53

9365703

PDAAT-834

ISN-46049

FUELWOOD USE IN MOROCCO

FINAL REPORT
OCTOBER 1984

Submitted to:

Development Sciences, Inc.
P.O. Box 444
Sagamore, MA 02561
and
U.S. Agency for International Development

Submitted by:

Energy and Environmental Engineering
P.O. Box 215
East Cambridge, Massachusetts 02141

OPN-5703-C-00-1001-00

TABLE OF CONTENTS

	Abstract	1
	Preface	2
I.	Introduction	3
II.	Current Fuelwood Resources	5
III.	Fuelwood Consumption and Demand	17
IV.	Regional Fuelwood Balances	27
V.	Comparative Fuel Analysis	38
VI.	Outlook and Future Prospects	43
VII.	Conclusions: Intervention Options	53
VIII.	Bibliography	57

LIST OF TABLES AND FIGURES

TABLES

TABLE #	TITLE	PAGE
1	Natural Forest Surface	7
2	Plantations Surface	9
3	Production Trade and Apparent Consumption of Forest Producers	11
4	Commercial Production of Fuelwood and Charcoal	13
5	Reforested Surface	15
6	Model National De Bois De Feu	23
7	Productivite Energetique Par Espece	30
8	Evaluation de l'utilization de l'alfa	33
9	Repartition de la Fore Naturelle et Des Reboiserents Par Province	35
10	Analyse Regionale De la Consommation Eneretique Par Province	36
11	National Energy Balance	40
12	Projection De La Balance Energetique	44
13	Analyse Regionale De La Consommation Energetique Par Province	48
14	Fuelwood Consumption Projection	52
15	Changes in Fuelwood Consumption	52

FIGURES

FIGURE #	TITLE	PAGE
1	Population Growth and Wood Demand	25
2	Surface Boissee et Pertes Cumulatives	26

Abstract

This study is an initial attempt to systematically understand the use of fuelwood and charcoal in Morocco. The approach followed, aims at developing a national appraisal of the fuelwood and charcoal situation through a regional aggregation of data. The need to collect and manipulate data led to the utilization of a computerized framework using Lotus 123. Results of the analysis indicate that fuelwood consumption is close to 11 million cubic meter per year or three times the renewal capacity of Moroccan forests. Projections in the future indicate a worsening situation if no corrective measures are taken.

PREFACE

This is a final report of progress made by Energy and Environmental Engineering, Inc. on the energy planning assistance project for Developmental Sciences, Inc. and the Ministry of Energy and Mines, Government of Morocco and U.S. Aid contract No. 5728-600-3001-00.

This report presents a study of the fuelwood situation in Morocco. The work was primarily undertaken during two visits to Morocco in February and May of 1984 During the site visits tge assistance of a number of people has proven invaluable in terms of data collection and evaluation of the approach taken. The results of the model were presented on May 17, 1984 to the cadres and chefs de divisions at the Direction des Eaux et Forets. A number of criticisms and suggestions were presented and the model has been improved by their inclusion. One recommendation we were unable to meet was the request to evaluate wood resources weighted by their energy content. Due to the lack of information in the U.S. on ergy content of forestry species, the energy content of various trees was taken as an average. Such a simplification does not affect the results of the analysis due to the relatively minor energy differences between trees and the uncertainty inherent in other variables.

I am especially grateful to Messrs. El-Asri, Jader, and Zitan from the DEFCS for their continuing enthusiasm for the project and their unwavering efforts in search of the magical "data". Without their support and technical input this study could not have developed appropriately.

I. INTRODUCTION

Fuelwood is the primary source of energy for the majority of the Moroccan people. In the rural areas where 57% of the population live[1], and among the majority of the urban population, the consumption of commercial fuels is minimal. While the electricity grid reaches most cities today, only 6% of the Moroccan villages are electrified. For the foreseeable future, the majority of rural areas will remain non-electrified; only a total of 20% of Moroccan villages are planned to benefit from rural electrification by the year 2000.

While the oil price increase of 1973 was the cause of a worldwide awareness of the commercial energy crisis, the recognition of the importance of the "other energy crisis" has slowly caught up with planners in developing countries. In Morocco several years of energy analysis and planning by the Ministry of Energy and Mines (MEM), and the Ministry of Agriculture and Land Reform (MARA) and others have not only highlighted the essential role of fossil fuels in the Moroccan Economy, but have also led to an increased awareness that the majority of the population is unconcerned by the problem of relatively inaccessible energy sources. In rural areas and to a lesser extent in urban areas, people are faced with the problem of limited biomass resource availability, expecially fuelwood and charcoal. These resources are needed today more than ever as higher commercial energy prices have made the substiturion of alternative commercial fuels unattractive for most households.

This study aims at investigating the use of fuelwood and charcoal in the urban and rural areas of Morocco. To date, a number of studies have briefly investigated the problem and have identified a number of global parameters. Most either focus on a specific forestry project (World Bank 1981, 1982a) or consist of overviews on a national scale (Belrhitis 1983, 1984, World Bank 1982b, Michaelides 1981) or nonrepresentative localized

---

(1) Based on the "Recensement National" Juillet 1982 results.

field surveys (Parkan 1981). Due to the fact that there is little agreement among the above named authors on the magnitude of the problem, especially its projected future impact, it was deemed necessary to review the literature and to develop an up-to-date assessment. Therefore, this report owes a great deal to previously published materials and to discussions held with the Ministere de l'Agriculture et de la Reforme Agraire (MARA) and the Ministere de l'Energie et des Mines (MEM) staff.

The impetus of this study is the work currently in progress for the joint MEM USAID energy planning project. The need to integrate the biomass sector into the national planning framework of the ENVEST model demands an initial investigation and model development of the fuelwood sector. Data and time availability have prevented us from evaluating the energy use of animal and crop residues at this time.

The study is structured into several sections. First, current fuelwood resources are evaluated and divided by region and type of tree. The next section studies the fuelwood and charcoal demand structure and reviews pertinent literature. Per capita fuelwood consumption and demographic data are then used as the basis of a regional demand disaggregation. Section IV develops a regional and national energy balance which is used to evaluate critical areas pf shortage. This section is followed by a comparative fuel analysis in both the rural and urban residential household sectors. These results form the basis of a demand and supply projection for a thirty year horizon. Finally, a section covering options and areas of intervention follows. It contains a summation of various policy and technical options available to remedy the fuelwood crisis.

II. CURRENT FUELWOOD RESOURCES

A. Forestry Sector Overview

The forest areas of Morocco consist of 4.9 million hectares of natural growth and almost 0.4 million hectares of plantations. Another 2.5 million hectares are covered with esporto grass (Alfa). Most forest areas are confined to Morocco's mountainous areas forming a crescent from Agadir to the Mediterranean and following the Atlas Mountains' physical setting. Main forest producing areas are located east of the Rabat Mohammedia region, in the Middle Atlas region, the Rif mountains in the North, and the Gharb Mamora area around Kenitra. Esparto grass mainly covers the Oriental region (Northeast).

Limited information is available on Moroccan forests. Only 15% of the forest areas have been inventoried and mapped. It is not known how much of the initial forest surface remains. Forest overexploitation, fires, and clearing for agricultural purposes have had a severe impact on forest surfaces. Based on qualitative discussions with MARA and FAO experts and on the experience of other developing countries, up to 20% of forest cover in Morocco could already be gone.(1) To remedy this critical lack of information, MARA has undertaken a satellite mapping of biomass resources through Landsat. While less accurate than direct inventory and mapping, this study will provide useful estimates by 1985.

Four-fifths of the Esparto grass areas have been mapped. However, those areas are less critical as their primiary utilization is the fabrication of paper and grazing; firewood usage is a last resort.

B. Forest Resources

Moroccan forests can be divided into three distinct categories: natural forests, plantations, and Alfa and maquis.

---

(1) MARA staff estimate

Natural Forests

Table 1 details the various type of trees which constitute the Moroccan forest. Due to the discrepancy in data and level of aggregation among various forest estimators, we chose to display the CNF, FAO and WB estimates. As far as this study is concerned, forestry surface estimates used are those of the CNF.

Plantations

Artificial forests cover an area of 360,000 ha and consist mainly of Eucalyptus conifers. Table 2 details the surface by type of tree and ownership.

C. Forestry Usage and Legal Status

The forest plays an important role in the Moroccan economy. National forest production covers domestic Alfa and fuelwood needs. Pulpwood and cork are exported while timber and sawnwood are imported. The forest sector contributes 200 million DH to agricultural GDP and provides a source of income for approximately 160,000 people in rural areas.(1) Furthermore, the forests form an integral part of the grazing rangeland and provide the equivalent of 1.5 million fodder unit/yr or 18% of the Moroccan livestock herd food requirement.(2)

---

(1) Based on World Bank 1982a

(2) Based on World Bank 1982b

Table 1.

Natural Forests Surface (10^3ha)

Name	CNF[1]	FAO[2]	WB[3]
Chene	1778		
Quercus Rotundifolia		1527	
Holm Oak			1430
Other Oak			25
Arganier	819		
Argania Spinosa		800	
Arganier			740
Autre feuillus	577		
Quercus Suber		273	
Cork Oak			425
Acacia			75
Total Feuillus/Evergreen	3,174	2,600	2,695
Cedre et Pin	228		
Cedrus Atlantica		134	
Pinus Halepensis		---	
Pinus Pinaster		80	
Cedar			140
Pine			80
Thuya	586		
Tetraclinis Articulata		586	
Thuya			950
Autre Resineux	325		
Juniperus spp		317	
Cupressus Sempervirens		6	
Albies Pinsapo		3	
Juniper			240
Cypress			6
Total Conifes/Resineux	1,139	1,126	1,516

Autres	639		
Maquis		500	
(Cistus spp			
Pistacia Lertisous			
Pistacia Atlantica			
Arbuto Uredo			
Ziziphus Lotus)			
Desert		73	
Others			689
TOTAL	4,952	4,299	4,900

(1) Based on Direction des eaux et forets et de la conservation des sols. "Conseil National des Forets", 3ene session, 1981

(2) Based on E.D. Michaelides "Wood Energy in the Near East and North Africa", FAO W/Q 5556, Rome, 1983

(3) The World Bank, "Staff Appraisal Report of a Forestry Project, Implementation Volume", Report No. 3676-MOR, 1982

Table 2. PLANTATIONS* SURFACE (103ha)

	STATE	PRIVATE	TOTAL
Eucalyptus	170	9	179
Oak, poplars, acacias	21	---	21
Conifers	158	2	160
TOTAL	349	11	360

*Based on Michaelides (1983)

Commercial Wood Production

Forest products production does not meet current or projected wood product demand. Table 3 summarizes the Moroccan commercial wood situation.

In 1979 the value of wood products amounted to 159 million DH. Cork accounted for forty million DH and wood pulp for 90 million DH. While wood exports have grown at a higher rate than that of agricultural products, the trade balance in wood products has deteriorated over the seventies. In 1979 wood product imports reached 365 million DH making it the third largest agricultural import by value after wheat and sugar. Overall, coniferous wood products represented 70 percent of the imports by value.

Moroccan apparent per capita consumption of wood based products is low compared to other similar developing countries. Therefore, it is expected that demand for these products will rise at a rate higher than the annual rate of population growth. With the population growing at an annual rate of 2.6 percent and the economy rapidly modernizing, non-energy wood product demand could double before the year 2000.

Forest Ownership and Legal Status

Based on the Dahir of October 10, 1917, forests and Esparto grass areas are public domain. Most plantations also fall under state ownership. However, the legislation recognizes the right of farmers to clear for agricultural land expansion on uncharted and non-inventoried forests. Thus, forest clearing is a wide-spread occurence even though the cleared land is generally low in productivity and erodes within a few years.

Another negative trend currently taking place is the mining of forest resources by well-endowed communes. The Dahir of September 20, 1976 has organized the population's participation in forestry development through decentralization. The new system relies on national, provincial and communal forestry councils and channels forests revenues to the communes where the forestry resources are located. In return, the communes must devote at least twenty percent of their revenues for reforestation. Because few communes have reinvested at the required reforestation

Table 3

Production-Trade and Apparent Consumption of Forest Producers[1] (1978-1979)

	Domestic Production	Imports	Exports	Apparent Consumption
Roundwood (10^3 m^3 u b)	508	208	---	716
Sawnwood (10^3 m^3)	71	338	---	409
Plywood (10^3 m^3)	30	---	3	27
Veneer Sheets (10^3 m^3)	38	---	1	37
Esparto Grass (10^3 t)	32	---	10	22
Unprocessed Cork (10^3 t)	21	---	5	16
Processed Cork (10^3 t)	6	---	5	1

(1) Based on World Bank 1982a

financing level, and because most of them use the legislation to exploit the forest resources as quickly as possible to generate income, the end result is negative. Forests in well-endowed communes are mined rapidly and little reforestation takes place.

