenced	140	38
Unlicenced	212	22
Total	352	50

2.5 Sweet, Soap and Oil Industries:

The total number of the above industries, whether utilising fuelwood or other fuels, were obtained from the official governmental records for the whole Province. About 86% of the total number of the mentioned industries were surveyed for getting the designed questionaire filled.

Table (2.9) Total number of industries in the Province and number of those utilising fuelwood.

Type of Industry	Total Number	No. of industries using fuel wood	No. of Questionaires
Sweet	55	21	20
Soap	20	5	2
Oil	23	3	3
Total	98	29	25

2.6 Analysis:

The outcome data of the survey questionaires was analysed with the help of an IBM Computer situated in the NEA premises for determining the following for each sector;

1. General descriptions of combustion system.

2. Types and sources of wood used.

3. Wood consumption.

4. Total cost of production.

5. Relative cost of fuelwood to total cost of production.

6. Impact of wood consumption on local stocks of trees.

7. Willingness to change to other energy sources.

Data from (1) is discussed in Chapter 3, while that from (2) through (7) is analysed in Chapter 4.

3. DESCRIPTION OF INDUSTRIES SURVEYED

3.1 Bakeries:

Most traditional bakeries in Khartoum Province are built from red bricks, while about 6% of the total bakeries are built using firebricks. The majority of bakeries surveyed separate the baking chamber from the combustion chamber (see table 3.1).

Table (3.1) Percentage of bakeries using one and separate chambers

AREA	Separate baking & combustion chambers	One chamber
1	100	0
2	93	7
3	89	11
Average	94	6

From table (3.1), it could be noticed that the tendency of building one chamber for both baking and combustion increases as one tends to go towards the outskirts and villages of the Province.

All red brick built bakeries have a semi circular baking chamber while the few fire brick built bakeries have a rectangular shape. Fig (3.1) shows a general layout of a typical traditional bakery.

In all bakeries surveyed, salt is added to the mixture used for building the baking chambers.

3.2 Brick kilns:

The green bricks to be fired in the kiln are made from a mixture of mud (usually brought from the river banks), animal dung and groundnut shells. The capacity of one kiln usually ranges from 80,000 to 120,000 green bricks which are stacked side by side before firing begins.

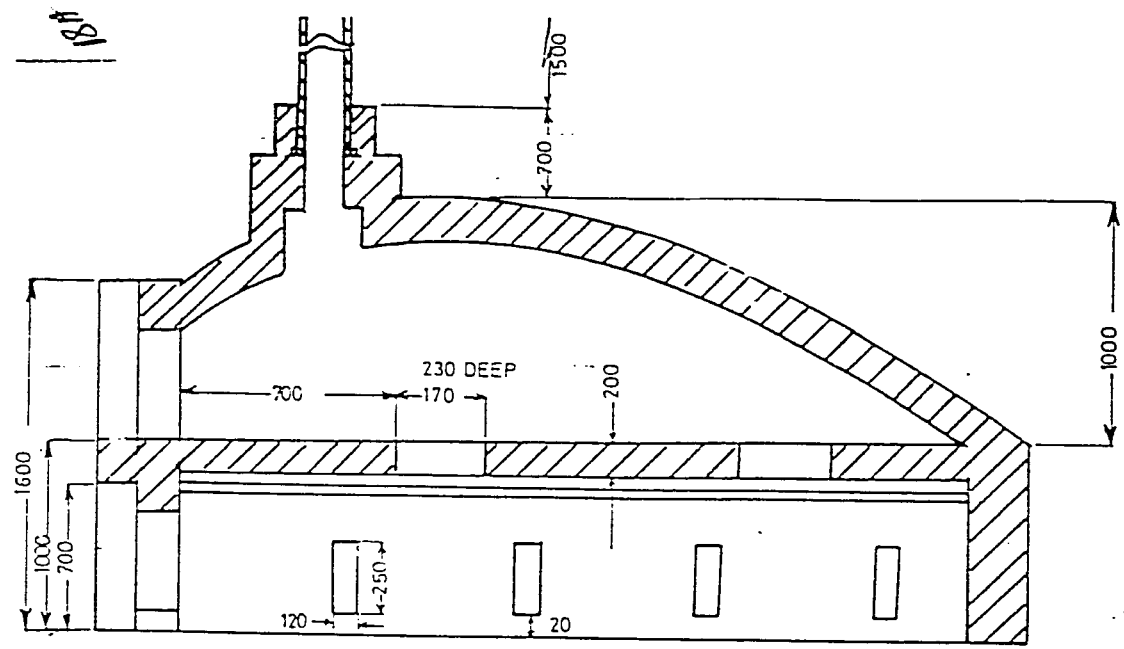
On the base and along the length of the kiln, there are about 9 tunnels to facilitate the accomodation of fuelwood. The kiln is built from outside using red bricks. Then the whole kiln is covered with mud. This is claimed to reduce the heat losses from the kiln. Figure (3.2) shows a schematic diagram of a traditional brick kiln.

3.3 Sweet,Soap and Oil Industries:

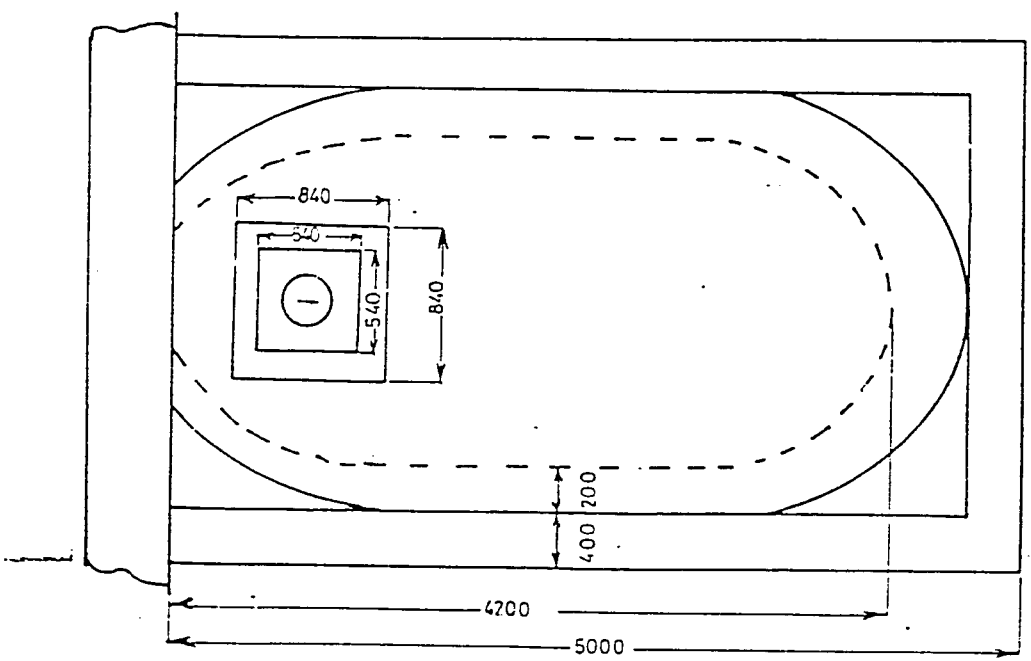
Fuelwood in these industries is either used for direct heating of the different solutions involved or for producing process steam. Direct heating is used in sweet and soap industries while process steam is made use of in the oil and sweet industries. The most common types of stoves used to obtain direct heating are the brick and metal stoves. Figure (3.3) shows one kind of a brick stove used in industry. Process steam is generated from second hand boilers which were originally utilised for operating the Sudan Railway steam trains.

