No. 49

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT
MAIN TEXT

OCTOBER 1993

NIPPON KOEI CO., LTD.

M P N
J R
93 — 147

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF CAMEROON
SOCIETE NATIONALE D'ELECTRICITE DU CAMEROUN

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT
MAIN TEXT
TOPOGRAPHY

OCTOBER 1993

NIPPON KOEI CO., LTD.

PREFACE

In response to a request from the Government of the Republic of Cameroon the Government of Japan decided to conduct a study on the Memvé Elé Hydroelectric Power Development Project in the Republic of Cameroon and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Cameroon a study team headed by Mr. Michito Kato, Nippon Koei Co., Ltd., seven times between December 1990 and August 1993.

The team held discussions with the officials concerned of the Government of Cameroon and the staff of the National Electricity Corporation (SONEL), and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

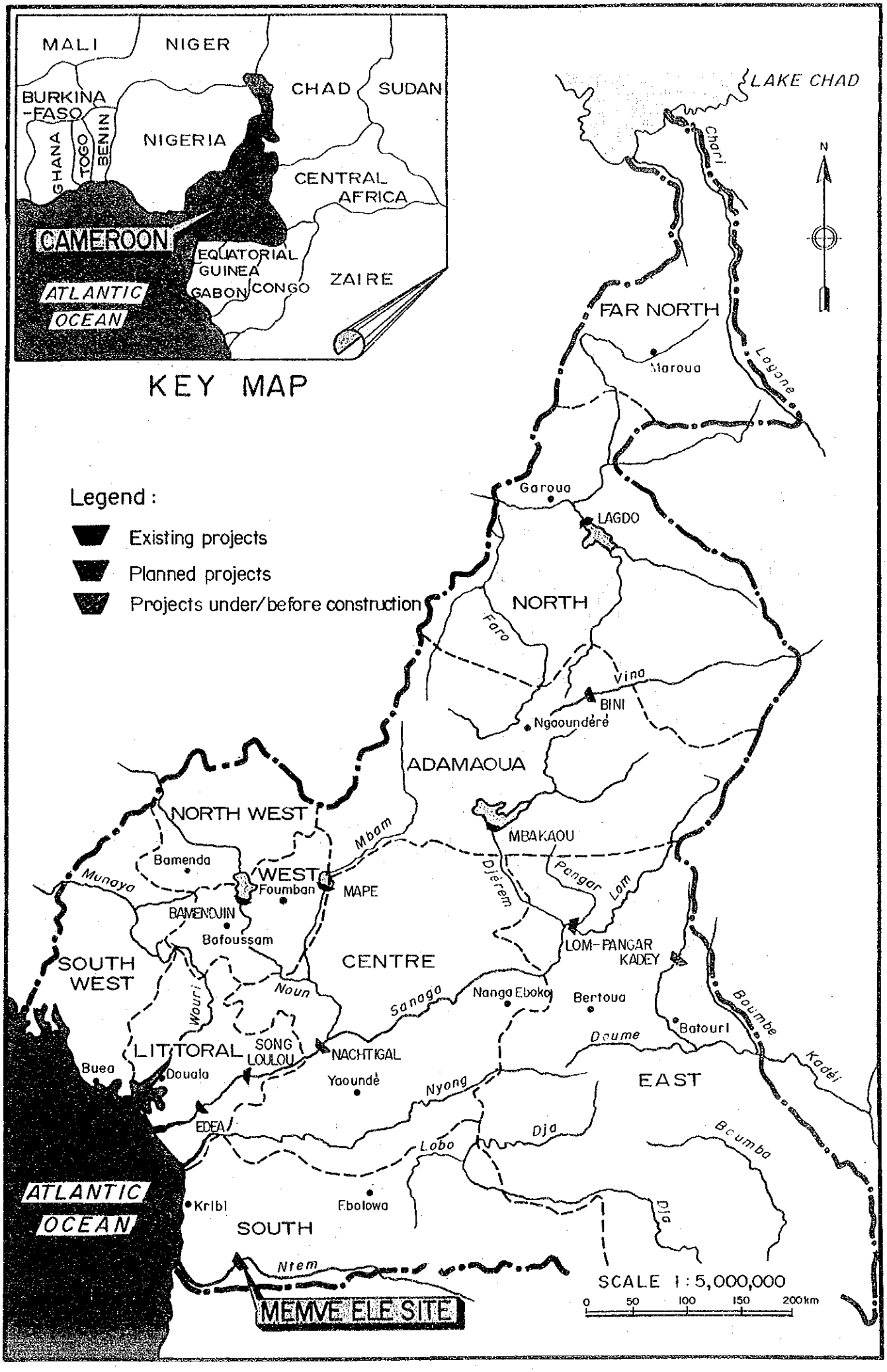
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Cameroon and the staff of SONEL for their close cooperation extended to the team.