Fuelwood Exploitation

Generally, fuelwood exploitation is achieved through public auction at fixed conditions by the Director des Eaux et Forets et de la Conservation des Sols (DEFCS). Prices vary according to site conditions, accessability and type of wood.

Belhritis (1983) provides a detailed analysis of the costs and taxes occuring in the production of fuelwood. Starting with a Eucalyptus forest he shows that typical fuelwood costs in the Gharb region are 80 DH/m^3 on site and 156 DH/m^3 delivered on the market. (Transport is assumed at 40 DH/m^3.) The volume of fuelwood production recorded by DEFCS is obviously below consumption levels. Almost all rural households and some small wood commercants gather fuelwood without permission through illegal cuts. The fuelwood produced commercially is generally consumed in cities.

Charcoal production is undertaken through a process similar to that of fuelwood. Once the trees and branches have been cut, they are assembled into piles, covered with dirt, and carbonized into charcoal. This production method is inefficient and wastes a large portion of the fuel heating value. However, charcoal is easy to transport and use (it burns without smoke), making it the fuel of choice in urban households.

Table 4 summarizes the commercial production of fuelwood and charcoal according to DEFCS statistics.

Since 1960 little change has occured in the total amount of fuelwood and charcoal produced. Charcoal production is preferred by forest harvesters for it is a choice fuel and carries a higher profit margin. Most of the charcoal produced is sold in the city. For the purpose of this study we will assume that commercial charcoal production is equivalent to total charcoal production and that 90% of charcoal consumption is allocated to the urban household sector.

Table 4

Commercial Production of Fuelwood and Charcoal[1]

Year	Fuelwood (10^3 m^3)	Charcoal (10^3 m^3 equivalent)	Total Production ($10^3 m^3$)
1960	296.3	580.7	877.0
1965	116.6	435.7	552.3
1972	350.8	435.7	766.5
1976	375.6	339.6	715.2
1980	392.3	285.8	678.1
1982	369.6	418.6	838.2

(1) Based on Jader (1983).

D. Fuelwood Production Capacity

DEFCS officials[1] estimate the renewal capacity of Moroccan forests at 2.5 million m^3/yr. The World Bank (1982a) quotes unnamed FAO sources and estimates a total of 3 million m^3/yr. Parkan (1981) also provides an evaluation of the productive capacity of the Moroccan forests. He bases his analysis on an estimation of the renewal capacity of each individual species. These estimates are then averaged across specie surface and by geographical region to generate a total estimate of 5.2 million m^3.

Reforestation

In 1970 the Moroccan government adopted a national reforestation plan calling for an annual plantation program of 22,000 ha during the 1970-2000 period. The plan aimed at meeting forestry needs based on an assessment of future wood consumption and current biomass resources. Table 5 details the reforestation achievements for selected years from 1949 until today. Since 1970 the reforestation goal of 22,000 ha has never been achieved except for the 1981-82 period. The data provided here details the areas successfully planted. The area planted initially is much larger. For instance, the total area planted between 1949 and 1982 was 496,213 Ha of which only 376,683 Ha survived. THe data presented in the table is for successfully planted spruces.

Today a concensus exists among experts and officials as to the real magnitude of the forestry crisis. All concur that the 1970 reforestation plan, even though never achieved, is too small to meet the real

(1) Meeting with Mrs. Jader and El-Asri, February 8, 1984.

Table 5

Reforested Surface (in ha)[1]

Year	Eucalyptus	Other Hardwood	Coniferous	Total
1949-50	2,034	1,109	1,076	4,219
1954-55	6,358	265	1,086	6,709
1959-60	8,741	617	1,492	10,850
1964-65	8,752	33	6,952	15,737
1969-70	6,148	784	9,410	16,342
1974-75	-----	-----	-----	13,432
1977-78	3,042	1,368	7,183	11,593
1978-79	-1,905	140	629	-1,136
1979-80	-558	766	-554	-346
1980-81	-3,259	1,073	14	-2,172
1981-82[2]	10,031	1,443	11,842	23,316
1982-83[2]	5,244	3,342	10,795	19,481

(1) Based on data provided by Mr Ahizoune, chef service de reboisement, DEFCS.

(2) Based on preliminary information on planted areas.

reforestation needs. MARA and the World Bank[1] have estimated the need for a reforestation program of 35-40,000 hal/yr in order to meet wood product demand in the year 2000 horizon. This estimate does not include the reforestation needed to maintain existing resources and to meet fuelwood demand. On the other hand, CNF[2] has identified the need to plant 52,000 ha/yr starting in 1978. The program includes 15,000 ha of protection plantations (most of which is erosion protection). El-Asri[3] has updated those estimates to 106,000 ha/yr of which 70,000 ha are needed for protection reforestation. Included in his calculations is the reforestation of an additional 125,000 ha /yr to meet fuelwood demand.

These estimates provide an order of magnitude estimate of the biomass deficit in Morocco. Practically, it is impossible for DEFCR to meet the identified reforestation needs within its current institutional, legal and financial setting. Michaelides, for instance, estimates that a reforestation level of only approximately 23,000 ha/yr is presently feasible.[4]

---

(1) World Bank 1981, 1982a

(2) CNF (1981).

(3) El-Asri (1983).

(4) Michaelides (1983).

III. FUELWOOD CONSUMPTION AND DEMAND

A. Structure of Residential Energy Demand

Households are the main consumers of traditional energy sources in Morocco. A familiar sight in the countryside is to observe women and children spending the better part of a day going through fields and forests gathering small branches and dead wood. The fuelwood is used to meet domestic heating, bread baking, and cooking needs. In the urban areas, a large portion of the urban poor are unable to afford commercial energy sources, such as gas and liquid fuels, or do not have access to electricity. Further, many of the city residents are new arrivals from the country with a definite cultural preference for traditional cooking and bread baking. This leads to a continued demand for fuelwood and charcoal.

Before the oil price rises of the Seventies, energy planners were less concerned with the growing demand for fuelwood in the rural and urban areas. The availability of cheap petroleum led to the belief that urban households will rapidly shift to electricity and liquid fuel consumption. Rural households were planned to benefit from rural electrification and had access to cheap liquid fuels. Today, the general rise in energy prices has disproportionately affected the low income groups which constitute the overwhelming majority of rural households and a large portion of the urban population. Substitution of liquid fuels and electricity for traditional fuels has abruptly stopped and the pressure on biomass resources has dramatically increased. Electricity price rise and the high cost of electric grid expansion have postponed the ambitious rural electrification programs planned during the era of cheap energy cost. Compounding the problem is the rapid rise of population and the world economic crisis which reduces income, increases pressure on available resources, and pushes segments of the population to substitute lower cost fuels or reliance on illegal cuttings to make ends meet.

The Rural Sector

In the rural sector fuelwood is gathered without entering the commercial market. The energy consumed in a rural setting includes: animate energy (human and animal work), residue fuel (cattle dung and crop residue), and wood fuels (fuelwood and charcoal). Fuelwood is by far the fuel of choice for it is free and generally available within walking distance. Families rely on wood for practically all cooking and heating needs. Lighting is met through gas lamps, kerosene lamps, or candles. Wealthier families may purchase fuelwood supplies and prefer to use charcoal for cooking convenience. If fuelwood cover becomes too sparce within walking distance to meet the community energy needs, then a shift toward agricultural and animal residue occurs. Such a step leads to a degradation of the agricultural cycle. Because, agricultural residue is partially used as animal fodder and in conjunction with animal residue returned to the soil as fertilizer, any significant diversion of these resources has a negative impact on agricultural production.

Urban Sector

In urban areas, fuelwood and charcoal are available only as commercial fuels. Because of the difficulty of wood gathering in towns and for the higher monetary income of urban dwellers, urban residents purchase their energy supplies. Generally, high and medium income households use electricity for lighting, butane gas for cooking, and liquid fuel or gas for heating. Lower income groups often do not have access to electricity. They often rely on wood for cooking bread in an individual or communal bread ovens. Meal preparation is undertaken using a charcoal stove. Charcoal is the preferred cooking fuel for its intrinsic advantages: low stove cost, high energy density, convenience, and smokeless combustion. A small butane burner (3 Kg bottle) is also used in most households for tea preparation.

Butane gas is slowly replacing charcoal as the choice fuel for cooking in lower income households. However, its market penetration has slowed down due to the price rise of butane. Because traditional charcoal manufacture has such low conversion efficiency, this continuing and growing reliance on charcoal can mean higher primary wood consumption in urban households,

B. Available Fuelwood Consumption Estimates

No authoritative assessment of the energy consumption in the Moroccan residential sector is currently available. There exists no representative household energy consumption survey for Morocco today. Although, much effort has been expanded to characterize and measure the energy flow in the industrial and commercial sectors through the energy planning project, little is known about the energy consumption profile of the Moroccan household. Some general information exist on the aggregate commercial energy consumption of the residential sector, however, the structure of the energy use and the components of the demand are seldom studied. Further the division of households among rural and urban settings is seldom achievable with the type of aggregate data currently available.

Even less understood is the structure of traditional fuel consumption. The official data regarding wood consumption significantly underrepresent the true magnitude of the forestry problem. The collection of (dead) wood is the only source of cooking and heating energy for the majority of rural households and the practice is protected by law. Foresters are keenly aware of the magnitude of the problem as they have seen the national forests dwindle at a rapid rate.

A number of estimates regarding consumption estimates have been advanced, both by Moroccan forestry staff and foreign consultants. Let us review some of these most recent studies.

Official data

There is no common position on the part of the Moroccan planners regarding the magnitude of the forestry crisis. National energy planners are familiar with all the subtleties of the commercial energy sector but are removed from the reality of the traditional energy crisis which occurs in the countryside. The foresters of the Ministry of Agriculture are more in touch with the traditional energy crisis. They manage the forestry resources and implement reforestation programs. Their analysis of the structure of forest products demand leads them to study the structure of fuelwood demand and to recognize its important role in the degradation of Morocco's forests.

Official data from the ministry of agriculture is developed by the Division des Eaux et Forets et de la Conservation du Sol (DEFCS). Data for 1982 indicates that 838,000 cubic meters of wood were commercially exploited for fuelwood or charcoal, purposes. DEFCS staff is well aware of the overexploitation of forest resources due to illicit cutting. They estimate the magnitude of the unofficial wood cutting at twice the amount cut officially.

The Ministry of Energy through its Division de Developement des Resources Energetiques has started investigating the fuelwood problem. Belrhiti (1984) discusses the current fuelwood situation and discusses the various wood consumption survey results and expert opinions. He concludes that most survey results cannot be extrapolated to the whole of Morocco and supports the MARA estimate of 2.5 million m^3 consumed per year.

A different perspective regarding the extent of the fuelwood problem is slowly emerging among DEFCS staff. Based on limited point surveys undertaken in certain mountainous regions, discussions with world forestry experts, and on the study of the situation in countries similar to Morocco, wood consumption estimates appear higher than anticipated. Current thinking seems to center around a consumption of approximately 10 to 11 million cubic meter per year(1).

FAO/World Bank estimates

The Food and Agricultural Organization (FAO) plays an active role in forestry project assistance in Morocco. Having had to develop long term plans for their involvement, the FAO assistance program has developed a fairly detailed understanding of the status and problems of the Moroccan forestry program. Through on site project experience and short term visits their experts have developed estimates of the fuelwood consumption. The approach taken is based on the estimation of both a rural and urban per capita consumption factor. These variables are currently evaluated at 0.8 m^3 per year in rural areas and 0.1 m^3 per year in urban areas. Based on the current distribution of the Moroccan population, fuelwood consumption is evaluated at 10.5 million m^3 per year.

The World Bank (WB) staff agrees with the FAO figures and uses them in their project papers. Further, they advance the figure of 3 million m^3 as the maximum allowable production from Moroccan forests.

C. National Consumption Model Based on the FAO/WB Approach

In order to investigate the impact of the various assumptions and evaluate the different analysis presented, it was deemed necessary to rely on modeling as a tool for a simplified but consistent representation of a complex reality. The FAO with the World Bank have presented a systematic analysis of the situation based on both their in depth understanding of the Moroccan forestry sector and their experience with other countries.

The framework we developed should be seen as a systematic modelization of the FAO/WB analysis. In effect, we have taken the results developed by these institutions, used them to build a framework, and developed a projection for the future.