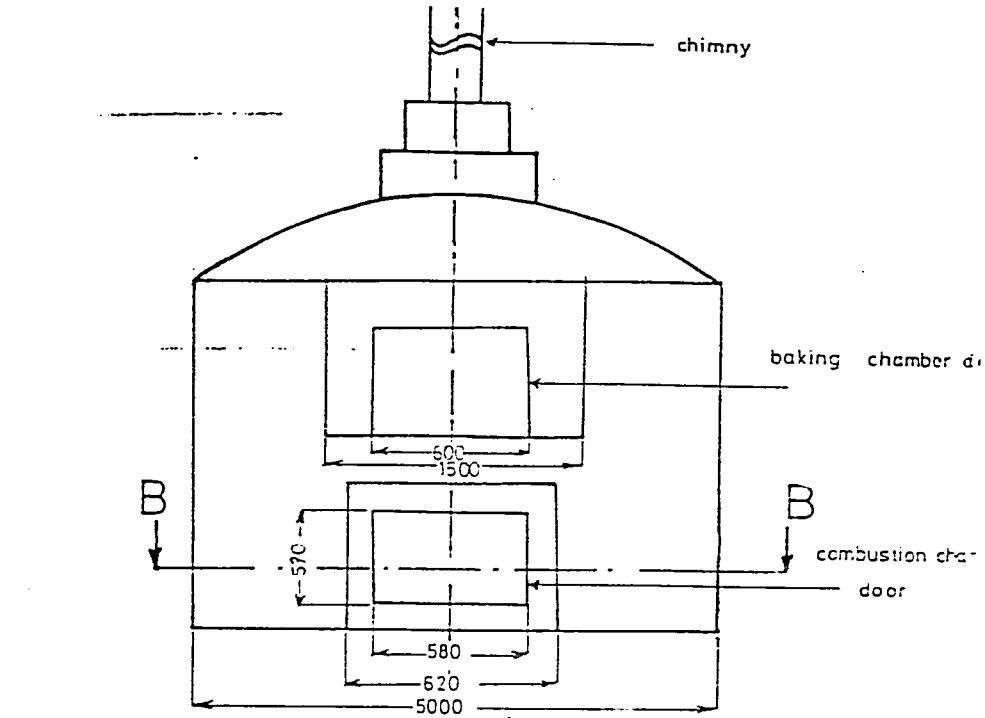
3.4 Restaurants:

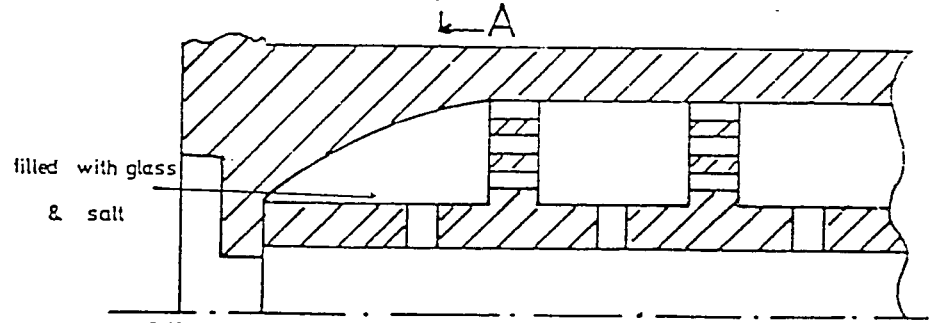
Restaurants usually utilise different types of fuels. Amongst those fuels is the fuelwood which is mainly used for frying fish. The most common types of stoves used in fish frying are the traditional three stone fire stove (Ladayat), brick stoves and the traditional metal stove (kanoon). Figure (3.4) shows one kind of a modified three stone fire stove used for frying fish.



A-A SECTION







B-B SECTION

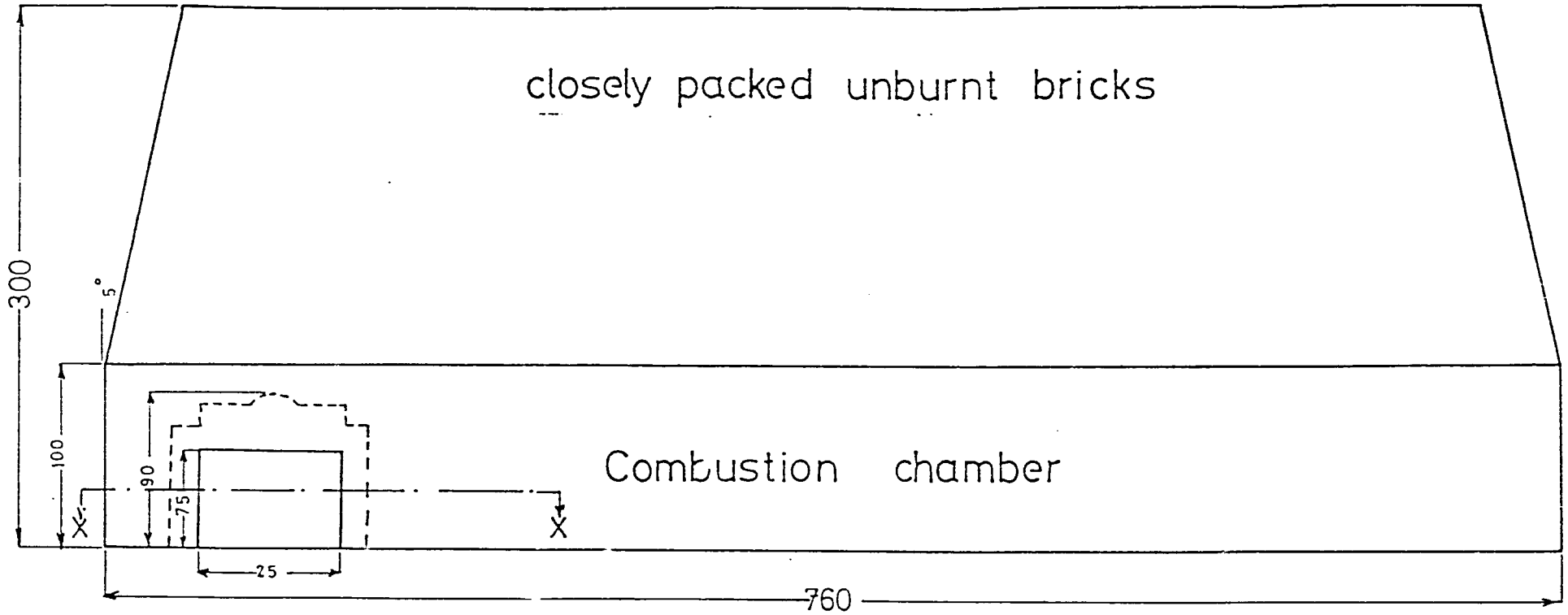
Fig. (3-1)