October 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency


MALI
NIGER
BURKINA -FASO
GHANA
TOGO
BENIN
NIGERIA
CHAD
SUDAN
CENTRAL AFRICA
CAMEROON
EQUATORIAL GUINEA
GABON
CONGO
ZAIRE
ATLANTIC OCEAN
KEY MAP
LAKE CHAD
Chari
N
FAR NORTH
Maroua
Logone
Garoua
LAGDO
Legend :
Existing projects
Planned projects
Projects under/before construction
NORTH
Faro
Vina
BINI
Ngaoundéré
ADAMAOUA
NORTH WEST
Mbam
MBAKAOU
Bamenda
Munaya
WEST
Foumban
MAPE
Djérem
Pangar
Lam
BAMENDJIN
Bafoussam
LOM-PANGAR
KADEY
SOUTH WEST
CENTRE
Wouri
Noun
Sanaga
Nanga Eboko
Bertoua
Boumbe
Batouri
Daume
LITTORAL
SONG LOULOU
NACHTIGAL
Buea
Douala
Yaoundé
Nyong
EAST
Kadéi
EDEA
Dja
Lobo
Boumba
ATLANTIC OCEAN
Kribi
Ebolowa
SOUTH
Ntem
MEMVE ELE SITE
SCALE 1:5,000,000
0 50 100 150 200km

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

List of Report

FEASIBILITY STUDY
ON
MEMVE ELE HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

MAIN TEXT

Table of Contents

List of Tables

List of Figures

Page

Abbreviations and Symbols

B/C	Benefit-cost ratio
B - C	Net benefit (benefit - cost)
cal	Calorie
cm	Centimeter
CFA	Communauté financière africaine
DST	Development Scale and Timing
e.g.	For example
EL.	Elevation
F.S.	Factor of safety
FSL	Full supply level
F	Franc
Fr	Froude number
g	Gram
g	Gravitational constant
GW	Gigawatt
GWh	Gigawatt-hour
h (hr)	Hour
H	Head
HT	High tension
Hz	Hertz
Hydro	Hydroelectric power
HWL	High water level
i.e.	That is
km	Kilometer
km2	Kilometer squared (km2)
kV	Kilovolt
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
L	Liter
l	Liter
LT	Low tension
MT	Medium tension
MW	Megawatt
MOL	Minimum operating level
max.	Maximum
m	meter
m2	meter squared (m2)
m3	meter cubed (m3)
m3/sec	meter cubed per second (m3/sec)
min.	Minimum
min	Minute
N	Newton
N.A.	Not available
No.	Number
#	Number
O&M	Operation and maintenance
P	Power
p.	Page
pp.	Pages
ppm	Parts per million
rpm	Revolution per minute
rps	Revolution per second
s	Second
vs.	Versus
V	Volt
VA	Volt ampere
W	Watt
WL	Water level
yr	Year

JICA	Japan International Cooperation Agency
SONEL	Société Nationale d' Electricité du Cameroun

I. INTRODUCTION

1.1 Background

The Republic of Cameroon is located at the west most part of Central Africa. It stretches about 1,200 km from Lake Chad to the Atlantic Ocean, or lies between latitudes 2° - 13° North and longitudes 8° - 16° East. The country is roughly triangular and has a total land area of 475,000 km2. Almost a half of Cameroon is covered by tropical rain forests with abundant precipitation.

Cameroon has steadily been developing since its independence. The high economic growth rate of 14% per year was recorded during 1979 to 1988. The gross domestic product (GDP) in 1988 is F.CFA 3,732 billion in current price level, that is translated to F.CFA 2,110 billion in constant price as of 1980. The income per capita in 1988 is as large as F. CFA 334,000. The sudden and large decrease of oil price caused in mid 1980s temporarily made the economic growth negative. It is, however, evaluated that this negative economic growth does not represent the long-term nor future trend of Cameroon economics; the high economic growth rate will be recovered in the very near future.

The topography of the country is very favorable for hydroelectric power development. All of nation-wide hydropower development and potential study is conducted by the sole Cameroonian government agency, National Electricity Corporation (SONEL). SONEL estimates exploitable hydropower potential to be approximately 20,000 MW or 105 billion kilowatt-hour per year.

SONEL is developing the abundant hydropower resources as its main power source. Non hydropower supply is by small-scale diesel generators; it is very limited to only areas isolated from the main transmission line systems. In 1991, the total installed capacity of power generating facilities by SONEL is reportedly of 804 MW. Its 90% or 723 MW is composed of hydropower plants and 10% or 81 MW is of diesel generators.

The electric power consumption in public sectors has continuously increased year by year in a long-term evaluation. The recent annual increase rate of the power consumption measured rather gentle value of 2.0% in last five years. It should, however, be recognized that this gentle increase rate is transitional because the economics is temporarily hovering around zero economic increase these years. The increase rate in long-term view must therefore be

characterized by 5.8% of the power consumption increase in ten years from 1975/76 to 1985/86 or 8.2% in five years from 1980/81 to 1985/86.

In the South Interconnection Network, the larger electric power network in Cameroon, the installed capacity of hydropower plants is 650 MW as of 1992. The system capacity is estimated to be 390 MW for the peak load or 2,570 GWh per year for the energy supply. However, the peak power demand is foretold at about 630 MW in 2010 based on the medium growth scenario by the microscopic method. To fulfill such the electricity demand, it is necessary for the South Interconnection Network to have about 850 MW of the installed capacity if 145 MW of the system capacity decrease in dry seasons and 70 MW of the capacity reserve are considered.

It is, after all, required to develop new hydropower plant(s) to cope with the electricity deficit in the near future. SONEL listed up two hydropower project nominees; the Memvé Elé Hydroelectric Power Project and the Nachtigal Hydroelectric Power Project. The proposed Memvé Elé Project, which is located on Ntem river flowing in the southern part of the country, was first studied by SONEL in the inventory survey as a dam-and-waterway development. It was also listed up in the Sixth Five-Year Development Plan (1986-1991) as one of the prior projects to be studied and designed.

1.2 Study Objectives

The Study aims at formulating the optimum project plan in the view of hydropower engineering and economy. The plan formulation is carried out by assessing the project from the aspects of economic and financial feasibility and further environmental impacts. The economic and financial feasibility is evaluated from internal rates of return (IRR) with sensitivity analyses as well as cash flow analyses.