The framework we developed should be seen as a systematic modelization of the FAO/WB analysis. In effect, we have taken the results developed by these institutions, used them to build a framework, and developed a projection for the future. The major features in the FAO/WB approach are that demand is driven by the per capita energy consumption both in rural and urban areas. The depletion capacity of Moroccan forests is assumed to be equal to the difference between the forest renewal capacity and the total fuelwood demand.

Table 6 details the results of the model. The table includes data in 5 year increments projecting the evolution of the fuelwood situation until 2020. The first portion develops the rural fuelwood and charcoal component. Because rural households are minimal consumers of charcoal, they have been allocated 10 % of the total charcoal consumption. The demand is driven by the increase of the population and we have taken fuelwood consumption per capita to remain constant over time. The second paragraph details the structure of urban fuelwood demand and is constructured in a similar fashion. The following paragraph sums the fuelwood and charcoal total demand. It is followed by estimates of the renewal capacity of the forest and the resulting fuelwood deficit.

Case 1 attempts to model the results of the FAO/WB estimate that the fuelwood deficit is equivalent to an annual loss of 20,000 hectares of forests. Case 2 develops a similar estimation of future forest losses based on a lower estimation of the wood density of Moroccan forests.

Based on current data for forest resources, World Bank estimates of population growth, and a constant per capita fuelwood consumption, the projections indicate a significant deterioration of the Moroccan forest cover. The case 1 scenario is based on the FAO/WB estimate of the annual deficit and their projection of annual losses of 20,000 hectare. Such estimates translate into an average biomass content of 361 M^3/Ha, a figure most forestry officials dispute as being too high for

Table 6.

MODEL NATIONAL DE BOIS DE FEU (FAO/WB)

PROJECTION DE LA DEMANDE	1982	1985	1990	1995	2000	2005	2010	2015	2020
POPULATION RURALE (1000)	11690	12151.863	12962.539	13827.297	14749.746	15733.732	16783.363	17903.016	19097.364
TAUX D'AUGMENTATION (%)	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3
CONSOMMATION RURALE BOIS (M3/CAPITA)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
CONSOMMATION RURALE CHARBON (M3/CAPITA)	0.004008	0.004008	0.004008	0.004008	0.004008	0.004008	0.004008	0.004008	0.004008
DEMANDE RURALE BOIS (1000M3)	9352	9721.49	10370.031	11061.838	11799.796	12[illegible]	13426.69	14322.413	15277.892
DEMANDE RURALE CHARBON (1000M3)	46.85352	48.704665	51.953856	55.419808	59.11698	63.0607	67.267718	71.755289	76.542236
POPULATION URBAINE (1000)	8686	9798.7801	11979.141	14644.661	17903.295	21887.6[illegible]d	26757.175	32711.006	39989.645
TAUX D'AUGMENTATION (%)	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1
CONSOMMATION URBAINE BOIS (M3/CAPITA)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CONSOMMATION URBAINE CHARBON (M3/CAPITA)	0.048553	0.048553	0.048553	0.048553	0.048553	0.048553	0.048553	0.048553	0.048553
DEMANDE URBAINE BOIS (1000M3)	868.6	979.87801	1197.9141	1464.4661	1790.3295	2188.7018	2675.7175	3271.1006	3998.9645
DEMANDE URBAINE CHARBON (1000M3)	421.73136	475.76017	581.62321	711.0422	869.25866	1062.6804	1299.1411	1588.2175	1941.6172
DEMANDE TOTALE BOIS (1000M3)	10220.6	10701.368	11567.945	12526.304	13590.126	14775.688	16102.408	17593.514	19276.856
DEMANDE TOTALE CHARBON (1000M3)	468.58488	524.46484	633.57707	766.46201	928.37564	1125.7412	1366.4088	1659.9728	2018.1595
SURFACE BOISEE (HA)	5100000	5034536	4914412.5	4779128.5	4626853.2	4455457.8	4262456.2	4044933.3	3799458.5
CAPACITE NATURELLE DE REPLENISSEMENT (M3/HA/AN)	0.588235	0.588235	0.588235	0.588235	0.588235	0.588235	0.588235	0.588235	0.588235
CAPACITE TOTALE DE REPLENISSEMENT (1000 M3/AN)	2999.9985	2961.4903	2890.8294	2811.2506	2721.677	2620.8562	2507.3259	2379.3714	2234.9745
PERTE ANNUELLE (1000 M3/AN)	7689.1864	8264.3426	9310.6929	10481.515	11796.824	13280.573	14961.491	16874.115	19060.041
CAS 1: HAUTE CAPACITE DE REPLENISSEMENT									
CAPACITE BIOMASSIQUE D'UN HECTARE (M3/HA)	361	361	361	361	361	361	361	361	361
SURFACE PERDUE ANNUELLEMENT (HA)	21,298	22,891	25,789	29,032	32,675	36,785	41,441	46,739	52,794
SURFACE CUMULATIVE PERDUE (HA)	21,298	88,355	211,377	349,904	505,822	681,327	878,985	1,101,805	1,353,335
CAS 2: CAPACITE DE REPLENISSEMENT NORMALE									
CAPACITE BIOMASSIQUE D'UN HECTARE (M3/HA)	200	200	200	200	200	200	200	200	200
SURFACE PERDUE ANNUELLEMENT (HA)	38,446	41,322	46,553	52,408	58,984	66,403	74,807	84,371	95,300
SURFACE CUMULATIVE PERDUE (HA)	38,446	159,494	381,567	631,629	913,085	1,229,898	1,586,700	1,988,924	2,442,973

Morocco. The model indicates that if action is not initiated at a national scale to reforest the countryside, 506 thousand Ha of forests (10% of cover) will be lost by the year 2000; and might reach up to 1353 thousands Ha (30% of cover) by the year 2020.

If the model is run with the lower biomass density of 200 M^3/Ha, the magnitude of the problem reaches severe proportions: the losses reach 913 thousand Ha by the year 2000; and 2443 thousand Ha by 2020. Such a loss would be equivalent to almost a fifth and half, respectively, of the total forest cover.

Results from the model are presented in graphical form in figures 1 and 2. Figure 1 provides a graphical modelization of the growth of fuelwood demand versus rural and urban population growth until the year 2010. The graph indicates the importance of rural population growth as the driving factor behind wood consumption. Graph 2 presents in graphical form, the cumulative losses suffered by the Moroccan forestry cover and the decrease suffered by existing forests if current trends continue. The data presented in the graph is that of the higher biomass density.

The description of the forestry deficit in terms of hectares lost has been criticized by several Moroccan foresters. They indicate that the forest biomass deficit does not translate itself in the field by direct losses of 20,000 ha/year or more. Rather, the forest undergoes a process of thinning out with an annual loss of trees within an area but where the forest continues to exist at a lower biomass density. Eventually, the forest recedes into shrubs and slowly disappears. While it is obvious that Moroccan forests are not receding annually at the 20 to 40 thousand ha per year rate, the situation is serious with the annual deficit extracting a heavy toll from existing resources. The usage of ha lost annually in our approach is a useful tool in terms of providing a useful yardstick of the magnitude of the problem.

Figure 1.

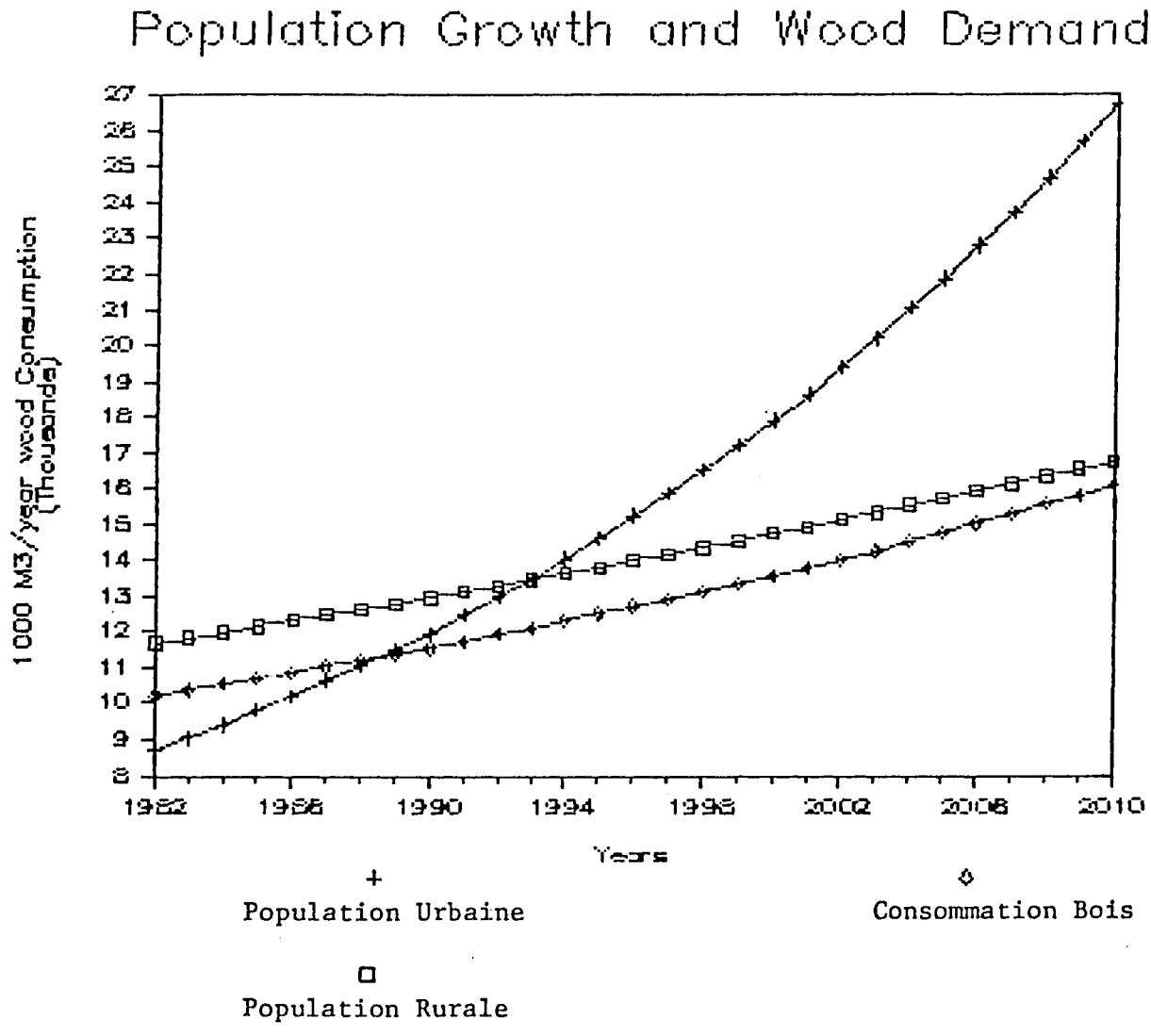
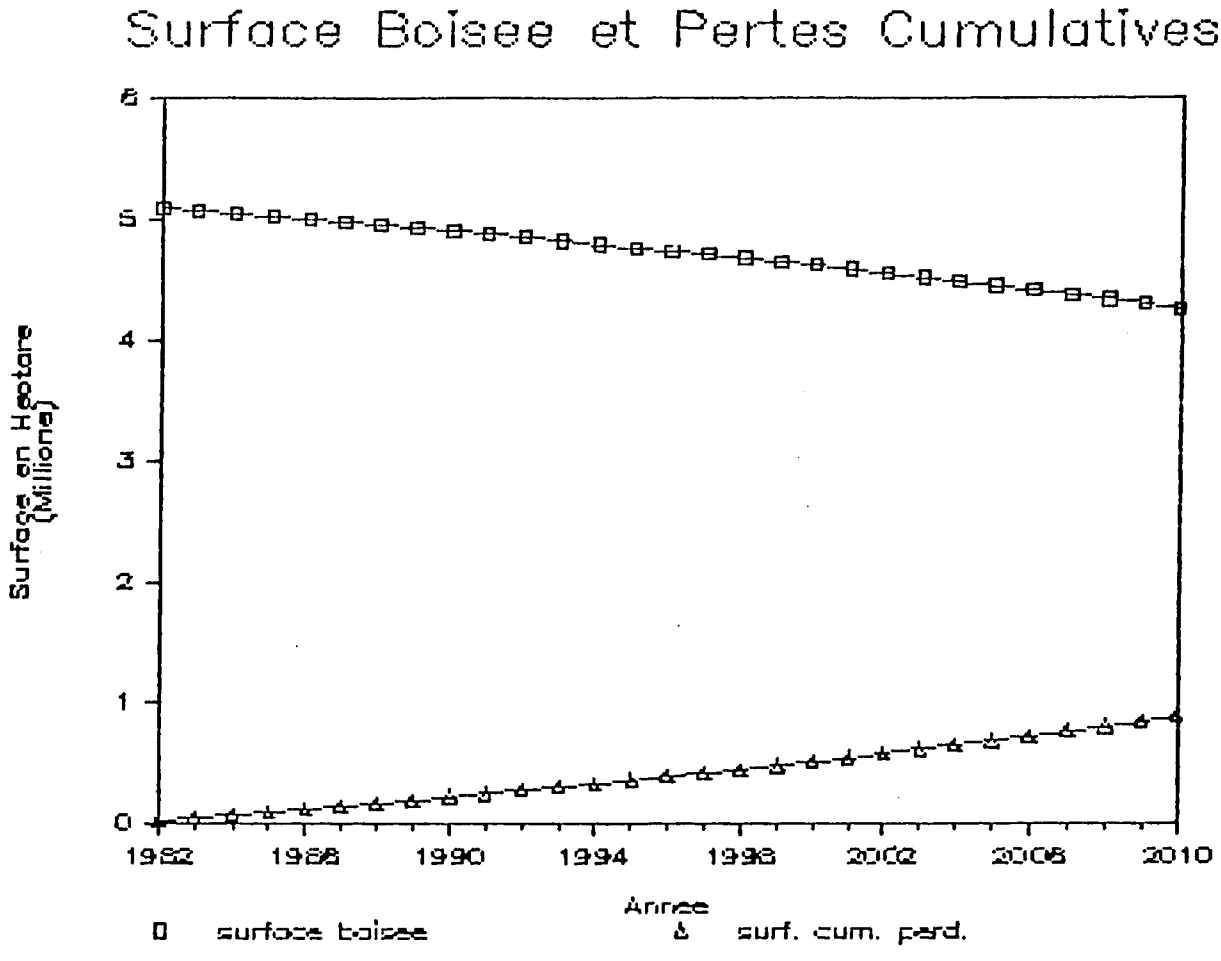