General layout of a typical traditional bakery

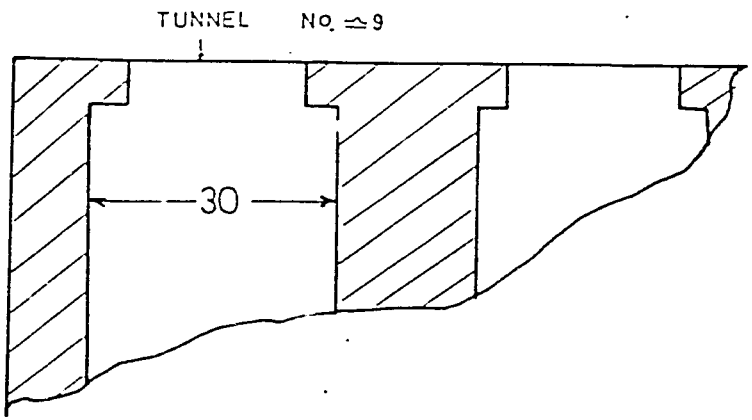
NATIONAL ENERGY ADMINISTRAT

TRADITIONAL BAKERY

NOT TO SCALE ALL DIM IN



DEPTH 760



X-X section

Fig. (3-2)

Schematic diagram of a traditional brick-kiln

NATIONAL ENERGY ADMINISTRATION

BRICK-KILN FOR 100000 BRICKS

NOT TO SCALE ALL DIM. IN Cm

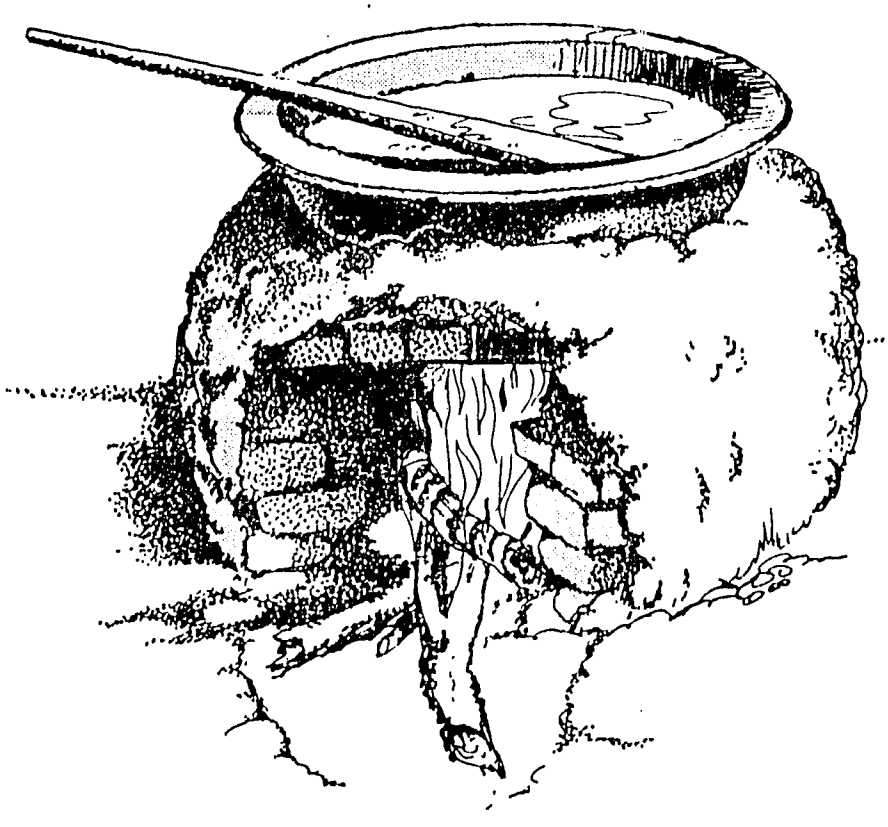


Figure (3.3) Schematic Diagram of
a Brick Stove Used in Industry

Figure (3.4) A Modified Three Stone Fire Stove Used for Frying Fish

Table (4.2) Percentage of Brick Kiln Owners who used to get their wood from nearby forests few years ago

Area	% age
Eastern Blue Nile	65
Western Blue Nile	45
Western Nile	67
Eastern Nile	62

So the deforstation along the river banks near Khartoum is quite clear from table (4.2). At the present, these banks were eihter changed to cultivating areas for producing cash crops (such as tomatoes, water melons etc) or used as building sites for new brick kilns.

4.1.4 Restaurants

Restaurant owners who bother to use Sunt in frying fish are 26% in average while the rest use different types of wood. From the restaurants surveyed, 87% get their stock of wood from the wholesalers but the rest obtain it from retailers mainly in donkey loads.

4.1.5 Sweet, Soap and Oil Industries

The type of wood used in Soap and Oil industries is sunt but in the sweet industry about 40% are not really sticking to this type and can burn any type available to them. For these industries, sunt is obtained from the wholesalers.

4.2 Fuel Wood Consumption

4.2.1 Summary of Results

Table (4.3) Summary of the Annual Fuel Wood Consupmtion in Khartoum Province Industries (1984)

Type of Industry	Annual Consumption		% of Total
	Kontars	Tons	
Bakeries	1,480,660	66,700	36.7
Brick Kilns	2,241,700	100,980	55.6
Restaurants	167,100	7,530	4.2
Sweet,Soap and Oil	141,900	6,400	3.5
Total	4,031,360	181,610	100

In 1980, the fuel wood consumption in Khartoum Province industries was estimated to be 68,200 Tons (1). This estimate excludes restaurants. (They were estimated under the commericial and Goverment services section in that assessment report and only restaurants utilising charcoal were surveyed. If fuel wood consumed by resturants is subtracted from the total in table (4.3), it could be noticed that the 1984 estimate is still about 2.6 times that of 1980. This is mainly because of the more specific and extensive nature of this study. Therefore those higher figures should replace the 1980 ones for planning purposes.

4.2.2 Bakeries

From the questionaires used for collecting data about bakeries, the results of the total annual fuel wood consumption in each area of Khartoum Province is shown in table (4.4).

Table (4.4) Annual Fuel Wood Consumption for Bakeries in each area.

Area	Average Consumption per day (Kontars)	Average Working days per year	Number of bakeries	Annual Consumption	
				Kontars	Tons
1	7.26	362	217	570,300	25,690
2	5.1	362	190	350,800	15,800
3	4.33	357	238	367,900	16,570
TOTAL			645	1,289,000	58,060

For table (4.4), the stratified mean for wood consumption per day and the standard deviation for this stratified mean were calculated to be 5.54 Kontars and 0.33 respectively. For 0.05 confidence limits, the error on the total annual fuel wood consumption is less than ± 12% within this confidence limits.

In order to assess the efficiency and the proper usage of wood, the average kg of wood/kg of flour and the average flour consumption per day and per bakery of each area in the Province were determined as shown in table (4.5).

Table (4.5) Averages for kg of wood/kg of flour and flour consumption per day per bakery for different areas

Area	Average kg of wood per kg of flour	Average kg of flour
1	0.5	630
2	0.6	400
3	0.8	250

It could be seen from table (4.5) that for each bakery, the average consumption of flour per day increases as one tends to go from the village to city centre bakeries while the wood consumption per kg of flour increases in the vice versa. This could be attributed to two reasons: one operational and the other technical and listed respectively as follows:

a) In villages, the baking process was not continuous and bakeries were operated for baking small quantities of bread, as compared to city centre bakeries. So, a substantial amount of heat was wasted per unit input in the former bakeries.

b) Unlike bakeries in areas 1 and 2, those in villages have one chamber which was used for both

baking and combustion. This would eventually reduces the baking area and therefore contribute to increasing the baking time and fuel wood consumption. Therefore bakeries in villages are not efficient both in operation and system design.