In parallel to the above studies, transfer of technology is conducted for young engineers of SONEL. The transfer of technology to SONEL engineers will be realized by in-situ technical discussions with the Study Team and be successful by technical training/ collaborations in Japan.

1.3 Work Progress

The Feasibility Study is scheduled to be complete by three stages: *i)* Project Identification as the first stage, *ii)* Field Investigation as the second stage, and *iii)* Feasibility Grade Design as the final stage.

The Project Identification was carried out by the Study Team from December 1990 to March 1991. The identification work confirmed the possibility of the next field investigation works. The finding was compiled in the *Progress Report 1* in March 1991.

From May 1991 to September 1992 the Field Investigations were performed. In the investigation work, all of practicable surveys, investigations and researches were carried out into all of aspects associated with the project realization. The *Progress Report 2* in September 1992 presents the procedures undertaken, results found, conclusions reached, and considerations to be paid for the feasibility grade design.

Since August 1992 the Study Team have discussed the Feasibility Grade Design referring to all of past work. The Feasibility Grade Design work aims to prove how the Project feasible. In January 1993, the Study Team concluded the fundamentals of the Project. The conclusions were compiled in *Interim Report* in January 1993. The report consists of the optimal project layout characterizing waterways, project scale in terms of plant discharge, and other major project features.

The *Draft Final Report* presenting the optimal scale and development timing of the Project was submitted in July 1993. The *Draft Final Report* also describes all of discussions Study Team made during this working period from September 1992 to July 1993. This is the *Final Report* discussing the final conclusions of the study.

1.4 Project Features

The project optimization study from September 1992 to July 1993 concluded the following project features:

(1)	Location:	Near Nyabessan village, Ma'an district, Ntem department, South province
(2)	River System:	Ntem river, Memvé Elé falls
(3)	Type of Power Generation:	Run-of-river with regulating pond

(4) Principal Features of Power Generation

Plant discharge:	450 m3/sec
Effective head:	52.3 m
Installed capacity:	201 MW in total
Number of generator units:	4 units
Annual average power output:	1,140 GWh

(5) Hydrology

Catchment area:	26,350 km2
Annual precipitation:	1,738 mm
Annual mean discharge:	398 m3/sec
Flood peak discharge	
10,000-yr probable flood:	3,450 m3/sec
1,000-yr probable flood:	2,880 m3/sec
200-yr probable flood:	2,480 m3/sec
100-yr probable flood:	2,300 m3/sec
Recorded max. flood:	2,110 m3/sec

(6) Water Storage

Full supply level (FSL):	EL. 392.0 m
Minimum operating level (MOL):	EL. 391.5 m
Gross storage:	130.0 mill. m3
Effective storage:	8.0 mill. m3
Water surface area at FSL:	19 km2

(7) River Diversion Work

Design discharge:	2,110 m3/sec
Diversion method:	Multi-stage diversion
Cofferdam:	Rockfill dam with inclined core, top of crest at EL. 386 m

(8) Dam

Type:	Earthfill dam
Top of dam:	EL. 395 m
Height of dam:	20 m
Dam crest length:	1,850 m
Embankment volume:	884,000 m3
Full supply level (FSL):	EL. 392 m

(9) Spillway

Type:	Gated concrete weir
Spillway design discharge:	3,450 m3/sec
Spillway gates:	5 sets x 11.0 m (W) x 10.5 m (H), radial gates
Sand flush gate:	1 set x 11.0 m (W) x 13.5 m (H), radial gate

(10)	Intake	
	Type:	Lateral type with raised sill at EL. 386 m in front of entrance
	Max. plant discharge:	450 m3/sec
	Screen at intake entrance:	12 sets x 13.5 m (W) x 5.5 m (H)
	Forebay:	160 m (W) x 230 m (L)
	Sand flush gate:	1 set x 1.0 m (W) x 1.0 m (H)
	Intake gate:	4 sets x 11.0 m (W) x 6.5 m (H)
(11)	Headrace Channel	
	Type:	Concrete lined trapezoid section
	Length:	2,400 m
	Bottom width of channel:	15 m
	Slope of side wall:	V : H = 1:2.0
(12)	Head Pond	
	Full supply level (FSL):	EL. 392 m
	Minimum operating level (MOL):	EL. 390 m
	Effective storage:	600,000 m3
(13)	Penstock Intake	
	Type:	Lateral type
	Screen:	8 sets x 10 m (W) x 18 m (H)
	Intake gates:	4 sets x 6.0 m (W) x 6.0 m (H)
(14)	Penstock	
	Type:	Embedded steel conduit
	Length:	4 lanes x 95 m
	Diameter:	6.0 - 4.0 m
(15)	Powerhouse	
	Type:	Semi-underground
	Installed capacity:	4 units x 50.3 MW
	Dimensions:	32 m (W) x 120 m (L) x 65.5 m (H)
(16)	Draft Tunnel:	4 lanes x 6.9 m (Dia)
(17)	Tailrace Surge Tunnel and Chambers:	7 m (W) x 6 m (H) x 770 m (L)
(18)	Tailrace Tunnel:	2 lanes x 9.0 m (Dia) x 1,380 - 1,450 m (L)
(19)	Tailrace Outlet:	Portal with gates and elevated sill
(20)	Switchyard:	Outdoor type
(21)	Generating Equipment:	
	Turbine	4 units x vertical shaft Francis; 52.3 m of rated net head, 112.5 m3/s of max. discharge, 55,900 kW of rated output, 200 rpm of rated speed for each unit