Population Growth and Wood Demand
1000 M3/year wood Consumption (Thousands)
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1982
1986
1990
1994
1998
2002
2006
2010
Years
+
Population Urbaine
◊
Consommation Bois
□
Population Rurale

Figure 2.


Surface Boisee et Pertes Cumulatives
Surface en Hectare (Millions)
0
1
2
3
4
5
6
1982
1986
1990
1994
1998
2002
2006
2010
Annee
surface boisee
surf. cum. perd.

IV. REGIONAL FUELWOOD BALANCES

A. Improved Regional Consumption Model

From the discussion in the previous sections, it becomes apparent that a more detailed analysis is needed regarding the key cause of forest destruction: the demand for fuelwood. It is clear that the taking of a national average for urban and rural per capita fuelwood consumption limits the analysis to the level of generalities. To understand the structure of energy consumption in the Moroccan household, we need to address the major factors affecting energy demand: availability of alternative fuels, energy prices, socio-economic factors, and most important the regional variations.

Regional Differences

Morocco is a country blessed with a variety of climates ranging from the mild Atlantic weather on the coastal plain to the harsh desert habitat of the Sahara. The presence of the Atlas mountains adds diversity by concentrating the rain and snow on its massive peaks and fertile valleys. Rural population density follows the rainfall pattern with high concentration on the coastal plain and the Atlantic side of the Atlas range.

In order to include regional disparities in our analysis, the framework was developed at the regional level with the unit of analysis being the province. The breakdown is based on the Moroccan official provinces with minor changes in order to accomodate the prefectures of Casablanca and Rabat-Sale, and newly designated provinces. In all the model includes 36 provinces and covers the whole of Morocco.

Incorporating Survey Results

The few point surveys or regional studies available regarding energy consumption in the residential sector are confined to rural areas and to the Rif or Central Atlas region. The results indicate a much higher per capita energy consumption than evaluated by either the FAO/WB or the MARA forestry experts. A number of reasons have been put forward to explain these high numbers(1). Belghiti (1984) dismisses the DANIDA study by noting the non representativity of the Rif region compared to the rest of the country: extremely cold winters and availability of wood resources make it one of the most fuelwood consuming regions of Morocco.

The approach retained in this study attempts to incorporate some of the survey results to go beyond the national average and focus on regional differences. For this purpose all the provinces were analysed by the Division de l'Economie Forestiere based on climatic setting, availability of alternative fuels, and level of urbanisation and development. Based on these criteria 4 categories were developed ranging from the rural-well forested mountain province to the desert bordering province. Estimates of annual per capita fuelwood demand ranged from .1 to .3 M^3 in urban regions and .6 to 1.2 M^3 in rural areas.

---

(1) The DANIDA (1979) survey undertaken in the Cercle de Targuist in the Rif mountains indicates a per capita rural fuelwood consumption of approximately 3 M^3/capita based on a household energy consumption of 14.8 tonne/year (6.3 Tonne for space heating, 4.0 for bread making, and 4.5 Tonne for cooking).

B. Regional Fuelwood Supply

In order to develop a consistent regional framework dealing with the residential energy sector, the renewal capacity of forests needs to be addressed on a regional basis. The most important variable to be evaluated is the renewal capacity of forests by specie and by region. In effect, the evaluation of the regional fuelwood energy balance depends on a thorough understanding of the production capacity of existing forests and artificial plantations. By renewal capacity we mean, the annual amount which can be harvested from a forest without diminishing the existing stock. Further, in areas where Alfa presence is important, an estimate needs to be developed regarding its use as an alternative energy source.

Energy Productivity by Specie

There exists no comprehensive study of the physical status of Moroccan forests. Only 15% of the forest area has been inventoried. While some forests are well known to the local foresters, on a national scale, little can be said authoritatively regarding the national resource.

---

(1) The renewal capacity data presented at the seminar of May 17, 1984 was a modified version of the information presented by Michaelides (1983). Similarly, energy utilization data are based on initial estimates by Mr. Amine from the division de l'economie forestiere. Later version of the model is benefiting from updated estimates from the division du Domaine Forestier and the division de l'economie forestiere, for respectively, the renewal capacity and the energy utilization.

Initially, we felt the need to include in our analysis the physical differences between various forests. Such a formulation

Table 7.

PRODUCTIVITE ENERGETIQUE PAR ESPECE

ESSENCE	CAPACITE DE RENOUVELLEMENT (M3/Ha/An)	UTILIZATION ENERGETIQUE (%)	PRODUCTIVITE ENERGETIQUE (M3/Ha/An)
Chene vert	0.72	100	0.72
Chene Liege	1.87	100	1.87
Chene Zeen	1.8	0	0
Arganier	0.3	100	0.3
Acacia Saharien	0	100	0
Essences Secondaires	0.2	100	0.2
Cedre	1.69	40	0.676
Pin Maritime	1.44	15	0.216
Pin d'Alep	0.6	15	0.09
Pin Laricio	0.24	15	0.036
Sapin	0.6	15	0.09
Genevrier	0.1	100	0.1
Thuya	0.46	70	0.322
Alfa (voir note)	0.138		0
Resineux	3	15	0.45
Eucalyptus	6	15	0.9
Autre Feuillus	6	90	5.4

NOTE; Les donnees sur la Capacite de renouvelleaent sont de Zitan chef de la division du Domaine Forestier d'apres la note du 18 Juin 1984. Les estimations de l'utilization energetique sont d'apres M. Ziad de la division de l'economie forestiere, rencontre du 10 Mai 1984. Pour l'alfa, nous avons transforme les donnees pour ce combustible en M3 equivalent bois. Nous utilisons un pouvoir calorifique de 16.74 GJ/Tonne pour l'alfa et 20.2 GJ/Tonne pour le bois. Nous assumons aussi une densite de .6 M3/Tonne pour les 2 combustibles. Donc la formule utilise est: 1 Tonne alfa = ((16.74 GJ/T alfa)/(20.2 GJ/T wood))*(.6 T/M3)= 1.38 M3 wood equivalent. Pour la productivite naturelle de l'alfa nous retenons le chiffre de 1 quintal/hectare.

leading to a more precise evaluation of the renewal capacity of the forests based on a regional breakdown. The dearth of useable data led to the decision to use national average productivity data which seemed more readily available.

Table 7 presents a detailed evaluation of the renewal capacity of the various tree species and their energy utilization(1). The implementation of the energy utilization variable is needed to disaggregate the industrial and other use components from the fuelwood and charcoal demand. The energy production capacity is the maximum rate of fuelwood harvesting attainable without forestry stock depletion.

Energy Utilization of Alfa

Alfa grows mostly in the northeastern part of the country and covers approximately 2.5 million hectare. The land it grows on is generally free of forestry cover and is of the subsaharan type. Alfa grows in clusters of dozens of plants together with open areas of a few meters separating them. Alfa has a high heating value due to the wax it contains. In the past a wax production industry exploited the Alfa resource and exported the major part of the production. Alfa is also used as feedstock for livestock and the Alfa growing steppes doubles as pastoral land for local herds. Finally, Alfa plays a relatively unknown but important role as erosion prevention barriers in the oriental region. Its presence in the subsaharan area limits desertification and protects a fragile ecological system.

Because of its good combustion characteristics, Alfa has seen its utilization as a fuelstock increase as local forests receded unable to meet the growing demand for fuelwood. The exploitation is still limited at this point in time, mostly due to the sparcity of the population in the subsaharan setting where Alfa grows. The Ministry of Energy has plans on the drawing boards to utilize the Alfa fields in the Oriental region to fuel a number of dendrothermal units to provide electricity to a number of

small villages. The planned units are of the 3 MW size and will rely on local villagers for the collection of the grass. While the project is interesting from an energy supply viewpoint, its impact on the environment and the local population have not been studied adequately and might prove to be major obstacles for the project's acceptance.

Table 8 provides a summary of the approach used to model the energy utilization of Alfa. The approach is the following: the surface covered with Alfa in each province is multiplied by an annual growth factor, yielding an annual renewal capacity. Since Alfa exploitation is limited to half the years in the plants life, the renewal capacity is halved to include this physical constraint. Finally, since Alfa utilization varies with the availability of fuelwood, access to the fields, and alternative usage of Alfa, a new factor is introduced to include the variation in fuel utilization according to provinces. The factor represents on a province basis the level of Alfa utilization as fuelwood. The final column in the table provides an estimate of the energy contribution of Alfa in M^3 of wood equivalent. The result indicating a national contribution of 100 thousand M^3 of fuelwood equivalent shows the limited role Alfa plays as a biomass fuel.

C. Regional Energy Balances

Having detailed in earlier sections the approaches used in the investigation of the supply and demand sides of the fuelwood model, we now move to the discussion of the integration of the components into a coherent framework and an analysis of the results.

Structure

The forestry distribution matrix (forestry distribution by

Table 8.

EVALUATION DE L'UTILISATION DE L'ALFA

PROVINCE	SURFACE ALFA (HECTARE)	POURCENT UTLISATION ENERGETIQUE (%)	PRODUCTION ENERGETIQUE TOTALE (M3/An)
Azilal			0
Beni Mellal			0
Ben Slimane	481		0
Khouribga			0
Settat			0
Al Hoceima	4,100	25%	71
Boulemane	524,000	50%	18,078
Fes	700		0
Taounate			0
Taza	155,318	25%	2,679
Er-Rachidia	12,000	75%	.621
Ifrane			0
Khenifra	144,600	25%	2,494
Meknes			0
Chefchaouen			0
Kenitra/Sidi Kacem			0
Khemisset			0
Rabat-Sale			0
Tanger			0
Tetouan			0
Figuig	1,000,000	75%	51,750
Nador	64,700	25%	1,116
Oujda	638,000	50%	22,011
Agadir/Taroudannt			0
Guelmim			0
Ouarzazate	38,015	50%	1,312
Tata			0
Tiznit			0
El kalaa Sraghna			0
Essaouira			0
Marrakech			0
Safi			0
AUTRE PROVINCES			
El-Jadida			0
Sahara			0
Tan Tan			0
Casablanca			0
TOTAL	2,581,914		100,132

NOTE: Le facteur d'utilisation energetique correspond au pourcentage de la production d'alfa qui est utilise a des fins energetiques. Ce facteur varie a travers les provinces, il est plus haut dans les provinces pauvre en bois. Pour calculer la contribution energetique de l'alfa nous procedons de la facon suivante: la surface alfatiere de chaque province est multiplie par la capacite d'accroissement de l'alfa. Nous prenons 50% de ce chiffre comme la limite d'exploitation des plantes (l'alfa doit etre laisse au repos pendant un nombre d'annees a peu pres egal au temps d'exploitation effective). Finallement cette expression est multipliee par le facteur d'utilisation energetique. Ce facteur est developpe a partir de donnees provinciales et depend de: l'accessibilite des nappes alfatieres a la population, l'availabilite de resources forestieres, et les utilisation alternatives de l'alfa.

specie and by region) as presented in table 9 forms the basis for the energy productivity calculation. The matrix is multiplied by the vector of energy productivity (annual fuelwood renewal rate by specie) and the vector of Alfa fuelwood production (fuelwood equivalent by province). Table 10 presents a summary of the regional fuelwood energy balance. The result is listed in the first column of the table and provides an estimate of the maximum level of fuelwood demand that can be met without loss in the forestry stock.