For pastry making bakeries, the average annual consumption of fuel wood is estimated as in table (4.6).

Table (4.6) Annual fuel wood consumption for Pastry making bakeries

Average fuel wood consumption per day (Kontars)	Average Working days per year	Number of bakeries	Annual Consumption	
			Kontars	Tons
4.4	330	132	191660	8630

So the total estimate for the two types of bakeries is shown in table (4.7)

Table (4.7) Total annual fuel wood consumption for all bakeries in Khartoum province

Type of Bakery	Annual Consumption	
	Kontars	Tons
Bread Making	1,289,000	58,060
Pastry Making	191,660	8,630
TOTAL	1480660	66690

It was estimated in 1979 that all bakeries in Khartoum Province consumed about 27,500 tons of fuelwood (5).. This is only about 40% of the present estimate.

4.2.3 Brick Kilns:

The total annual fuelwood consumption of brick kilns in the four areas surveyed is shown in table (4.8).

Table (4.8) Annual fuel wood consumption for Brick kilns in each area

Area	Consumption per kiln (Kontars)	Annual Number of kilns/ firing place	Total Number of firing places	Annual consumption	
				Kontars	Tons
Eastern Blue Nile	100.75	8	2085	1,680,500	75,700
Western Blue Nile	98.00	8	400	313,600	14,120
Western Nile	95.00	8	40	30,400	1,370
Eastern Nile	94.62	8	287	217,250	9,790
TOTAL			2812	2,241,750	100,980

In 1979, it was estimated that Khartoum Province brick kilns consumed 25,500 tons of fuelwood (5). This is just about one quarter of the present estimate. From table (4.8), it could be deduced that for the year 1984, the Eastern Blue Nile area consumed about 75% of the total annual consumption for all brick kilns in the Province. This is because the type of soil in this area is mainly silt which was brought out from the annual flood. This silt was the main ingradient for making green bricks and therefore helped substantially in the flourishing of such kind of industry in such area. It is interesting to know that the 1980 survey (1) estimated that the annual consumption of brick kilns in Sudan to be 90,000 tons which is 11% less than the estimated total for Khartoum Province brick kilns alone.

The average fuel wood consumption per 1000 bricks in each of the four areas listed in table (4.8) is respectively 0.96, 0.97, 0.93 and 0.99 kontars. This means that there is no appreciable difference in the fuelwood consumption per unit output i.e. per 1000 bricks. Therefore, it could be argued that the efficiency of kiln operation is about the same in the whole Province.

2.2.4 Restaurants

The total annual fuelwood consumption for licensed and unlicensed restaurants in the whole Province is shown in table (4.9).

Table (4.9) Annual fuelwood consumption for restaurants

restaurant	Average consumption per day per restaurant (Kontars)	Working days per year	Number of restaurants	Annual Consumption	
				Kontars	Tons
Licensed	1.59	340	140	75,700	3,140
Unlicensed	1.25	345	212	91,400	4,120
TOTAL			352	167,100	7530

For table (4.9), the stratified mean for fuel wood consumption per day per restaurant and the standard deviation for this stratified mean were calculated to be 1.39 and 0.14 respectively. For 0.05 confidence limits, the error on the total annual fuel wood consumption for all restaurants in Khartoum Province is about $\pm$ 10% within the confidence limits.

The average consumption of kg of wood/kg of fish for licensed and unlicensed restaurants is calculated to be 1.42 and 1.35 respectively. This small difference is expected since all restaurants use nearly the same kind of stoves for frying fish.

4.2.5 Sweet, Soap and Oil Industries

For each of the above industries, the total annual fuel wood consumption is presented in table (4.10).

Table (4.10) Annual Fuel wood consumption for Industries

Type of Industry	Average consumption per day (Kontars)	Working days per year	Number of Factories	Annual Consumption	
				Kontars	Tons
Sweet	9.23	310	21	60,100	2,710
Soap	25.0	280	5	35,000	1,580
Oil	65.0	240	3	46,800	2,110
TOTAL				141,900	6,400

As mentioned earlier in the methodology, about 86% of the total sweet, soap and oil industries were surveyed. Accordingly, the total presented in table (4.10) is assumed to give close to the actual figure of the annual fuel wood consumed.

It is not meaningful to compare the average wood consumed per unit output in these industries as the production conditions are different in each case.

4.3. Total cost of production and relative cost of fuel wood to total cost of production

4.3.1 Summary of Results

It is interesting to get an idea about the total annual amount of money spent by each industry in getting their stock of fuel wood and this is shown in table (4.11). Also added in this table is a summary of the relative cost of fuel wood to total cost of production in the different industries surveyed.

Table (4.11) Annual Cost and Relative Cost of fuel wood to total cost of production in Khartoum Province industries

Type of industry	Annual wood consumption (Kontars)	Average price per Kontar (£S)	Annual fuel wood cost (£S)	Relative cost %
Bakeries	1,480,660	6	8,883,960	9
Brick kilns	2,241,700	5	11,208,500	17
Restaurants	167,100	6	1,002,600	6
Sweet	60,000	5.5	330,550	11
Soap	35,000	5.5	192,500	3
Oil	46,000	5.5	257,400	3.5
TOTAL	4,031,360		21,875,510	

The average price of fuel wood per kontar differs from one industry to the other and is cheapest in the brick kilns industry. The main reason for this is that the brick kilns owners buy their fuel wood from wholesalers in large quantities as compared to other industries. Therefore, they get it cheap. On the other hand, usually bakery and restaurant owners obtain their stock of fuel wood from retailers and in small quantities and therefore they have to pay the extra money involved in this respect due to transportation, mid-sailers etc.

It is clear from table (4.11) that about 22 million Sudanese pounds has been spent in using fuel wood energy in Khartoum industries for the year 1984. This large amount of money could be substantially reduced if other cheap sources of energy is used and/or

efficient measures for utilising fuel wood are applied, especially in the brick kilns industry because:

a) More than half of this total cost is spent on supplying brick kilns with their energy needs from fuel wood.

b) at the present, brick making is the only industry which depends totally on fuel wood as its source of energy.

c) the relative cost of fuel wood to total cost of production is highest in brick kilns as compared to other industries.

4.3.2 Bakeries

Table (4.12) Cost of production and relative cost of fuel wood according to town and location of bakeries (per kg of flour per day per bakery)

Area	Production cost (£S)	Fuel wood cost (£S)	Relative cost %
1	0.94	0.065	7
2	0.95	0.073	8
3	1.00	0.11	11
Average weighted by number of bakeries	0.96	0.082	9

From table (4.12), it could be noticed that the relative cost of fuel wood to cost of production is higher in village bakeries than in city centre bakeries.

This is mainly because, as mentioned earlier, the village bakeries are not quite as efficient both in operation and system design.

4.3.3 Brick Kilns

Table (4.13) Cost of production and relative Cost of fuel wood in brick kilns (per 1000 bricks per kiln per firing place)

Area	Production Cost (£S)	Fuel wood Cost (£S)	Relative Cost %
Eastern Blue Nile	30	5.11	17
Western Blue Nile	27	5.15	19
Western Nile	25	4.67	18
Eastern Nile	29	5.23	18
Average weighted for number of firing places	29	5.12	17

The average relative cost of fuel wood to cost of production is about the same for all brick kilns in different areas. It constitutes a substantial fraction relative to the cost of production.