	Generator	4 units three-phase synchronous, 55,900 kVA of rated capacity, 11 kV of rated voltage, 50 Hz of rated frequency, 0.9 of rated power factor, 52,000 kW of electrical output
	Main transformer	4 units, 55,900 kVA capacity, 11/145-132-119 kV voltage
(22)	Transmission Line System:	225 kV, 285 km long, Connected to the South Interconnection System
(23)	Substation:	Expansion of Oyomabang substation in Yaoundé

II SOCIO-ECONOMIC SCENES

2.1 General

2.1.1 Geography

Cameroon, situated in Central Africa, is at the crossroads of Equatorial Africa to the South and Tropical Africa to the North. It shares common boundaries with six countries as Nigeria to the West, Chad to the North-West, Central Africa Republic to the East, Congo, Gabon and Equatorial Guinea to the South. The country has a coastal line of 402 km bordering the Gulf of Guinea, and area of 475,000 km2 consisting 465,402 km2 of land area and 9,598 km2 of water area including rivers, creeks and lakes.

2.1.2 Administrative Units

Administratively, the land is divided into 10 provinces which province itself consists of some departments as of 1991. The departments amount 49 units in the country as a whole and contain several small size communities called arrondissement, which are regarded as the smallest local administrative units in principle. While, some arrondissements are further divided more into the other administrative units named district. In this case, the districts are the smallest units for administration. Fig. 2.1 shows locations of the said provinces as of 1991.

2.1.3 Fiscal Year

The Government of Cameroon is using a fiscal year ending 30th of June. Therefore, years indicated in this study are from first of July in a calendar year to 30th of June in the next calendar year.

2.1.4 Gross Domestic Products (GDP) and Gross National Products (GNP)

Gross Domestic Products (GDP) of Cameroon amounted to F.CFA 3,732 billion in current price as of 1988 at an average growth rate of 14.0% during last 10 years from 1979 as shown in Table 2.1. While, GDP in 1980 constant price amounted to F.CFA 2,110 billion

in 1988 with the average growth rate of 5.2% during last 8 years from 1980 as shown in Table 2.2.

Per capita income indicated approximately F.CFA 334,000 in 1988 with the annual average growth rate of 10.7% from 1980 to 1988 as shown in Table 2.1.

Gross National Products (GNP) of Cameroon amounted to F.CFA 3,383 billion in current price as of 1989 with an average growth rate of 12.1% during last 9 years from 1980 as shown in Table 2.2. While, GNP in 1987 constant price amounted to F.CFA 3,425 billion in 1989 with the average growth rate of 4.4% during last 9 years from 1980 as shown in Table 2.2. Furthermore, the annual average growth rate of GNP per capita was only 3.2% during the same period. The GNP per capita was US $1,000 as of 1989 in current price.

2.1.5 Estimate of GDP Increase

As mentioned above, the GDP in Cameroon was actually increased at the rate of 5.2% during last 8 years. But the situation since 1981, the annual growth rate of GDP from 1985 to 1986 was lower as 7.3%, than that from 1984 to 1985 as 8.9%, and those from 1986 to 1987 and from 1987 to 1988 were decreased from each the previous year as -5.0% and -7.3% since 1985 as the peak year in growth rate.

This situation was supported by the results of the World Bank survey. The World Bank estimated the annual growth rate of GDP as of 1989 from 1988 as -3.3% by the information of the World Tables, IBRD, 1991. Furthermore, the World Bank reported that the GDP at 1987 constant price of F.CFA 2,232 billion in 1985 was decreased to F.CFA 1,928 billion in 1992 with the annual average decreasing ratio of -2.09% by the paper of Special Program of Assistance Status Report for Cameroon prepared for the April 1992 Multi-donor Meeting. The decreasing trend has become a little bit soft comparing with that in previous years, but it is not expectable to increase the GDP rapidly to the future.

As mentioned hereunder, the Government of Cameroon published the Industrial Development Plan 1989-2000 at present. According to this Plan, the Government expects the GDP to increase by the annual average growth rate of 2.55% up to 2000 on pessimistic viewpoint (Scenario A), 3.72% on rather optimistic viewpoint (Scenario B), 3.64% on the

standpoint between the Scenario A and Scenario B (Scenario C), and 4.82% on the most optimistic viewpoint (Scenario D).

This Plan is formed based on the actual investment schedule. For realizing the investment, the social infrastructure such as construction of roads or their betterment should be done first. Therefore, making investment might take a long time.

The Plan includes the betterment of these social infrastructure, and the activities of betterment of social infrastructure are also factors to increase the GDP. Considering these pessimistic and optimistic factors, it is expectable to better some social infrastructures and to execute some of the investments scheduled in early stage of the Plan. Accordingly, it seems that the GDP will increase with the rate assumed in Scenario A or less as the expectable maximum growth up to 2000. After 2001, the GDP will increase higher than before when the betterment activities for the Governmental finance, the social infrastructure and land use are performed.

Concerning the above-mentioned matters, several financing assistance programs are planned from the European Investment Bank, Paris Club and African Development Bank led by the World Bank at present. The future movement of these programs are not assumable now, but it is sure that the betterment activities of the Governmental finance and social infrastructure are gradually executed in the future. It may be expectable that the GDP will increase by the rate assumed in Scenario C up to 2010, and the rate in Scenario B after 2010

2.1.6 External Trade and Balance of International Payment

Exports and imports of Cameroon indicated F.CFA 444,550 million and F.CFA 432,633 million respectively in 1988 as shown in Table 2.3. Of about 70 countries which are related to export/import, seven countries of European Economic Community (EEC) have held first place in the trade amount both of exports and imports, for example, 66% in exports and 63% in imports.