The fuelwood demand component is based on the rural and urban demand. The fuelwood demand is derived from the regional population estimates and their per capita fuelwood consumption. The last 4 columns in the table provide a measure of the total consumption and how it compares with the supply. One measure of comparison is the annual deficit which indicates in M^3/year of fuelwood how large the annual loss. Another unit of measure is the forestry losses in hectares per year (based on a wood density of 250 M^3/ha). The final measure is the ratio of demand over the renewal capacity of regional forests.

Analysis of Results

The summation of the regional energy renewal capacity indicates that the national renewal capacity of Moroccan forests is about 3.5 million M^3/year. Meanwhile, the national consumption of fuelwood reached 10.9 million M^3/year of which rural demand consisted of 9.8 million M^3/year. Such figures indicate a situation where consumption reached 309% of renewal capacity and losses in forestry were equivalent to 29 thousand ha/year.

Analysis of the provincial fuelwood balances indicates that only the provinces of Figuig and Khemisset have an energy surplus; every other province is victim of a fuelwood deficit. A number of provinces suffer from a crisis situation with the deficit reaching more than 9 times the renewal capacity of forests. These provinces are: El-Jadida, Safi,Tata, Guelmin, El Kalaa

Table 9.

REPARTITION DE LA FORET NATURELLE ET DES REBOISEMENTS PAR PROVINCE (Surface en Hectare)

PROVINCE	CV	CL	CZ	AG	AS	ES	CE	Ppr	PN	PL	SA	GE	TH	Alfa	RES.	EUC.	A.FEUL.
Azilal	229,849				1,091	5,162		1,000	23,712			50,531	21,372		4,539	43	43
Beni Mellal	110,456		226			19,231	906		2,914			6,585	6,286		701	299	241
Ben Slimane		22,656				11,389							10,291	481	6,354	4,437	391
Khouribga	547	296				33,826							40		879	4,952	475
Sefrou	2,588	513				7,034							2,134		2,637	6,972	1,183
Al Hoceima	352	8,690				69,913	11,501	311	300					4,100	12,644	757	953
Boulemane	92,750					9,181	5,991					1,995	5,090	524,000	657	46	34
Fes	57,059		160			7,195	3,875	1,981				6,427	21,644	700	12,755	2,156	2,352
Taounate	6,547	5,943	3,634			15,393							147				
Taza	153,325	11,972	719			24,176	14,359	6,604	26,132			2,105	60,761	155,318	11,700	852	433
Er-Rachidia	4,115											37,640		12,000			
Ifrane	27,915		5,996				15,455	60				692					
Khenifra	219,642	17,068				14,397	48,921	-7				13,059	9,954	144,600	5,440	452	462
Meknes	59,678	1,340				3,203	26,030	20				838	-7,554		9,487	1,575	421
Chefchaouen	2,403	28,653	2,117			101,676	3,852	2,784	-	102	2,513		2,035		10,473	399	29
Kenitra/Sidi Kacem		63,925				1,464						325			13,295	71,254	3,343
Khemisset	27,215	115,299	529			96,175							50,335		12,424	32,254	2,059
Rabat-Sale		23,774				2,166							939		1,597	2,252	255
Tanger						8,634									4,742	1,512	322
Tetouan	24	44,243	3,965			147,961	100	84	15				350		14,557	5,198	977
Figuig												89,575		1,000,000			
Kenitra	3,500	1,210				2,040			1,800				100	44,700	12,546	4,119	1,753
Oujda	146,676					6,586			5,000				131,108	432,000	21,543	4,254	448
Agadir/Taroudannt	44,436			525,450		45						3,415	101,951		1,191	4,954	2,054
Guelmim				3,100									4,668		0	377	438
Ouarzazate	24,824			3,700	2,340	7,480			707			45,875	13,440	38,015	452	17	34
Tata					38,800							3,420					
Tiznit				132,450									3,800		71	434	537
El Kalaa Sraghna															474	2,423	354
Essaouira	4,431			137,236		7,620						4,254	97,831		1,372	1,551	8,513
Marrakech	192,320	330		11,090		2,659			4,743			45,736	37,884		5,343	1,455	332
Safi				3,896											748	7,089	1,674
AUTRE PROVINCES																	
El-Jadida															2,499	7,639	5,337
Sahara															0	0	11
Tan Tan																	
Casablanca																	
TOTAL	1,434,132	351,412	17,344	821,832	42,231	611,606	131,540	12,851	65,325	102	2,513	314,472	589,713	2,581,914	169,844	175,296	31,337

Total Forets: 4,395,075

NOTE: Nous supposons que la province de Casablanca (constituee des 5 prefectures) n'a aucune couverture forestiere naturelle ou de reboisements. La couverture forestiere de Casablanca est allouee a la province de Ben Slimane. Les provinces de Sidi Kacem and Taroudannt sont incluses respectivement dans les provinces de Kenitra et Agadir, ceci a cause de la structure des services forestiers qui chevauchent 2 provinces . Les donnees pour Rabat-Sale sont developpees a partir des renseignements du service forestier de Kenitra.

Liste des Abbreviations:

CV: Chene Vert
CL: Chene Liege
CZ: Chene Zeen
AG: Arganier
AS: Acacia Saharien
ES: Essences Secondaires
CE: Cedre
Ppr: Pin Maritime
PN: Pin d'Alep
PL: Pin Laricio
SA: Sapin
GE: Genevrier
TH: Thuya
RES.: Resineux
EUC.: Eucalyptus
A.FEUL.: Autre Feuillus

Table 10.

ANALYSE REGIONALE DE LA CONSOMMATION ENERGETIQUE PAR PROVINCE

PROVINCE	POPULAT. URBAINE (1982)	POPULAT. RURALE (1982)	POPULAT. TOTALE (1982)	CONSOM. BUTANE TOTALE (Tonne)	CONSOM. BUTANE URBAINE (GJ/CAPITA)	CONSOM. BUTANE RURALE (GJ/CAPITA)	CONSOM. TOTALE ELECTR. (GW-Hr)	CONSOM. ELECTRIQUE (GJ/Capita)	CONSOM. TOTALE PETR.LAMP. (Tonne)	CONSOM. PETR.LAMP. (GJ/Capita)	CONSOM. URBAINE BOIS (GJ/Capita)	CONSOM. RURALE BOIS (GJ/Capita)	CONSOM. ENERGETIQUE TOTALE (GJ/Capita)
Azilal	32,339	354,776	387,115	800	1.03454	0.01711	2.709	0.07302	31	0.00369	3.63600	14.54400	13.81158
Beni Mellal	255,817	412,886	668,703	5,988	0.97890	0.11007	19.217	0.29987	1,739	0.11978	2.42400	12.12000	9.27283
Ben Sliman	34,262	140,202	174,464	333	0.40646	0.01803	1.694	0.10132	119	0.03142	1.21200	9.69600	8.25692
Khouribga	241,457	195,545	437,002	11,204	1.94052	0.43487	13.873	0.33126	253	0.02667	1.21200	9.69600	6.63305
Settat	143,956	548,403	692,359	6,883	1.99956	0.09526	10.235	0.15426	2,284	0.15195	1.21200	7.27200	6.80940
Al Hoceima	59,490	251,808	311,298	5,044	3.54582	0.15203	6.488	0.21748	764	0.11304	3.63600	14.54400	13.59057
Boulemane	12,493	118,977	131,470		0.00000	0.00000	0.642	0.05096	229	0.08023	3.63600	14.54400	13.63865
Fes	548,209	257,255	805,464	25,502	1.94542	0.75239	68.173	0.88318	7,235	0.41373	1.21200	9.69600	6.78297
Taounate	21,173	514,799	535,972	3,555	7.02171	0.05241	2.287	0.04453	523	0.04495	2.42400	12.12000	12.15417
Taza	108,260	505,225	613,485	5,816	2.24668	0.08737	10.458	0.17788	1,601	0.12020	2.42400	12.12000	11.17548
Er-Rachidia	64,731	356,476	421,207	4,964	3.20704	0.10569	7.555	0.18716	1,942	0.21236	1.21200	7.27200	7.32253
Ifrane	44,547	55,708	100,255	1,589	1.49173	0.21649	4.643	0.48325	85	0.03905	3.63600	14.54400	11.00261
Khenifra	130,862	232,854	363,716	1,430	0.45699	0.04661	9.120	0.26165	387	0.04901	3.63600	14.54400	11.12431
Meknes	386,085	240,783	626,868	10,969	1.18815	0.34576	41.979	0.69878	7,794	0.57268	1.21200	9.69600	6.60678
Chefchaoun	26,499	282,525	309,024	1,307	2.06268	0.03511	2.338	0.07895	77	0.01148	3.63600	14.54400	13.90803
Kenitra/Sidi Kacem	413,083	817,011	1,230,094	8,846	0.89556	0.08218	43.343	0.36767	8,911	0.33367	2.42400	12.12000	9.92061
Khemisset	115,135	290,701	405,836	1,640	0.59569	0.04282	7.417	0.19070	525	0.05958	2.42400	12.12000	9.81922
Rabat-Sale	893,042	126,959	1,020,001	26,182	1.22607	1.56521	171.285	1.75227	1,243	0.05613	1.21200	7.27200	5.04298
Tanger	312,227	124,000	436,227	12,879	1.72503	0.78831	38.764	0.92726	3,217	0.33967	1.21200	7.27200	5.66028
Tetouan	364,725	339,480	704,205	8,211	0.94149	0.18358	35.005	0.51870	1,093	0.07149	2.42400	12.12000	8.26451
Figuig	36,452	64,907	101,359	1,385	1.58896	0.16195	1.779	0.18315	36	0.01636	1.21200	7.27200	5.96728
Nador	115,062	478,193	593,255	10,067	3.65893	0.15978	12.241	0.21531	1,505	0.11685	2.42400	12.12000	11.41006
Oujda	478,919	301,843	780,762	16,000	1.39715	0.40232	37.246	0.49779	1,572	0.09274	1.21200	9.69600	6.09499
Agadir/Taroudannt	296,839	841,403	1,138,242	14,917	2.10158	0.13456	32.389	0.29692	4,606	0.18639	1.21200	7.27200	6.82247
Guelmim	42,886	85,790	128,676	125	0.12189	0.01106	3.075	0.24936	1	0.00036	1.21200	7.27200	5.55000
Ouarzazate	48,914	484,978	533,892	2,474	2.11520	0.03872	2.055	0.04016	1,087	0.09378	1.21200	7.27200	7.07970
Tata	3,142	96,808	99,950	125	1.66375	0.00980	0.338	0.03529	0	0.00000	1.21200	7.27200	7.17658
Tiznit	40,650	272,490	313,140	8,074	8.30641	0.22489	4.258	0.14189	95	0.01397	1.21200	7.27200	7.91518
El kalaa Sraghna	71,605	505,990	577,595	352	0.20558	0.00528	4.534	0.08191	229	0.01826	1.21200	7.27200	6.65102
Essaouira	46,858	346,825	393,683	2,157	1.92509	0.04720	4.242	0.11244	214	0.02504	1.21200	9.69600	9.09439
Marrakech	482,605	784,090	1,266,695	18,961	1.64307	0.18354	70.055	0.57710	6,725	0.24454	1.21200	9.69600	8.02488
Safi	267,162	439,456	706,618	6,801	1.06459	0.11746	21.908	0.32352	405	0.02640	1.21200	9.69600	7.31380
AUTRE PROVINCES													
El-Jadida	150,037	613,314	763,351	6,109	1.70277	0.07560	14.280	0.19520	1,937	0.11688	1.21200	9.69600	8.73597
Sahara	135,953	27,912	163,865	2,297	0.70657	0.62460	7.437	0.47358	0	0.00000	1.21200	7.27200	3.41043
Tan Tan	41,451	5,589	47,040	526	0.53068	0.71431	2.222	0.49290	1	0.00098	1.21200	7.27200	2.97839
Casablanca	2,263,469	173,195	2,436,664	61,925	1.14413	2.71372	481.941	2.06387	11,497	0.21733	1.21200	9.69600	5.35192
TOTAL	8,730,396	11,689,156	20,419,552	295,437	1.41520	0.19183	1197.225	0.61180	69,962	0.15781	1.49044	10.19574	7.95828

NOTE: les donnees du " Activite du secteur petrolier 1982" indiquent que 157891 tonnes de butane sont consommees dans des bouteilles de 12 kilo, tandis que 134956 tonnes ont ete distribuees par des bouteilles de 3 kilo. La consommation par capita pour les secteurs residentiels urbains et ruraux a ete calcule a partir de la formule : ((157891)+2/3(134956))/292847 pour le secteur urbain et 1-formule pour le rural. Nous utilisons le facteur de conversion de 49.41 GJ/Tonne butane. Pour le petrole lampant nous utilisons les donnees provinciales mais n'avons pas de division rural/urbain. Le facteur de conversion pour le petrole lampant est de 46.06 GJ/Tonne. De meme pour l'electricite nous utilisons les donnees de l'ONE pour 1982. Nous supposons que le secteur residentiel utilize toute la basse tension qui n'est pas utilise comme force motrice ou eclairage publique. Finalement, pour le bois nous utilisons le facteur de conversion de 20.2 GJ/Tonne et une densite de 0.6 Tonne/M3.