4.3.4 Restaurants

Table (4.14) Cost of Production and Relative Cost of Fuel Wood in Restaurants (per kg of fish per day per restaurant)

Type of Restaurant	Production Cost (£S)	Fuel wood Cost (£S)	Relative Cost %
Licensed	3.16	0.19	6
Unlicensed	3.16	0.19	6

The average relative cost of fuel wood to cost of production for both licensed and unlicensed restaurants is exactly the same since they are basically using common types of stoves.

4.3.5 Soap, Sweet and Oil Industries

Table (4.15) Cost of production and relative cost of fuel wood in different industries (per unit input per day industry factory)

Type of industry	Production Cost (£S)	Fuel wood Cost (£S)	Relative Cost %
Sweet	1.82 per kg of sugar	0.2 per kg of sugar	11
Soap	3.33 per kg of fats	0.1 per kg of fats	3
Oil	0.75 per kg of cotton seeds	0.37 per kg of cotton seeds	3.5

The relative cost of fuel wood to the cost of production is highest in sweet industry when compared to

other two types of industries. This is mainly because the sweet industries consume a significant amount of fuel wood and depend mainly on it as compared to other industries.

4.4 Equivalent Area of Forests to Meet Annual Fuel Wood Demand by Industries

Having obtained the annual consumption of fuel wood in the different industries, it is quite enlightening to estimate the needed area of forests to be reserved for sustained yield of production. To do this, the following assumptions are made:

1. 1 cubic metres of stacked sunt = 440 kg.
2. Average volume of sunt/feddan = 37 m^3 (2).
3. 20 years rotation. (2)
4. All industries are using sunt (in fact about 86% are using it at present)

Table (4.16) Equivalent area of forests to meet annual fuel wood demand by Khartoum Province Industries (1984)

Type of industry	Annual fuel wood consumption		Area to be managed (feddans)	
	Ton	m^3	Annual	20 years rotation
Bakeries	66,700	151,590	4,100	82,000
Brick Kilns	100,980	229,500	6,200	124,000
Restaurants	7,530	17,100	460	9,200
Sweet, Soap and Oil	6,400	14,550	390	7,800
TOTAL	181,610	412,740	11,150	223,000

At present, most of the Khartoum industries demand from sunt, come from the Central and Eastern Regions. It is estimated that the actual plantation areas of sunt in these two regions is about 79,190 feddans (3), which allow an annual removal area of 4000 feddans. Sunt plantation area in the Khartoum province is estimated in 1980-81 to carry a volume of wood of 31450 Tons which allow for annual removal area of 3750 Tons which is quivalent to an area of 230 feddans (5). Therefore the total stock of sunt fuel available annually is coming from an area of 4230 feddans of managed forests. This area is not only insufficient to meet the annual demand of Khartoum Province industries, (about 11000 feddans), but a significant part of its wood production goes to timber production and other uses. In addition the annual replacement of planted area is estimated to range from 2 to 3 thousands feddans which is less than the estimated removed area (4).

It could be noticed from table (4.16) that the annual required manged forest area to cover the balance for Khartoum industries sunt consumption is about 8000 feddans (it is assumed that 1000 feddans manged forest supply timber production and other uses). This is equivalent to a volume of 296,000 m^3. In practice, this stock of wood is obtained from natural unreserved forests and land being cleared for mechanised farming which contain different species of wood. Also, at present these unreserved and cleared forests supply fuel wood to charcoal kilns and household sectors. Eventually, these areas are expected to be completely exhausted in the near future. So, in order to secure a continuours future supply for all fuelwood consuming sectors, more forests should be reserved and put, if possible, under management plans.

Unreserved forests in the central & Eastern Regions at the moment have low yields of about 10 m^3/feddan. This is mainly because these forests are situated away from the Nile and are not expected to produce high yields or grow as fast as those near the Nile Banks. This yield, however, could be improved if significant changes in species, irrigation management and other inputs were made. Unfortunately, this is

not within the means of the Forestry Department at present. According to the assumption of the present yield of unreserved forests the 296000 m^3 of fuel wood stock needed by Khartoum industries will require about 29,600 and 592,000 feddans based on annual and 20 years rotation respectively. Of course the wood produced from these areas is not necessarily sunt and the industries probably would have no choice except to use any type of wood available to them.

So the total area which should be reserved to supply Khartoum industries only is 671,190 feddans. This constitutes about 53% of the total reserved area in the Eastern and the Central Regions which is estimated by Beyomi (3) to be 1,253,490 feddans.

4.5 Tendency for change to other sources of energy

4.5.1 Summary of results:

Table (4.17) Acceptance for change to groundnut shells as alternative energy source in industries.

Type of industry	Acceptance %
Bakeries	88
Brick Kilns	82
Restaurants	26
Sweet,Soap and Oil	100

According to NEA recent surveys, there is no surpulus of groundnut shells in Khartoum province due to the competition of their usage in fodder and for direct heating in some of oil industries especially in Gezira Province. This lead to the increase in their price and at the moment it is about 3.5 £S per sack i.e about 8 £S per kontar which is 20% higher than that of sunt fuelwood.

However, industry owners were asked in the questionaire about the possibilites of using groundnut shells mainly to see their views about their willingness to changing for other sources of energy and groundnut shells is mentioned just as an example. In fact, some laboratory work has been done by the Building and Road Research Institute (BRRI) in collaboration with NEA in using compressed groundnut shells in firing of clay bricks (7). Results were found satisfactory and it was recommend that their work should be extended to fire bricks in large traditional kilns.

4.5.2 Bakeries:

From the survey undertaken, the traditional bakeries owners were asked whether they would accept an alternative energy source for wood such as groundnut shells. About 88% of them are quite willing to accept this new source of fuel if it could be proved to work satisfactorily in their bakeries.

Table (4.18) shows the response of the bakery owners to whether they have the intention to changing to electric bakeries in the future.

Table (4.18) Intention for change to electric bakeries (in % age)

Area	Yes (%)	No (%)
1	76	24
2	60	40
3	33	67

It could be noticed from table (4.18) that the percentage of tendency for change to electric bakeries decreases as one goes towards the outskirts (area 2) and villages (area 3) of the Province. Before discussing table (4.18) two points worth to be mentioned.

Firstly, the concentration of electric bakeries [illegible] more in areas 1&2 than the traditional bakeries.

more than that of the traditional wood fuel bakeries since the former services are quick and the quality of their unit production is better as compared with the latter bakeries. So, in the light of the above two points, the traditional bakeries in areas 1 and 2 cannot compete with their neighbouring electric bakeries and this could be the reason why they express their willingness for change to electric bakeries. People living in area 3 could get their bread from areas 1 and 2 but it is easier for them to obtain their stock of bread from the local traditional bakeries. So, the bakeries owners in this particular area are not likely to change to electric bakeries in the near future and might as well be persuaded to change to compressed groundnut shells more easily.

4.5.3 Brick Kilns

When the brick kiln owners were asked whether they could use compressed groundnut shells as an alternative energy source, the response to this question is shown in table (4.19). As brick kilns utilise more than half of the total wood consumption per annum in the Khartoum Province, then a substantial amount of wood could be saved if the owners of these kilns are convinced to use alternative energy sources other than wood.