The export for these countries was represented by two commodities of agricultural products and mineral products which accounted for 74% of the total exports in 1988. Especially, banana, coffee (arabica and robusta), cocoa (beans and processing products as butter) in the agricultural products, and crude oil in mineral products are the main goods for the exports.

On the other hand, the import was represented by five commodities of food products, semi-manufactured goods, industrial equipment, household consumable and consumable for enterprises which accounted for 83% of the total imports in 1988.

In Cameroon, the imports had exceeded the exports from 1970 to 1983 except 1973 and 1974 according to the data as shown in the said Table. However, this trading situation have been reversed since 1984 except 1987.

The long term capital in Cameroon including domestic loan and foreign grant was plus side as F.CFA 76.2 billion in 1982, F.CFA 180.7 billion in 1983, F.CFA 191.3 billion in 1984, F.CFA 38.6 billion in 1985, F.CFA 80.1 billion in 1986 and F.CFA 108.8 billion in 1987 as shown in Table 2.4. However, the balance of the international payment dropped into minus side in 1987. For stabilization of the international payment of Cameroon, it may be necessary to introduce further these long term capital.

2.1.7 Government Finance

In 1987, the Government finance of Cameroon amounted to F.CFA 879.5 billion (equivalent to 22.0% of GDP) in expenditure and F.CFA 742.8 billion in receipts, at the average annual rise rate of 14.6% and 13.7% respectively during the period from 1982 to 1987 (see Table 2.5).

Of the expenditures, the development expenditure accounted for F.CFA 340.0 billion in budget in 1987 which is nearly 40%. On the other hand, the receipts represented by the Government revenue only of the said amount, and no any receipts like foreign grant since 1987.

On the viewpoint of budget scale, the receipts have been reduced year by year. Accordingly, the actual receipts were decreased, and the expenditures were also curtailed.

Therefore, the Government financial statistics show that the expenditures exceeded receipts since 1987. These deficits were supplemented by foreign loans and domestic loans.

2.2 Socio Economic Features

2.2.1 Population

According to the statistic data, the population of Cameroon was 11,181,035 (24 persons/ km2) of which urban and rural population consisted 39% and 61% respectively in 1988 provided that the figures since 1977 were estimated ones. The average annual growth rate of population showed about 3.0% for the country as a whole during the period from 1971 to 1988 as shown in Table 2.6.

The Government of Cameroon has made a population census in 1987 as mentioned above. But the results are not published yet. The Government reported work progress about the said population census with a paper of "Situation et Perspectives Demographique du Cameroun". The column noted (2) in Table 2.7 shows the results. In accordance with this data, the population was at 10,483,655 in total in 1987, and was distributed to each province as shown in the table. This table explains that the Littoral Province and West Province have the highest population density such as 67/ km2 and 97/ km2 respectively. Those provinces have the cities as commercial centers named Douala and Bafoussam respectively.

Here, Wouri Department consists of 4 arrondissements, namely Douala I, Douala II, Douala III and Douala IV, so Wouri Department is called as Douala city in general. And, Mfoundi Department also consists of 4 arrondissements as Yaoundé I, Yaoundé II, Yaoundé III and Yaoundé IV, so Mfoundi Department is called as Yaoundé city in general. Therefore, population densities of Wouri and Mfoundi Departments mean the population densities of Douala and Yaoundé cities.

On the viewpoint of the above, the population densities of Wouri and Mfoundi Departments were counted as 1,350 persons per km2 and 2,782 persons per km2 based on the data mentioned in Table 2.6. These are considerable phenomena because that Douala is the biggest commercial center and Yaoundé is the capital city of the country.

The South Province, in which located a planned Memvé Elé Dam in this study, has a small population density as 8 persons per km2 as of 1987 because that the province is not urbanized yet.

According to other Governmental data as "Perspective de l'Economie Camerounaise a l'Horizon 1991", the population in 1991 was estimated as 12,243,700 in the whole country.

The working active population was 4,363,301 in 1988 in the country as a whole, and its average annual growth rate was 3.6% in the whole country during the period from 1982 to 1988. Table 2.8 shows its detail. According to this Table, the annual growth rates of the actual working population in the country was about 4% in the primary, secondary and tertiary sectors of industries, but that of not-occupied persons has decreased as -16.3%. The increasing of annual growth rate of the actual working population in the specific industrial sectors means the increasing of employment, and the decreasing of not-occupied persons comparing with the annual average growth rate of working active population has supported the increasing of employment, too.

The Government of Cameroon made a population projection up to 2020 by five years interval dividing into 3 scenarios as i) in the case of high growth, ii) in the case of middle growth and iii) in the case of low growth for the whole country in the said paper of "Situation et Perspective Demographique du Cameroun" based on population census data of 1976 and 1987. A sub table (1) shown in Table 2.9 indicates the said projection. With this data and annual growth rates of population in each province based on the data in 1976 and 1987 shown in Table 2.7, the population distribution up to 2020 by five years interval to each province may be estimated as shown in Table 2.9 (2) for the case of high growth and the case of middle growth.

A report prepared in 1987 by the World Bank said "As in all African societies, most couples in Cameroon want to have many children. The 1978 National Fertility Survey found that the average number of births desired was 8, with only 3 percent of fertile married women wishing to stop bearing children. This desire for children has diminished slightly among educated and urban women, but still the proportion of women wanting to stop bearing children have been very small in every category, never reaching as much as 10 percent."