Sraghna, Nador, Er-Rachidia, and Taounate. Providing an explanation for the cause of the high deficit is beyond the scope of this study. The usefulness of the model lies in the detection of crisis situation provinces based on a population driven fuelwood demand. The situation in the field can be different if, for instance, the renewal capacity of the forest resources is higher than the national average or if the rural population has undertaken a shift to an alternative fuel such as butane.

D. Sources of Additional Forestry Losses

Other factors non related to energy can add to the forest losses. Farmers in several areas are still engaged in the deforestation of forests near their fields in non inventoried areas. They attempt to increase the size of the land under cultivation in this manner. However, because the land loses its natural vegetation and the soil loses its nutrient after a few years, too often the land has to be abandoned and is eroded. The CNF (1981) has in the past estimated the magnitude of this loss at approximately 6000 ha/year.

Commercial and industrial demand for wood is increasing in Morocco. As indicated in earlier sections, there already exist competition between fuelwood demand and industrial wood demand. With wood product import already the third largest agricultural import by value and demand rapidly growing, the competition over limited resources is bound to grow. As Moroccan forests shrink in size and commercial exploitation grows, the rural household is caught in the "rising price/less fuelwood available" spiral. This competition between users will be settled through a market price of wood which will insure availability of wood to the commercial sector and limit the supply for rural households unable to pay the market price. The situation can be seen unfolding with industrial wood prices following the international price and fuelwood prices rising over time.

V. COMPARATIVE FUEL ANALYSIS

A. Role of Wood in the Energy Sector

Historically, wood provided the largest portion of Moroccan energy needs. It is only during the last three or four decades with the availabilty of cheap petroleum and the acceleration of the process of development that a structural change in energy demand occurred. The process of industrialization led to the growing use of higher energy density fuels such as coal and of cleaner and higher quality fuels such as petroleum.

Such a shift is most visible in the transport sector where liquid fuels and electricity replaced animal traction. In industry, modern machinery driven by steam or electricity, increased the productivity of human labor. Similarly, in agriculture, electricity and liquid fuels permitted large scale irrigation and mechanization. Finally, in the residential sector, electricity provided lighting and gave households the possibility to reach for a radically different lifestyle.

The development of the modern sector has led to the growth of commercial energy demand. The oil crisis of 1973 and the price increases which followed, led to an increase in worldwide awareness of the importance of commercial fuels to the development process. In Morocco, the oil price increases have severely affected the economy through the balance of payment impact. In addition, it has had the impact of making the energy planners aware of the limitation of past growth models based on unlimited supply of cheap petroleum.

It is through this difficult search for ways to reduce the magnitude of Morocco's dependence on imported fuels that energy

planners have started to realize the importance of wood in meeting a significant portion of energy consumption. Such awareness is exemplified by the activities of the DEFCS in the Ministry of Agriculture and of the Division du Developement des Resources Energetiques (DDRE) at MEM.

Table 11 presents a national energy balance wich includes the wood componenent being consumed by residential households.
The energy balance table presents a profoundly different view of the Moroccan situation when wood is included. Wood is the largest single source of local fuel and even exceeds petroleum in overall importance. The national resources of fuelwood meet 41.6% of all the energy currently consumed in the country. Also, the residential sector overwhelmingly relies on fuelwood to meet its energy needs (most of the petroleum consumption for households comes from transport activities). It should be noted, however, that devices fueled by wood and charcoal are notably inefficient compared to devices consuming commercial fuels. Thus, the substitution of commercial fuels for biomass and consequent use of more efficient devices would reduce input energy requirements for biomass substitute fuels.

B. Structure of Household Energy Consumption

The use of energy in Moroccan households can be separated into three components: cooking, lighting, and heating. The structure of the consumption varies according to the availability of alternative fuels such as electricity and the location of the household. Urban households have an energy consumption pattern that is structurally different from that of rural households.

Urban Households

Urban households can be divided among two broad categories: the ones with access to electricity and the ones relying on other means of lighting. The electrified households generally use

Table 11. National Energy Balance (1982)

(1000's TEP)

SECTOR	GAS	PETROLEUM	ELECTRICITY	COAL	FUELWOOD	TOTAL
AGRICULTURE	0	291	61	0	0	352
INDUSTRY	64	1086	782	67	0	1999
TRANSPORT&SERVICES	0	1075	41	0	0	1116
RESIDENTIAL	0	611	349	8	3157	4125
	64	3063	1233	75	3157	7592

Table 11 shows more than forty percent of Morocco's input energy requirements is supplied by wood. It whould be noted that devices fueled by wood are traditionally characterized as operating at low thermal efficiency. On the other hand, devices fueled by liquid and gaseous fuels typically operate at higher thermal efficiencies. Thus, for a given amount of useful energy delivered, input energy requirements using liquid and gaseous fuels are likely to be less than wood fueled input energy requirements. However, to take advantage of the substitution of liquid and gaseous fuels for wood will require the increased capital expenditure to also replace the wood fueled devices with the more efficient liquid and gas fueled devices.

electricity for lighting purposes only. Due to the high cost of electricity in term of purchasing power, the utilization of electric motors for household chores is confined to a limited strata of society. Cooking, generally, is performed using a gas stove which may or may not include an oven. Poorer households use the 3 Kg butane bottle, others with larger cooking units may prefer the 12 Kg bottle.

A large segment of the urban population does not have access to or does not use electricity. The lifestyle of those households tends to follow the habits of rural habitants. Lighting is based on the use of candles, kerosene lamps, or, a gas lamp plugged to a 3 Kg gas bottle. Cooking is generally performed using the 3 Kg size gas bottle in conjunction with a two to three head small stove. In the poorer households cooking is done on a clay stove using charcoal or wood. The gas stove is then used as a tea water heater or in cases of sudden need. Bread baking as a rule is done in an outdoor stove fueled by wood.

Rural Households

The vast majority of rural households do not have access to electricity. Traditionally, these households relied on candles and kerosene lamps to provide lighting. But the advent of the small 3 Kg gas bottle outfitted with a translucent combustion head led to a rapid switch to the cleaner and more economic innovation. Since the Seventies, the use of gas for lighting has increased rapidly, with the countryside providing a major market. Recently, however, the demand for butane bottles seems to be slowing. The explanation for the trend lies not as much with the saturation of the rural market which is barely tapped, but with the rapid price rise of butane in last few years which has changed the economic competitiveness of various fuels.
In the country side, fuelwood is used almost exclusively to meet all of the cooking needs. As opposed to the situation prevalent in the cities where fuelwood is generally available only as a

commercial commodity, the rural household usually has available fuelwood within a reasonable walking distance and at no monetary cost. Charcoal, while appreciated for its energy density and ease of use, has a limited utilization as a cooking fuel.In the Rif and in the middle to high Atlas, the winters tend to be cold, hence the need for space heating. Fuelwood is generally used to provide the heating source.

VI. OUTLOOK AND FUTURE PROSPECTS

A. Future Forestry Status

The approach presented in the preceding sections focuses on the current state of the Moroccan forestry sector. In order to develop effective policy options, the analysis needs to be extended to the future in an attempt to project current trends and evaluate their impacts. A number of variables and parameters affect the development of the situation. Development of an effective policy needs to be based on a clear understanding of the interactions of the various factors and an educated extrapolation of the current trend.

Table 12 presents the portion of the model dealing with the projection in the future of the energy balance. The table presents the development of energy demand as a function of both urban and rural population growth per province.

The first six columns of the table provide historical data detailing the division of population between urban and rural areas based on province level data. Census results from 1971 and 1982 are compared and a growth rate derived for each of the provinces. On the average, the population growth rate for the urban population is significantly higher than that of the rural areas. based on the 1971-1982 trend the Moroccan urban population is growing at 4.46% per year and 1.45% in the rural areas.

The right hand portion of the table develops a projection in the future of the rural and urban population based on the historical trend. An energy consumption factor is used to evaluate the per capita energy consumption for each province. The multiplication

Table 12.