Table (4.19) Acceptance to use Groundnut shells in Brick kiln Industry

Area	YES (%)	NO (%)
Eastern Blue Nile	80	20
Western Blue Nile	80	20
Western Niie	83	17
Eastern Nile	85	15
Average	82	18

4.5.4 Sweet, Soap and Oil Industries

When the owners of the above industries asked if they could accept the introduction of groundnut shells as an alternative new energy source to wood, almost all of them indicated that they wouldn't mind trying them.

4.5.5 Restaurants

The owners of the surveyed restaurants utilizing wood for fish frying were asked about the possibilities for changing to Butagas (Liquid Petrolieum Gas). About 74% of them are not likely to change as they think that frying fish using wood improves the taste of the fish. However, almost all of them are ready to try the groundnut shells as an alternative energy source to wood.

5- CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

5.1 Conclusions:

1. The total demand of fuelwood by Khartoum industries for the year 1984 was estimated as 181,610 Tons. This is about 2.6 times of the estimate for 1980 in NEA's previous study.

2. In Khartoum Province, there exists three types of bakeries utilising fuelwood as their energy source:

   a. red brick built bakery having one semi-circular chamber for both combustion and baking and this is found to be the least efficient type when compared to the other two types. However, this kind of bakery constitutes 6% only from the total number of bakeries in the Province.
   b. red brick built bakery having two separate chambers a semi-circular combustion chamber and a rectangular baking chamber. The percentage of this type of bakery from the whole Province bakeries is 90%. The efficiency of this type is higher than the former.
   c. fire brick built bakery having two separate rectangular chambers and this has the highest efficiency as compared to the former two types.

3. The total amount of fuelwood consumed by all bakeries in Khartoum Province industries for the year 1984 was estimated as 66,700 Tons. This was estimated as 27,500 Tons in 1979. The recent estimate constitutes about 36.7% from the total consumption of Khartoum industries. The average weighted relative cost of fuelwood to total cost of production in all bakeries is 9%. In general, this small relative cost seems not to be encouraging for bakery owners to take any suggested energy conservation measures and new improvements in the existing designs seriously. However,village bakers may be more likely to accept new changes as their relative cost of fuelwood is higher than that of city bakeries (11% versus 9%).

4. There is a strong tendency for bakers to change from traditional to electric bakeries, especially in city and semi-urban areas. This could lead to reduction in annual fuelwood consumption in this sector, but it is likely to be insignificant to the total consumption of Khartoum industries from fuelwood.

5. The total consumption of fuelwood in all brick kilns for the year 1984 was 100,980 Tons. This resembles 55.6% from the total consumption of Khartoum industries. The average relative cost of fuelwood to total cost of production in brick kilns is 17%. This high consumption and high relative cost are good factors to encourage both energy researchers and brick kilns owners to look for more efficient system design, apply energy conservation measures and try using other cheap and available energy sources in brick kilns.

6. The fuelwood consumption in Sweet, Soap and Oil industries for the year 1984 was estimated to be 6,400 Tons. This constitutes 3.5% from the total consumption of Khartoum industries fuelwood. The relative cost of fuelwood in Sweet industry to total cost of production is 11%, which is considerably high as compared to Soap and Oil industries (in average 3.2%). So, the Sweet industry owners are likely to accept measures for conserving fuelwood energy.

   At the present, the country is experiencing some difficulties in supplying these industries with their needs from conventional fuels such as furnace oil, gas oil and petrol. If this situation remains as it is, it is likely that some of the industries will shift to using fuelwood. This incidently would lead to more consumption of fuelwood in the future.

7. The fuelwood consumption in restaurants for the year 84 was 7,530 Tons. This is about 4.2% from the total consumption. Fuelwood energy could be conserved in this sector if more efficient, stoves are to substitute the presently used inefficient traditional three stone fire stoves.

8. The equivalent area of managed forests needed to meet annual Khartoum industries demand from Sunt fuelwood is approximately 230,000 feddans on a sustained yield basis (assuming 20 year rotation). At present about 38% of

this demand is supplied from reserved managed forests in the Eastern and Central Regions as the Khartoum Province sources are very low. The rest of the demand is supplied from natural unreserved forests located outside the Province. As the most of the industries' fuelwood supply comes from these low yield natural forests, it is expected that fuelwood supply will be irregular and its price will rise due to the transportation constraints from the far distances of wood production. This eventually will contribute in the disturbance of the economic situation of the industries which solely depend on fuelwood as their energy source.

5.2 Recommendations for Future Work

1. A technical survey is needed. The first priority of this survey should be given to brick kiln industry, as it has both the highest share of fuelwood consumption and relative cost of fuelwood to total cost of production as compared to other industries. The second priority goes to bakeries. It is suggested that the evaluation of the survey should cover the following points.
   a. Investigation of the different combustion methods.
   b. Measurement of the thermal efficiency of the existing systems and trial of possible ways whereby the efficiency could be improved without any major system modifications.
   c. Comparison, based on technical and economical aspects, of using fuelwood versus other alternative energy sources such as briquetted groundnut shells cotton stalks and other agricultural residues.
   d. introudction of improved and new efficient system designs.

2. Economic viability study of fuelwood versus oil and electricity fired bakeries should be made. Similar studies are needed in Sweet, Soap and Oil industries.

3. More work is needed to improve the efficiency of the different kinds of fuelwood stoves used in Restaurants, Soap, Sweet and Oil industries.
4. Previous surveys considered that household sector as a major consumerr of fuelwood in Khartoum Province. Accordingly, appropriate survey methodologies could be developed to check and update the consumption of fuelwood in this sector.
5. In brick making industry, up-to-date reliable records are needed. This need is particularly urgent because this sector consumes more than half of the total consumption of fuelwood in all industries.
6. In the field of resource management, it is recommended to increase the area of fuelwood plantations in the Central Region in order to meet some of the demand in the future.
7. This kind of effort should be extended to other regions of Sudan.

Appendix 1

Preliminary Data Questionaire

Town: _____

Type of Industry: _____

Name of owner or enterprise	Type of fuel used	Location	Purpose for which fuel is used

Appendix 2
Main data Questionaire

A. Traditional bakeries questionaire:

Name of interviewer: _____

1. Date: 1. _____
   2. _____

2. Town : 1. Khartoum _____
   2. Khartoum North _____
   3. Omdurman _____

3. Area Location:
   1. Mid-Town _____
   2. Outskirts _____
   3. Villages _____

4. Sample Number: _____

5. Purpose of wood usage:
   1. Making bread _____
   2. Pastry and Sweets _____
   3. Other _____

6. Type of bakery:
   1. Separate bakig and combustion chambers _____
   2. One chamber for baking and combustion _____

7. Shape of baking chamber:
   1. Semi-Circular _____
   2. Rectangular _____
   3. Other _____

8. Approximate baking chamber area (M^2) _____

9. Bakery construction materials:
   1. Thermal or Fire bricks _____
   2. Red bricks _____
   3. Mud bricks _____

10. Insulating material:
    1. Glass.
    2. Salt.
    3. Other.

11. Approximate volume of combustion chamber (M^3): _____

12. Number of shift _____
    1. One shift _____
    2. Two shifts _____
    3. Three shifts _____

13. Shift hours: _____

14. Flour consumption per day : _____ (Kg)

15. Price of flour per Kg : _____ (£)

16. Number of workers: _____

17. Total wages of workers per day: _____ (£)

18. Flour transport cost per day: _____ (£)

19. Other production materials cost per day: _____ (£)

20. Annual maintenance cost: _____ (£)

21. Other daily expenses: _____ (£)

22. Monthly electricity and water costs: _____ (£)

23. Daily wood consumption: _____ (Kontar)

24. Wood price per Kontar: _____ (£)

25. Type of wood used:
    1. Sunt _____
    2. Other typres _____

26. Availability of wood during the whole year:

    1. Yes _____
    2. No _____

27. Source of wood supply:

    1. Zariba _____
    2. Camel load _____
    3. Donkey load _____
    4. Other _____

28. If obtained from Zariba, which one?

    1. Main Zariba _____
    2. Nearby Zariba _____

29. If obtained by camel or donkey loads is it from:

    1. Nearby forests _____
    2. Forests outside Khartoum _____

30. Was the source of wood supply in the past from nearby forests?

    1. Yes _____
    2. No _____

31. Number of days the bread production stopped last year for reasons other than wood supply shortage: _____

32. Reasons for stoppages:

    1. Shortage of flour _____
    2. Maintenance _____
    3. Non-availability of transport _____
    4. Other reasons _____