And, the report said that the fertility rates in rural and urban areas were 4.38% and 5.32% respectively in 1983, and that in the whole country was 4.6% in the same year. The fertility rate in the whole country had decreased as 4.3% in 1987, but is still high. A reason of estimating the population distribution up to 2020 by five years interval to each province

mentioned above in 2 cases only as the case of high growth and the case of middle growth only is to be considered these high fertility rates.

In this connection, the mortality rates in Cameroon were 1.5% and 1.4% in country wise average in 1983 and in 1987 respectively reported in the said report. On the other hand, the infant mortality rates were 9 % and 12% in urban and rural areas respectively as of 1978, and the child mortality rates were 2% and 3% in urban and rural areas respectively in the same year. So that the total mortality rates including infant and children were 11% and 15% in urban and rural areas at that time. These mortality rates were increased as 13.2% and 16.0% as of 1987 indicated in the said report.

The report said also that the distribution rates of children and adults were 44% and 56% in 1980, but those are estimated as 48% and 52% in 1990, 49% and 51% in 2000, and 51% and 49% in 2015. The report indicates that Cameroon will be young-wised country in population in the future.

According to the said paper "Situation et Perspective Demographiques du Cameroun", the average age of marriage for women was 20.9 years and marriage rate for women in the country was 93%. Furthermore, the marriage rate for men was less than 92% in the same year. Polygamy is still common in Cameroon. According to the 1978 National Fertility Survey, 40% of all married women were living in a polygamous union. By a reason of such social situation, households statistics could not be made in recent years. About 15% of such married women had not any child because of sterility and so on.

Taking into account the situation mentioned above, an average family size may be estimated as 7.6 persons per household assuming 90% of marriage rate for men and distribution rate of men and women in whole population.

2.2.2 Industrial Perspectives

As already studied in the previous item, composite rates of GDP for industry groups as primary sector represented by agriculture and agro- industry, secondary sector represented by manufacturing and tertiary sector represented by trading were 20.5%, 31.8% and 34.1% respectively in 1988. The remaining rate of 13.6% was for public administration and others.

This means that Cameroon is a rare trading country among developing countries. However, difference between trading and another industry groups is not so big. It can be presumed that the production, processing and trading are balanced in Cameroon. The features of external trade have been studied in the previous item, so the agricultural and other industrial features are studied hereunder in the following items.

Agriculture and Agro-industry

As shown in Table 2.8, approximately 80% of the working active population of the country engaged in the primary sector in 1988. The primary sector of industries is represented by agriculture and agro- industry as mentioned above.

There are a lot of agricultural production in Cameroon. Among this, the remarkable products for trading are cocoa, coffee, cotton, banana, tobacco. Table 2.10 shows the volume of these agricultural production.

According to the data shown in this Table, the products of cocoa, coffee and cotton for trading and rubber, palm oil and sugar for agro- industry have gradually increased year by year. The increasing ratio of cocoa, coffee and cotton were 2.7%, 2.5% and 6.1% respectively during the period from 1982 to 1988, and those of rubber, palm oil and sugar were 9.2%, 7.8% and 8.2% respectively during the same period.

That increasing of agriculture and agro-industrial production resulted the volume of products as 135,116 tons in cocoa, 112,832 tons in coffee, 113,699 tons in cotton, 29,227 tons in rubber, 102,960 tons in palm oil and 105,722 tons in sugar in 1988. Here, the figures in palm oil only was in 1987 because of lack of data for 1988.

In this connection, cultivation area is shown in Table 2.11. According to the data, the cultivation area for cocoa and sorghum were rather wider as 3,487 km2 and 3,731 km2 respectively than the other products, that of maize was the second one as 2,057 km2 and coffee (arabica), coffee (robusta), groundnuts, cassava and oil-palm were the third ones as 1,011 km2, 1,541 km2, 1,341 km2, 1,136 km2 and 1,023 km2 respectively in the country as a whole in 1987.

Provincially, Extreme North Province had the widest traditional cultivated area of 4,027 km2 and the cultivated area which was highest modernized was in Littoral Province as 27.5%.

Statistics for food crops for people's living are not made public yet as of 1990. However, the main food crops are plantain banana, cocoyams, maize, cassava, Irish potatoes and rice according to the result of field investigation. And, the products are varied by the area where the people live in.

Industrial Features as a Whole

Table 2.12 shows statistics of major industrial establishments and employees who are engaged in those establishments in the country as a whole. Industrial group shows the whole manufacturing in Cameroon.

The establishments of manufacturing industries which have 50 or more employees in Cameroon amounted 94 in number as of 1988, and number of employees indicated approximately 44,000 in the same year. In the total number of employees, those of agro-industry, processing of agricultural products, soft drinks and tobacco, and electric, gas and water were rather high in composite rate for total employees comparing with others as 6,557 persons, 8,209 persons, 7,688 persons and 6,928 persons respectively in 1988.

By these establishments, total turnover in Cameroon counted as F.CFA 426,691 million, and the turnover of soft drinks and tobacco was the highest as F.CFA 131,801 million (30.9%) in 1988, that of electric, gas and water was the second one as F.CFA 58,803 (13.4%) and that of basic metallurgy industry was the third one as F.CFA 49,085 million (11.5%) in the same year as shown in Table 2.13.