PROJECTION DE LA BALANCE ENERGETIQUE

AN: 2005 — REDUCTION ANNUELLE DE LA CONSOMMATION DE BOIS/CAPITA RURAL: 0% URBAIN: 0%

PROVINCE	POPULAT. URBAINE (1971)	POPULAT. URBAINE (1982)	TAUX AUGMENT. URBAIN(%)	POPULAT. RURALE (1971)	POPULAT. RURALE (1982)	TAUX AUGMENT. RURAL(%)	POPULAT. URBAINE 2005	POPULAT. RURALE 2005	CONSOM. URBAINE (M3/Cap.)	CONSOM. RURALE (M3/Cap.)	CONSOM. URBAINE TOT.(M3)	CONSOM. RURALE TOT.(M3)	CONSOM. TOTALE (M3/An)
Azilal	7,140	32,339	14.72%	319,573	354,776	0.95%	761,066	441,416	0.300	1.200	228,320	529,700	758,019
Beni Mellal	117,296	255,817	7.35%	324,412	412,886	2.22%	1,306,194	683,625	0.200	1.000	261,239	683,625	944,864
Ben Slimane	22,244	34,262	4.01%	119,420	140,202	1.47%	84,541	196,084	0.100	0.800	8,454	156,867	165,322
Khouribga	143,170	241,457	4.87%	185,134	195,545	0.50%	720,196	219,244	0.100	0.800	72,020	175,395	247,415
Settat	95,645	143,956	3.79%	480,289	548,403	1.21%	338,460	723,653	0.100	0.600	33,846	434,192	468,038
Al Hoceima	22,496	59,490	9.24%	224,098	251,808	1.07%	454,481	321,318	0.300	1.200	136,344	385,582	521,926
Boulemane	5,399	12,493	7.93%	100,930	118,977	1.51%	72,193	167,820	0.300	1.200	21,658	201,384	223,042
Fes	371,573	548,209	3.60%	218,968	257,255	1.48%	1,236,246	360,323	0.100	0.800	123,625	288,259	411,883
Taounate	8,732	21,173	8.39%	441,180	514,799	1.41%	134,924	710,844	0.200	1.000	26,985	710,844	737,829
Taza	70,890	108,260	3.92%	427,448	505,225	1.53%	262,392	716,619	0.200	1.000	52,478	716,619	769,097
Er-Rachidia	30,716	64,731	7.01%	301,963	356,476	1.52%	307,637	504,354	0.100	0.600	30,764	302,613	333,376
Ifrane	30,920	44,547	3.38%	50,235	55,708	0.94%	95,586	69,155	0.300	1.200	28,676	82,986	111,662
Khenifra	60,027	130,862	7.34%	221,937	232,854	0.44%	667,601	257,447	0.300	1.200	200,280	308,936	509,217
Meknes	288,431	386,085	2.69%	203,747	240,783	1.53%	710,359	341,420	0.100	0.800	71,036	273,136	344,172
Chefchaoun	16,497	26,499	4.40%	231,269	282,525	1.84%	71,382	429,378	0.300	1.200	21,415	515,253	536,668
Kenitra/Sidi Kacem	257,377	413,083	4.39%	677,765	817,011	1.71%	1,110,840	1,207,543	0.200	1.000	222,168	1,207,543	1,429,711
Khemisset	48,647	115,135	8.15%	299,561	290,701	-0.27%	697,467	273,013	0.200	1.000	139,493	273,013	412,507
Rabat-Sale	534,114	893,042	4.78%	83,473	126,959	3.89%	2,616,026	305,109	0.100	0.600	261,603	183,065	444,668
Tanger	201,968	312,227	4.04%	83,692	124,000	3.64%	776,328	282,110	0.100	0.600	77,633	169,266	246,899
Tetouan	248,311	364,725	3.56%	292,668	339,480	1.36%	814,861	462,967	0.200	1.000	162,972	462,967	625,939
Figuig	19,841	36,452	5.69%	68,411	64,907	-0.48%	130,032	58,150	0.100	0.600	13,003	34,890	47,893
Nador	44,176	115,062	9.09%	436,341	478,193	0.84%	851,565	579,127	0.200	1.000	170,313	579,127	749,440
Oujda	295,347	478,919	4.49%	291,842	301,843	0.31%	1,315,848	323,875	0.100	0.800	131,585	259,100	390,685
Agadir/Taroudannt	127,183	296,839	8.01%	707,950	841,403	1.58%	1,746,496	1,207,328	0.100	0.600	174,650	724,397	899,046
Guelmia	18,100	42,886	8.16%	59,105	85,790	3.45%	260,404	186,970	0.100	0.600	26,040	112,182	138,222
Ouarzazate	26,042	48,914	5.90%	386,798	484,978	2.08%	182,742	778,267	0.100	0.600	18,274	466,960	485,234
Tata	1	3,142	6.00%	88,022	96,908	0.87%	12,002	118,116	0.100	0.600	1,200	70,869	72,070
Tiznit	26,035	40,650	4.13%	251,151	272,490	0.74%	103,195	323,148	0.100	0.600	10,319	193,889	204,208
El kalaa Sraghna	29,957	71,605	8.24%	431,189	505,990	1.46%	442,830	706,979	0.100	0.600	44,283	424,187	468,470
Essaouira	32,465	46,858	3.39%	310,936	346,825	1.00%	100,927	435,815	0.100	0.800	10,093	348,652	358,744
Marrakech	352,822	482,605	2.89%	639,843	784,090	1.87%	929,033	1,199,437	0.100	0.800	92,903	959,550	1,052,453
Safi	162,083	267,162	4.65%	392,462	439,456	1.03%	759,591	556,694	0.100	0.800	75,959	445,355	521,314
AUTRE PROVINCES													
El-Jadida	92,185	150,037	4.53%	498,738	613,314	1.90%	415,437	945,079	0.100	0.800	41,544	756,064	797,607
Sahara	1,104	135,953	6.00%	1,731	27,912	6.00%	519,306	106,617	0.100	0.600	51,931	63,970	115,901
Tan Tan	10,722	41,451	13.08%	10,604	5,589	-5.66%	700,552	1,465	0.100	0.600	70,055	879	70,934
Casablanca	1,582,316	2,263,469	3.31%	114,403	173,195	3.84%	4,784,889	412,196	0.100	0.800	478,489	329,757	808,246
TOTAL	5,401,972	8,730,396	4.46%	9,977,288	11,689,156	1.45%	26,493,631	16,612,704			3,591,649	13,831,071	17,422,721

NOTE: Les provinces de Tata et du Sahara ont des donnees incompletes ou peu precises pour l'une des annees 1971 ou 1982. Dans ces cas , et pour ne pas avoir de taux d'augmentation trop haut, nous utilizons un taux de 6%.

of the energy consumption factor by the population estimate permits the calculation of a total rural and urban energy consumption.

In 1971, the level of urbanization in Morocco was 35%. Due to the rapid rate of urbanization caused by the rural migration to the cities, the rate of urbanization reached 43% by 1982. If current trend continues unabated the rate of urbanization will reach 50% within 10 years. The primary impact of the continued urbanisation at such a rapid pace is on fuelwood consumption. Because the range of urban fuelwood consumption is between .1 to .3 M^3 per capita compared to a range of .6 to 1.2M^3 per capita in rural areas, the urbanisation trend negatively affects fuelwood demand even if per capita consumption does not change. Running the model for different future horizons indicates that while fuelwood consumption will grow in absolute value due to the continued growth of population, the rate is dramatically lower than that expected under a no migration case. Further, if the energy consumption factors are reduced due to fuel substitution and more efficient energy transformation devices, fuelwood consumption can be reduced below current levels.

B. Changes in Energy Consumption Coefficients

The analysis of the factors affecting the demand for, and consumption of fuelwood needs to include the availability of alternative fuels and the changes in energy consumption coefficiants. The energy situation in the residential sector is characterized by the prevalence of a number of alternative energy sources able to meet all three basic energy needs: heating, cooking, and lighting. The urban householder often has access to the electric grid and, like his rural counterpart, can choose between a number of liquid, gaseous, and solid fuels. The choice of household fuel is affected above all by the availability of the fuel and the consumer ability to pay for the convenience of higher energy density and ease of use. In this

study, the evaluation of the energy demand demand curve for each fuel and the elasticites of substitution are not studied. The investigation of the pattern of fuel substitution, price elasticities of demand, and the economic costs associated with fuel switching need to be addressed in future studies.

Table 13 presents a regional breakdown of residential energy consumption by provinces. The focus is on developing per capita regional energy consumption factors based on the current fuel mix. The fuels included in the analysis are butane, electricity, kerosene, and fuelwood. The first three columns present regional population data. They are followed by an assessment of the rural and urban consumption of butane. Based on provincial butane distribution data from MEM, residential consumption was evaluated. It was assumed that all the 12 Kg butane bottles and two third of the 3 Kg bottles are consumed in the urban sector with the balance going to the rural sector. Electricity data was developed from ONE's information on low voltage consumption from which we subtracted the energy used for motive power and public lighting. Kerosene data was derived from MEM regional distribution information. Finally, wood consumption information was gathered from previous sections of this report.
Due to the complete lack of information regarding the division of the kerosene and electricity consumption between rural and urban sectors, it was deemed unconstructive to provide unsupported claims regarding their breakdown. The final column in the table provides a total energy consumption estimate but it is based on the weighted average provincial fuel consumption regardless of the setting(1).

---

(1) The energy consumption of electricity is given in electric GJ. For a real evaluation of the various forms of energy this relation between fuelwood demand and residential setting leads to a direct linking of fuelwood demand growth to the degree of urbanisation. need to be brought back to a common denominator i.e. primary fuel form. Thus, to convert electricity which is a transformed energy form back to its primary form, the consumption factor need to be divided by the average thermal efficiency factor of the electricity generating plants. As a

rule of thumb an efficiency figure of 1/3 can be used.

Table 13.

ANALYSE REGIONALE DE LA CONSOMMATION ENERGETIQUE PAR PROVINCE

PROVINCE	POPULAT. URBAINE (1982)	POPULAT. RURALE (1982)	POPULAT. TOTALE (1982)	CONSOM. BUTANE TOTALE (Tonne)	CONSOM. BUTANE URBAINE (GJ/CAPITA)	CONSOM. BUTANE RURALE (GJ/CAPITA)	CONSOM. TOTALE ELECTR. (GW-Hr)	CONSOM. ELECTRIQUE (GJ/Capita)	CONSOM. TOTALE PETR.LAMP. (Tonne)	CONSOM. PETR.LAMP. (GJ/Capita)	CONSOM. URBAINE BOIS (GJ/Capita)	CONSOM. RURALE BOIS (GJ/Capita)	CONSOM. ENERGETIQUE TOTALE (GJ/Capita)
Azrilal	32,339	354,776	387,115	800	1.03454	0.01711	2.709	0.07302	31	0.00369	3.63600	14.54400	13.91158
Beni Mellal	255,817	412,886	668,703	5,988	0.97890	0.11007	19.217	0.29987	1,739	0.11978	2.42400	12.12000	9.27263
Ben Slimane	34,262	140,202	174,464	333	0.40646	0.01803	1.694	0.10132	119	0.03142	1.21200	9.69600	6.25492
Khouribga	241,457	195,545	437,002	11,204	1.94052	0.43487	13.873	0.33126	253	0.02667	1.21200	9.69600	6.63305
Sellal	143,956	548,403	692,359	6,883	1.99956	0.09526	10.235	0.15426	2,284	0.15195	1.21200	7.27200	6.80940
Al Hoceima	59,490	251,808	311,298	5,044	3.54582	0.15203	6.488	0.21748	764	0.11304	3.63600	14.54400	13.59057
Boulemane	12,493	118,977	131,470		0.00000	0.00000	0.642	0.05096	229	0.08023	3.63600	14.54400	13.63865
Fes	548,209	257,255	805,464	25,502	1.94542	0.75239	68.173	0.88318	7,235	0.41373	1.21200	9.69600	6.73297
Taounate	21,173	514,799	535,972	3,555	7.02171	0.05241	2.287	0.04453	523	0.04495	2.42400	12.12000	12.15417
Taza	108,260	505,225	613,485	5,814	2.24668	0.08737	10.458	0.17788	1,601	0.12020	2.42400	12.12000	11.17548
Er-Rachidia	64,731	356,476	421,207	4,964	3.20704	0.10569	7.555	0.18716	1,942	0.21236	1.21200	7.27200	7.32253
Ifrane	44,547	55,708	100,255	1,589	1.49173	0.21649	4.643	0.48325	85	0.03905	3.63600	14.54400	11.00261
Khenifra	130,862	232,854	363,716	1,430	0.45699	0.04661	9.120	0.26165	387	0.04901	3.63600	14.54400	11.12431
Meknes	386,095	240,783	626,868	10,969	1.18815	0.34576	41.979	0.69878	7,794	0.57268	1.21200	9.69600	6.60679
Chefchaoun	24,499	282,525	307,024	1,307	2.06268	0.03511	2.338	0.07895	77	0.01148	3.63600	14.54400	13.90803
Kenitra/Sidi Kacem	413,083	817,011	1,230,094	8,846	0.89556	0.08218	43.343	0.36767	8,911	0.33367	2.42400	12.12000	9.92061
Khemisset	115,135	290,701	405,836	1,640	0.59569	0.04282	7.417	0.19070	525	0.05958	2.42400	12.12000	9.81922
Rabat-Sale	893,042	126,959	1,020,001	26,182	1.22607	1.56521	171.285	1.75227	1,243	0.05613	1.21200	7.27200	5.04298
Tanger	312,227	124,000	436,227	12,879	1.72503	0.78831	38.764	0.92726	3,217	0.33967	1.21200	7.27200	5.66028
Tetouan	364,725	339,480	704,205	8,211	0.94149	0.18358	35.005	0.51870	1,093	0.07147	2.42400	12.12000	8.26451
Figuig	36,452	64,907	101,359	1,385	1.58896	0.16195	1.779	0.18315	36	0.01636	1.21200	7.27200	5.96728
Nador	115,062	478,193	593,255	10,067	3.65893	0.15978	12.241	0.21531	1,505	0.11685	2.42400	12.12000	11.41006
Oujda	478,919	301,843	780,762	14,000	1.39715	0.40232	37.246	0.49779	1,572	0.09274	1.21200	9.69600	6.09499
Agadir/Taroudannt	296,839	841,403	1,138,242	14,917	2.10158	0.13456	32.389	0.29692	4,606	0.18639	1.21200	7.27200	6.82247
Guelmim	42,886	85,790	128,676	125	0.12189	0.01106	3.075	0.24936	1	0.00036	1.21200	7.27200	5.55909
Ouarzazate	48,914	484,978	533,892	2,474	2.11520	0.03872	2.055	0.04016	1,087	0.09378	1.21200	7.27200	7.07970
Tata	3,142	96,808	99,950	125	1.66375	0.00980	0.338	0.03529	0	0.00000	1.21200	7.27200	7.17858
Tiznit	40,650	272,490	313,140	8,074	8.30641	0.22489	4.258	0.14189	95	0.01397	1.21200	7.27200	7.91518
El Kalaa Sragnna	71,605	505,990	577,595	352	0.20558	0.00528	4.534	0.03191	229	0.01826	1.21200	7.27200	6.45102
Essaouira	44,858	348,925	393,683	2,157	1.92509	0.04720	4.242	0.11244	214	0.02504	1.21200	9.69600	9.09439
Marrakech	482,605	784,090	1,266,495	18,981	1.64307	0.18354	70.055	0.57710	4,725	0.24454	1.21200	9.69600	8.02498
Safi	267,162	439,456	706,618	6,801	1.06457	0.11746	21.908	0.32352	405	0.02640	1.21200	9.69600	7.31389
AUTRE PROVINCES													
El-Jadida	150,037	613,314	763,351	6,109	1.70277	0.07560	14.280	0.19520	1,937	0.11663	1.21200	9.69600	8.73597
Sahara	135,953	27,912	163,865	2,297	0.70657	0.62460	7.437	0.47358	0	0.00000	1.21200	7.27200	3.41043
Tan Tan	41,451	5,589	47,040	526	0.53068	0.71431	2.222	0.49290	1	0.00095	1.21200	7.27200	2.97539
Casablanca	2,263,469	173,195	2,436,664	61,925	1.14413	2.71372	481.941	2.06387	11,497	0.21733	1.21200	9.69600	5.35192
TOTAL	8,730,396	11,689,156	20,419,552	295,437	1.41520	0.19183	1197.225	0.61180	69,962	0.15781	1.49044	10.19574	7.95828