33. Intention for changing to automatic bakery

    1. Yes _____
    2. No _____

34. If yes, what are the reasons

    1. To increase flour cota. _____
    2. High wood cost _____
    3. Shortages of wood supply _____
    4. Can not compete with the automatic bakery _____
    5. Other reasons _____

35. Do you accept change to other sources of fuel e.g ground nut shells briquettes:

    1. Yes _____
    2. No _____

36. Do you accept applying suggested changes for improving combustion efficiency?

    1. Yes _____
    2. No _____

37. Building capital cost: _____ (£)

38. Date of installation: _____ (£)

39. Current price of building: _____ (£)

40. Any comments: _____

_____

_____

_____

B. Brick Kilns Questionaire:

1. Name of interviewer: _____

2. Date: 1. _____
   2. _____

3. Location:
   1. Eastern Blue Nile area: _____
   2. Western Blue Nile area: _____
   3. Western Nile area: _____
   4. Eastern Nile area: _____

4. Sample Number: _____

5. Purpose of wood usage:
   1. Brick kilns: _____
   2. Pottery making: _____

6. Number of firing place per Kamina: _____

7. Number of kilns per firing place per year: _____

8. Number of working months per year: _____

9. Number of combustion tunnels per kiln: _____

10. Nature of firing place:
    1. fixed: _____
    2. Movable: _____

11. Number of bricks per kiln: _____

12. Amount of red bricks according to quality per kiln:
    1. Grade 1 _____
    2. Grade 2 _____
    3. Broken _____

13. Time taken in setting one kiln ready for firing: _____ _____ (days)

14. Complete firing time per kiln: _____ (days)

15. Mixing materials used with mud:
    1. Animal dung: _____
    2. Groundnut shells: _____
    3. Others

16. Quantity of dung used per kiln (Lorries): _____

17. Number of worker per kiln: _____

18. Total wages of workers per kiln: _____ (LS)

19. Other expenses per kiln: _____ (LS)

20. Quantity of wood used per kiln: _____ (LS)

21. Price of wood per Kontar: _____ (LS)

22. Type of wood used:
    1. Sunt: _____
    2. Other: _____

23. Source of wood supply:
    1. Zariba: _____
    2. Camel load: _____
    3. Donkey load: _____
    4. Other: _____

24. If obtained from Zariba, which one?
    1. Main Zariba: _____
    2. Nearby Zariba: _____

25. If obtained by camel or donkey load, is it from:
    1. Nearby forests: _____
    2. Forests outside Khartoum: _____

26. Was the source of wood supply in the past from nearby forests?
    1. Yes: _____
    2. No: _____

7. Number of days brick making stopped last year for wood supply shortage: _____

28. Number of days brickmaking stopped last year for other reasons: _____

29. Do you accept changing to other fuels?
    1. Yes: _____
    2. No: _____

30. Number of preparation tables per kiln: _____

31. Average daily production of green bricks per table?

32. Any Comments: _____
_____
_____
_____
_____

C- Restaurant Questionaire:

1. Name of interviewer: _____
2. Date: 1. _____
   2. _____
3. Town:
   1. Khartoum _____
   2. Khartoum North _____
   3. Omdurman _____
4. Selected Council:
   1. Mid-Town _____
   2. Outskirts _____
   3. Villages _____
5. Sample number: _____
6. Purpose of fuelwood usage:
   1. cooking fish _____
   2. other _____
7. Type of stove used:
   1. 3 stone fire _____
   2. Brick stove _____
   3. Metal stove _____
8. Number of stoves per restaurant: _____
9. Type of restaurant:
   1. Licenced _____
   2. Unlicenced _____
10. Quantity of raw material used/day: _____ (kg)
11. Source of wood supply:

1. Zariba:_____
2. Camel or donkey load:_____
3. Other:_____

12. Cost of raw material used/kg:_____ (LS)

13. Wood consumption/day:_____ (LS)

14. Wood price/Kontar: _____ (LS)

15. Type of wood used:
    1. Sunt:_____
    2. Other:_____

16. Was the wood supply in the past from near forests:
    1. Yes:_____
    2. No:_____

17. Number of days you stopped last year due to shortage of wood supplies:_____

18. Number of days you stopped last year from reaons other than above:_____

19. Acceptance of using other energy sources:
    1. Yes:_____
    2. No: _____

20. Do you accept using Butagas?
    1. Yes:_____
    2. No: _____

21. Approximate cost of stove:_____ (LS)

22. Date of stove manufacture:_____

23. Present estimated stove cost: _____ (LS)

24. Any Comments and observations:

_____

_____

_____

D. Sweet, Soap and Oil Industries Questionaire:

1. Name of interviewer: _____
2. Date:
   1. _____
   2. _____
3. Name of factory: _____
4. Town:
   1. Khartoum: _____
   2. Khartoum North: _____
   3. Omdurman: _____
5. Type of industry:
   1. Sweet: _____
   2. Soap: _____
   3. Oil: _____
   4. Other: _____
6. Sample number: _____
7. Total number of workers in factory: _____
8. Total daily payments of workers: _____ (LS)
9. Daily production: _____
10. Number of shifts per day: _____
11. Purpose of using fuelwood:
    1. Direct heating: _____
    2. Steam generation: _____
12. Type of stove used for direct heating:
    1. 3 stove fire: _____
    2. Metal stove: _____
    3. Brick stove: _____
13. Number of stoves in the factory: _____
14. Pot size: _____ (m^3)

15. Mass of solution:_____ (kg)

16. Maximum solution temperature:_____ (^{o}C)

17. Treatment time: _____ (hrs)

18. Fuelwood needed per shift per stove:_____(Kontar)

19. Type of boiler used:
    1. Kocran:_____
    2. Standard Castle: _____
    3. Old Steam Train:_____
    4. Other types:_____

20. Number of boilers in use:_____

21. Estimated boiler efficiency:_____

22. Purpose of steam usage:
    1. Heating water:_____
    2. Heating solutions:_____
    3. To obtain cooling:_____
    4. Drying:_____
    5. Other usages:_____