On the view point of increasing of production, other foodstuff industry has the highest increasing ratio as 19.5% and that of other type of manufacture was the second one as 11.9% since 1975. Almost of all industry groups were increased in production comparing with those in 1975 as shown in Table 2.14, but production of fishery, leather and shoes and transportation equipment were decreased since 1975. Contrarily, almost of all products were decreased since 1984 except agro-industry, processing of agricultural products, soft drink and tobacco, wood and timber and electric, gas and water.

Several remarkable products of goods are shown in Table 2.15 in volume, and main export commodities are shown in Table 2.16 in amount. In accordance with these data, it can be presumed that agriculture, agro- industry and mining represented by plywood, timber and cement shown in Table 2.15 and cocoa, coffee and crude oil shown in Table 2.16 are the main industry in Cameroon.

Commercial activities as the tertiary sector of industrial group indicated also high tendency. Table 2.17 shows main import commodities in Cameroon. It shows that consumable for enterprises has the highest composite rate of total import amount as 23.2% in 1988. And, an annual increasing ratio of imported food, soft drinks and tobacco was the highest (16.8%). According to this Table, the annual increasing ratio of imported agricultural equipment was also high as 14.0%. This means that the presumption mentioned above may be supported in commercial activities too.

High increasing ratio of raw materials of animal and vegetable origin (9.7%) and consumable for housing (7.3%) may also support the commercial activities in Cameroon, because these are the articles for people's living.

Industrial Development Plan 1989-2000

The Government of Cameroon have made public the Industrial Development Plan 1989-2000 (the Plan).

In this Plan, the Government of Cameroon projected several kind of economic and financial indicators divided into 4 scenarios, i.e. the Scenario A which was made on pessimistic viewpoint in economic growth rate, the Scenario B which was made on rather optimistic viewpoint, the Scenario C which was made from the standpoint between the Scenario A and B, and the Scenario D which was made on most optimistic viewpoint.

According to this Plan, the GDP was projected to become as follows as a macro-economic prospect.

Scenario	Total GDP in 2000 (F.CFA billion) (1985 constant price)	Growth ratio (%)
A	5,043	2.55
B	5,874	3.72
C	5,732	3.64
D	6,680	4.82

Note: Increasing ratio means average annual increasing ratio for the period from 1989 to 2000.

The Plan says that the investment amount will become as a sum of F.CFA 596,988 million in total which will be invested to 29 projects up to 2000. Among this, the investment for petroleum will be F.CFA 297,850 million with 49.9 % in composite rate. The detail of investment program is shown below.

Industrial sector	Investment amount (F.CFA million)	Composite rate (%)
Agriculture/agro-industry	11,231	1.9
Forestry	31,280	5.2
Wood/timber/lumbering	14,810	2.5
Chemical industry	9,205	3.2
Aluminum/bauxite	175,000	29.3
Metals	47,000	7.9
Petroleum/gas	297,850	49.9
Mechanic/electric products	612	0.1

The Plan also explains the development schedule and scale by each industrial sector. The investment schedule is divided into three terms, namely i) short term from 1988 to 1990, ii) the medium term from 1990 to 1995 and iii) the long term from 1995 to 2000. The investment amount for the short term is a sum of F.CFA 52,012 million which is 8.7% for the total investment amount, that for the medium term is a sum of F.CFA 38,926 million (6.5%) and that for the long term is a sum of F.CFA 506,050 million (84.8%).

In the short term investment period, the metallurgy is the main investment target as indicated the investment amount of F.CFA 26,000 million, approximately 50% in share in the short

term investment amount. Others are divided into 5 industrial sectors as agriculture/agro-industry, forestry, chemical industry, petroleum/gas, and mechanic/electric products. But, the investment amount for petroleum /gas as amounted to F.CFA 4,600 million is only 1.6% for the total investment amount for it. Most part of development amount for petroleum/gas will be invested in the long term investment period.

In the medium term, the investment amount consists of agriculture/agro-industry, forestry, wood/timber/lumbering, chemical industry and metallurgy. Those investment amounts are not so big, but the investment for agriculture/agro-industry and wood/timber/lumbering will be finalized in this term.

In the long term, as mentioned above, the investment for petroleum/gas is the main target as amounted to F.CFA 293,050 million (57.9% for the total investment amount in the long term), and the second target is the development of aluminum/bauxite as amounted to F.CFA 175,000 million (34.6%).

Besides the development program mentioned above, the Government of Cameroon has several plans as development of equipment and materials for construction, as development and improvement of infra-structure like road betterment or arrangement of transportation network or facilities including railway network, seaports and airports. These are also explained in the Plan.

Anyway, in the beginning of 21st century, Cameroon will make a fresh start in industrialization, so demand of energy will also increase more than present demand scale because that the energy is the basic needs for industrialization too as well as for human life.

2.2.3 Price

Urban consumer price in Douala as well as Yaoundé rose to about 4.4 times for the period from 1966 to 1988 in general. Prices of food, beverage, housing, clothing, transportation and other services indicated somewhat higher rise in rates than those of leisure and health in Yaoundé and lower in Douala in the same period as shown in Table 2.18.

This situation was not so far from changing for the period from 1982 to 1988. The average annual increasing ratio was about 6% in general both in Douala and in Yaoundé, but those of beverage and health became higher increasing ratio comparing with those in general.

In Douala, the average annual increasing ratios of imported articles and local articles are almost same; 6.3% and 6.4%, respectively. Those values in Yaoundé are 6.7% and 5.1%, respectively. The imported articles were rather expensive comparing with local articles. The average increasing ratio of prices is 7.2% per year for the country.