NOTE: les donnees du " Activite du secteur petrol
1982" indiquent que 157891 tonnes de butane sont
consommees dans des bouteilles de 12 kilo, tandis
134956 tonnes ont ete distribuees par des bouteil
de 3 kilo. La consommation par capita pour les
secteurs residentiels urbains et ruraux a ete cal
a partir de la formule : [(157891)+2/3(134956)]/2
pour le secteur urbain et 1-formule pour le rural
Nous utilisons le facteur de conversion de 49.41
GJ/Tonne butane. Pour le petrole lampant nous
utilisons les donnees provinciales mais n'avons
division rural/urbain. Le facteur de conversion
le petrole lampant est de 46.96 GJ/Tonne. De mes
L'electricite nous utilisons les donnees de l'Gw
1982. Nous supposons que le secteur residentiel
utilise toute la basse tension qui n'est pas uti
comme force motrice ou eclairage publique. Final
pour le bois nous utilisons le facteur de conver
de 20.2 GJ/Tonne et une densite de 0.6 Tonne/M3.

C. Factors Affecting Fuelwood Demand

Urbanization

The demand portion of the model is based on a per capita fuelwood demand factor which varies with climate and geography but is primarily a function of residential setting. The analysis presented points to the structural differences in energy demand caused by the residential setting. A direct impact of any policy aiming at stemming the rural migration to the cities would be to increase the rate of exploitation of the forestry cover. Such a policy if implemented without a concerted effort toward energy substitution will lead to an increased demand for fuelwood.

Table 14 provides a breakdown of the population growth in its rural and urban component.

Alternative wood usage and demand

Commercial consumption of wood and paper products in Morocco is below that of other developing countries at a similar level of development. Demand for those products is strong and has far outstripped local production capabilities. Wood product imports today are valued right after wheat and sugar in term of commercial importance.

This imbalance between local production and the rapidly growing demand has led to renewed efforts to commercially exploit the Moroccan forests. The World Bank is currently financing a large eucalyptus plantation project in the Gharb Mamora region. If the project is successful, other import substitution or export oriented projects will be implemented to take advantage of the commercial potential of the Moroccan forest.

Such an intensification in the commercial exploitation of the Moroccan forest can lead to a conflict among competing forestry usage. On one hand, millions of villagers are relying on the available "free" fuelwood resources; on the other, commercial exploiters will try to minimize forest product losses. Such a situation will raise the economic cost of fuelwood utilization and reduce available fuelwood resources overall.

Energy Prices and alternative fuels

Two of the most important tools at the disposal of policy makers are pricing and fuel substitution. Their usefulness as effective demand shapers is dependent on a careful dosage of the policy intervention mix. For instance, raising the price of a non substitutable commodity beyond its true economic cost will hurt economic activity in the long run.

In the case of the energy sector in Morocco, energy price rises of recent years have generally brought the country to the level of international energy prices. The impact these decisions have had on the forestry sector is apparent through the change in the rural rate of diffusion of butane gas. Clearly, any significant rise in the price of electricity or butane will reduce demand for those energy sources and lead to substitutions to a more economic fuel such as fuelwood. Similarly, the diffusion of Meskala gas at a competitive price can produce fuel substitution away from fuelwood.

A difficulty inherent in the comparison of commercial and non commercial fuels is the question of the evaluation basis. How attractive is a butane stove when the alternative (fuelwood stove) is monetarily free? What is the value of time in the countryside and how do we develop a utility based economic evaluation of fuel usage? Clearly, the value of women and

children labor expended gathering fuelwood for several hours every day is not zero. Nevertheless they are not the same as labor expended (mostly by men) working on a farm for a monetary wage. In that case any serious evaluation of fuel substitution and pricing needs to be based on economic values of various energy paths.

Table 15 provides a comparative assessment of the impact of a change in fuelwood demand possibly through fuel substitution. The changes in fuelwood demand modeled here are annual decreases ranging between 0 to 4% per year. The table is set up as to show the impact of such policy options on the rural and urban sectors singly, or, implemented on both at the same time. The critical result of the analysis is the importance of implementing fuelwood demand management policies as soon as possible and to focus the intervention where it is more effective: the rural sector.

Table 14. FUELWOOD CONSUMPTION PROJECTION

Years	Urb.Pop (103)	Rural Pop (103)	Total Fuelwood Consumption (103)
1982	8,730	11,689	10,907
1985	9,971	12,215	11,501
1990	12,524	13,161	12,616
1995	15,881	14,201	13,926
2000	20,371	15,347	15,495
2005	26,494	16,613	17,423
2010	35,038	18,014	19,865

Table15.

CHANGES IN FUELWOOD CONSUMPTION BY 2005 DUE TO DEMAND REDUCTION

	0%/yr Urban	2%/yr Urban	4%/yr Urban
0%/yr Rural	17,423	16,088	15,236
2%/yr Rural	12,282	10,948	8,691
4%/yr Rural	9,000	7,665	6,813

VII. CONCLUSION: INTERVENTION OPTIONS

The analysis presented in the previous chapters has pointed to the gap between existing forestry resources and the increasing fuelwood demand. Morocco faces a serious imbalance between fuelwood consumption and the renewal capacity of its forestry resources. The FAO[1] in a review of developing countries fuelwood supplies lists Morocco as one of the countries facing a serious deficit situation. Clearly, a rate of fuelwood consumption three times larger than renewal capacity coupled with the rising commercial demand for wood products and agricultural land is an indication of the severity of the forestry crisis.

Up until the energy crisis of the seventies, few planners in developing countries (Morocco is no exception) made deliberate efforts to control or improve fuelwood supplies. It was assumed that the transition from traditional fuels to commercial energy was automatic and rapid. However, the commercial energy price rise of the seventies coupled with the slowdown in economic growth experienced in the developing world, seem to indicate a continuation of the traditional reliance on fuelwood. Recent experience in Morocco and elsewhere in the developing countries point to a continued reliance on fuelwood in the country side and among urban poor. This situation will continue until a new low cost technology can affect the economics of residential energy utilization.

The increasing recognition of the gravity of the situation and the extent of the forestry problem constitute the first step to resolving it and sloving down the current unchecked trend. As is common with problems incorporating economic, social, technical

---

(1) De Monthalembert, M.R. and Clement, J. "Fuelwood Supplies in the Developing Countries", Rome, 1983.

and policy components; there exist no simple or obvious solution that will increase forestry supplies. Rather, there exist a number of complementary actions and policy options which if combined in a strategic thrust will do much to alleviate the Moroccan forestry crisis and develop Morocco's largest indigenous energy supply.

A. Forestry Solutions

Forestry solutions to the fuelwood crisis generally take the form of increased productivity of the existing resource stock or the provision of new resources. Forest productivity suffers from the combined effect of grazing, fires, logging and wild cutting. Productivity can be increased significantly through more rational management of biomass resources and by applying simple protection methods.

The local population need for new arable land, pasture and fuelwood must be taken into account and is indispensable to the success of forestry management. To ensure successful management of forest land, forestry services must work in cooperation with the people concerned. Local populations must be made aware of the role of the forest for their well being. Successful experience in South Korea and other developing countries indicate that a most effective way of getting rural population to adopt a responsible attitude toward their forest resources is to entrust them with its management. The forestry service then takes on the role of provider of technical assistance with the rural population reaping the benefit of their actions. Further, forestry management solutions aimed at increasing available fuelwood productivity are important for their nature as an effective low cost energy supply options.

Often, populations dependent on fuelwood are concentrated in areas with critical forestry shortages. The remaining natural

forest cover is unable to sustain current levels of demand even if its productivity is significantly enhanced. In such cases, the creation of additional forestry resources is preferred. Forest plantations have also been preferred for they are easy to establish and manage successfully.

Forest plantations are also limited by major difficulties. ecological conditions affect long term yields and are often unfavorable to plantations. The lack of productive land especially in the degraded and previously forested land puts fuelwood in competition for non marginal land. Finally the attitude of the habitants is a determining factor. People do not feel concerned with projects undertaken without their input and are not interested in potential yields more than a decade from now.

B. Actions on Energy Demand

The introduction and difusion of the 3 Kg butane bottle in the rural areas of Morocco represent a highly visible example of a successful substitution of fuelwood demand by a commercial fuel. Substitution or supplement by other fuels may be in certain cases necessary in order to supplement localized fuelwood resources that are clearly insufficient th cover minimum needs.

The traditional sector in Morocco can benefit from a series of technological improvements in combustion efficiency. Current wood stoves are characterized by a very low combustion efficiency. The thermic yield currently seldom exceeds 10% of the fuel's calorific value. Experiments in various developing countries show that is is possible to raise stove efficiencies by at least a third using local materials and technical skills. The dissemination of such stoves or at least the design principles can have a rapid impact in the country side due to the appropriateness of the innovation and its very attractive

economics. Similarly, the charcoal manufacturing sector can benefit from the same kind of transformation efficiency improvement through the introduction of modern kilns.

C. Increased Awareness

The policy options developed in the preceding sections cannot be implemented in a vacuum. Information and extension work is key to the increased awareness of the population most directly affected by the problems of fuelwood energy supply. Incentive measures are needed to complement forestry measures and must provide powerful means of motivation to groups historically bound by traditional energy use.

The Moroccan forestry institutions need to be strenghthened to implement any significant solutions. The energy and forestry institutional framework need to adapt itself to the changing role it is called on performing. Already, Moroccan institutions exhibit a shortage of qualified staff. In the case of DEFCS the shortage of funds and of trained personnel limits the effectiveness of its reforestation and forest management programs. An adaptation of institutional structures and an increase in allocated resources is a prerequisite to for translating fuelwood strategies into actions. It also shows the degree of political commitment by the government to these strategies.

A critical component for the success of a national fuelwood strategy is the development of a significant applied research program in Morocco. While, the solutions to most technical problems are known, their application in the field is dependent on a number of local factors. Considerable research and study need to be undertaken to develop technical solutions well adapted to the Moroccan environment.

VII

Bibliography

Michaelides, E.D., "Wood Energy in the Near East and North Africa", W/Q5556, FAO, Rome 1983

Belrhiti, M., "Etude Socioeconomique sur le bois de feu au Maroc,"MEM Division du developement des resources energetiques, 1984.

Belrhiti, M., "Bois de Chauffage et charbon de bois au Maroc" Memoire de 3eme cycle, Institut Agronomique et Veterinaire Hassan II, 1983.

de Monthalembert, M.R. et Clement, J., "Fuelwood supplies in the developing countries", FAO Forestry paper #42, Rome, 1983.

World Bank, "Kingdom of Morocco, Staff appraisal report of a forestry project," Report no. 3076-MOR 1981.

World Bank, "Kingdom of Morocco Staff appraisal report of a forestry project,Implementation volume", Report no. 3676-MOR 1982.

World Bank, "Morocco Issues and Options in the Energy Sector", Report no. 4157-MOR, 1982.

World Bank, "Prospects for Traditional and Non-Conventional Energy Sources in Developing Countries", Working paper no. 346 , 1979.

Direction des Eaux et Forets et de la conservation des sols Conseil National des Forets, Troisieme Session", 1981

Jader, H., "Direction des Eaux et Forets et de la conservation des sols, "le Secteur Forestier et la Production d'Energie au Moroc", no date.

Parkan, "Projet de l'amenagement Sylvo-Pastoral et de Development Economique zone no.5 Zebzat", FAO, 1981.

El-Asri, Direction des Eaux et Forets et de la conservation des sols, "Sommaire sur les besoins de reboisement", 1983.