23. Distance of boiler from steam usage:_____(m)

24. Were there any problems encountered because of this distance?
    1. Yes:_____
    2. No: _____

25. Number of hours per shift:_____

26. Quantity of steam per hour: _____ (Tons)

27. Boiler working pressure: _____ (psi)

28. Fuelwood needed per boiler/shift:_____(Kontar)

29. Total fuelwood consumption/day:_____ (Kontar)

30. Plant operation:
    1. Continuous:_____
    2. Irregular:_____

31. If the production is irregular how many working days/year
_____

32. Price of wood per Kontar:_____ (LS)

33. Type of wood used:
    1. Sunt:_____
    2. Other type:_____

34. Availability of fuelwood:
    1. Yes:_____
    2. No:_____

35. Number of days factory stopped last year?_____

36. Was there any energy sources used other than wood?
    1. Yes:_____
    2. No: _____

37. Accept change to fuels other than wood?
    1. Yes:_____
    2. No: _____

38. Wood source:
    1. Main Zariba
    2. Near Zariba
    3. Other

39. Materials used and price:

    1)_____(LS)_____
    2)_____(LS)_____
    3)_____(LS)_____
    4)_____(LS)_____
    5)_____(LS)_____
    6)_____(LS)_____

40. Electricity consumption per month:_____(LS)
41. Maintenance cost per year:_____(LS)

42. Estimated building cost: _____ (LS)

43. Equipment cost: _____ (LS)

44. Date of building factory: _____ (LS)

45. Present cost of building: _____ (LS)

46. Other costs per day: _____ (LS)

47. Any additional information:

_____

_____

_____

_____

_____

Appendix 3
Procedure for Determining Sample Size of Bakeries

1. Total number of traditional bakeries in Khartoum Province = 645 and distributed according to areas as follows:

Mid-Town area	= 217
Outskirt area	= 190
Villages area	= 238
Total	645

The above three areas are taken as the main strata.

2. The results of a pilot survey in 16 bakeries in these three strata gave the amount of wood consumed/day in Kontars as follows:

Mid-Town area:	2,4,2,2,2,1.25,4,4
Outskirt area:	6,5,6,5,4
Villages area:	4,4,6

3. The variance S for these strata is calculated from the followingformula:

$$S = \sqrt{\frac{\sum x^2 - (\sum x)^2/N}{N-1}} \qquad \text{(Ref. 6)}$$

Where X - individual value of sample
N - total number of samples

$$S_1^2 = \frac{65.5 - (21.25)^2/8}{7} = 0.15$$

$$S_2^2 = \frac{138 - (26)^2/8}{4} = 0.75$$

$$S_3^2 = \frac{68 - (14)^2/8}{2} = 1.35$$

4. If it is decided that the error E on the estimate of daily consumption is to be within ±0.5 Kontar at 0.05 probability level, then the sample size n could be calculated using the following formula:

$$n = \frac{N\left(\sum_{h=1}^{3} N_h S_h^2\right)}{\frac{N^2E^2}{4} + \sum N_h S_h^2}$$

h- number of strata

$$n = \frac{645\ (217 \times 0.15 + 190 \times 0.75 + 238 \times 1.35)}{\frac{645^2 \times 0.5^2}{} + (217 \times 0.15 + 190 \times 0.75 + 238 \times 1.35)}$$

$= 12.08$

∴ the total number of bakeries to be selected = 12

5. If this number is increased, the error of estimate of daily consumption/bakery will be reduced. It was decided to increase the number of bakeries to be surveyed to 50. This will reduce the error to less than 15%.

6. If these 50 bakeries were located according to the weight of the three main strate, our sample will be distributed as follows:

Mid-Town area: $\frac{217}{645} \times 50 = 16.8 = 17$

Outskirts area: $\frac{190}{} \times 50 = 14.7 = 15$

Villages area: $\frac{238}{645} \times 50 = 18.4 = 19$

7. If post stratification according to the three towns is made, the distribution of samples will be as follows:

Mid-Town area= Khartoum $\frac{78 \times 17}{217} = 6$

Khartoum North $\frac{87 \times 17}{217} = 7$

Omdurman $\frac{52 \times 17}{217} = 4$

Outskirts area= Khartoum $\frac{56 \times 15}{190} = 4$

Khartoum North $\frac{92 \times 15}{190} = 7$

Omdurman $\frac{42 \times 15}{190} = 4$

Villages area = Khartoum $\frac{27 \times 18}{238} = 2$

Khartoum North $\frac{173 \times 18}{238} = 13$

Omdurman $\frac{38 \times 18}{238} = 3$

So the sample size and distribution of bakeries according to town and location is shown on the following table:

Town	Area			Total
	1	2	3	
Khartoum	6	4	2	12
Khartoum North	7	7	13	27
Omdurman	4	4	3	11
TOTAL	17	15	18	50

Appendix 4

Location of Kaminas in Khartoum Province according to area

A) Eastern Blue Nile Area - Khartoum North

Location	Number of Kaminas	Number of firing places	Number of Questionaires
El Safarat	3	5	1
Hilat Kuko	500	1000	4
El Garif Sharg	500	1000	6
Omdurman	20	40	2
Soba	8	8	1
El Ailafoun	12	12	4
El Bagir	3	6	1
El Esaylat	7	14	1
TOTAL	1053	2085	20

B) Western Blue Nile Area - Khartoum

Location	Number of Kaminas	Number of. firing places	Number of Questionaires
Burri	19	57	3
El Geraif Garb	30	150	5
Kilo 10	10	20	1
El Higairat	2	2	1
Soba Garb	40	140	6
Butri	7	14	2
Tutti	12	17	2
TOTAL	120	400	20

C) **Western Nile Area - Omdurman**

Location	Number of Kaminas	Number of firing places	Number of Questionaires
El Gamair	5	13	1
El Sarha	3	6	1
El Hittana	5	10	2
Khour Omer	1	1	1
Millatary Area	1	1	1
Wadi Sayedna	3	9	1
TOTAL	18	40	6

D) **Eastern Nile Area - Khartoum North**

Location	Number of Kaminas	Number of firing places	Number of Questionaires
Shambat	15	25	3
El Halfaya	63	200	6
El Kadro	15	15	1
Abu Halima	1	1	1
El Khogalab	5	10	1
El Faki Hashim	5	10	1
El Khilala	4	4	-
El Daba	2	2	-
El Tamaniat	3	3	-
El Kabashi	4	4	1
Wawasi	5	5	-
Wad Ramli	5	5	-
El Sagai	3	3	-
TOTAL	130	287	14

REFERENCES

1. National Energy Administration, "Base Year Energy Supply/Demand Balances and Demand Projection Methodology Annex 1" March 1983, Khartoum.

2. Yahia I. M. Bushara, " Working Plan for the Acacia Nilotica" Forest Reserves, Gezira Circle (1973-1982), Oct. 1974.

3. Abdel Aziz Bayoumi, "Forests in Sudan: The Resources and Administration", Khartoum, May 1983.

4. E. A. EL Siddig and J.C. Hetherington, "The Stem and Brance Volume of Acacia Nilotica in the Fung Region in the Sudan", University College of North Wales Bangor, 1982.

5. Mohmed El Amin Mukhtar, "Trends of Consumption of Wood Fuel in Khartoum Province and Suggestion Measures for Satisfying Future Needs", M.Sc. Thesis, Dept. of Forestry, Faculty of Agriculture, University of Khartoum, October, 1982.

6. Frank Freese, "Elementary Statisical Methods for Foresters", Agricultural Handbook 317, U.S. Dept. of Agriculture, Forest Service, January, 1967.

7. Omer Ibrahim Yagi et al, "Alternative Sources of Energy For Firing of Clay Bricks: The Use of Compressed Groundnut Shells in Firing of Clay Bricks," Building and Road Research Institute (U of K) in collaboration with NEA, December, 1983.