Table 2.19 shows the prices of several daily articles and retail price index for consumers living in Yaoundé. In 1988, wheat flour, rice, sugar, salt and cooking oil costed at F.CFA 113 per kg, F.CFA 120 per kg, F.CFA 265 per kg, F.CFA 71 per kg and F.CFA 544 per liter, respectively. And, the retail price index have exceeded the consumer price index as about 6.5 times comparing with that of 1966. Furthermore, the average annual increasing ratio of retail price also exceeded that of several daily articles. It seems that these high prices of daily articles put pressure on people's living on the viewpoint of the per-capita income mentioned in previous item.

2.3 Perspective of Energy and Electric Power in Cameroon

2.3.1 Energy

Cameroon is the one of oil producing countries in Africa. Energies of solids, liquids, gas and electricity were produced as 47,159, 119,678, 101,324 and 46,919 thousand tons in coal equivalent in 1986. Of these production, 44,817 thousand tons were imported and 112,475 thousand tons were exported in the same year as shown in Table 2.20.

Consumption of energy was 33,864 thousand tons in solids, 99,408 thousand tons in liquids, 73,052 thousand tons in gas and 42,746 thousand tons in electricity, and those composite rates were 13.6%, 39.9%, 29.3% and 17.2% respectively in 1986.

2.3.2 Production of Electric Power

The work of power generation and its distribution is presently executed by the Société Nationale d'Eléctricité du Cameroun (SONEL). SONEL is the one of joint-stock agencies

with co-managing established on May 18, 1974. Since 1985, the Cameroon State Interest of the Government invests the capital of 93% amounting to a sum of F.CFA 30 billion, the remaining is covered by the Central Economic Cooperation Fund in Europe. Detailed explanation about its organization is given in this chapter hereunder.

The total hydro-power energy production was 2,648.5 GWh in 1989 with average annual increasing ratio of 4.9% during the period from 1971 to 1989, the total thermal power was 41.0 GWh in 1989 with 3.5% in average annual increasing ratio during the same period. Therefore, the total power production both of hydro and thermal powers was 2,689.5 GWh, and its average annual increasing ratio was 4.9%. This increasing ratio had supported the demand of electricity in Cameroon during these 20 years.

2.3.3 Power Consumption

Demand of electricity in Cameroon composes of three categories. The customers in the first category are represented only by 5 companies as of 1989, namely i) ALUCAM which produces aluminum material, ii) CELLUCAM which produces paper pulps, iii) SOCATRAL which produces aluminum and zinc products, iv) CIMENCAM which produces cement and v) SONARA which refines petroleum. They are the biggest manufacturers in Cameroon, and they usually use electricity which is distributed by high tension (HT, high voltage) transmission line.

The customers in the second category consist of small and medium scale industries, shops and/or firms. They usually use the power distributed by medium tension transmission line.

And, the third category is for domestic customers who use the electricity of low tension transmission line. The domestic customers consist of ordinary domestic users like inhabitants for their house lighting, users who use motors, public uses like street lighting, special services and agencies concerning SONEL.

The energy consumption shown in Table 2.21 is indicated by these categories. And, Table 2.22 shows income of SONEL by the categories and number of customers.

The data explain that the energy consumption by the high tension category customers was 1,368.9 GWh by 4 customers, and income from these customers amounted F.CFA 6,125

million. On the other hand, the energy consumption by medium and low tension category customers were 481.8 GWh and 543.1 GWh each and SONEL received the power income as sums of F.CFA 14,449 million and F.CFA 26,889 million respectively. This indicates that high tension category customers are treated well in power tariff.

Accordingly, the high tension category customers have paid as their power charges amounted to a sum of F.CFA 1,531 million per one customer, the medium tension category customers have paid a sum of F.CFA 13 million per customer and the low tension category customers have paid a sum of F.CFA 89 thousand per customer for one year in 1989.

The unit power charge for the customers of high, medium and low tension categories were F.CFA 4.5, F.CFA 30.0 and F.CFA 49.5 per KWh respectively as of 1989.

The power consumption in Cameroon is varying by regions. Table 2.23 shows power consumption situation by region. The consumption of low tension category customers in Littoral and West Provinces were the highest in energy as 295.5 GWh and those in Central, South and East Provinces were the second highest as 164.7 GWh which share 54.4% and 30.3% respectively for the total consumption in Cameroon.

This situation was almost the same with that of the medium tension category customers also. The shares of consumption in energy in Littoral and West Provinces, and Central, South and West Provinces were 59.7% and 21.1% respectively for the consumption in the country as a whole.

Sales amount and number of customers in these five provinces were also about 50% in share for the total amount and number in the country. But, on the viewpoint of average annual increasing ratio, North Province was highest in energy and sales amount, too, both in low tension category customers and medium tension category customers as about 20% and 30% or more.

2.3.4 Finance of SONEL

The total revenue of SONEL was F.CFA 61,696 million in 1990 and their total expenditure was F.CFA 55,843 million, so the cash balance of finance was F.CFA 5,853 million in the

same year as shown in Table 2.24. Of the expenditure, development cost for power station itself was F.CFA 9,111 million and it shared approximately 16% for the total expenditure.

The average annual growth ratio of revenue and expenditure were 15.85% and 14.43% respectively and cash balance of finance was always plus side except in several years. SONEL is a self-financing agency with no any subsidy for financing from the Government, so the financing situation is reasonable.

Table 2.1 Gross Domestic Products by Industry of Origin

(Current price)

(F.CFA billion)

Industry of origin	(1) 1979	(1) 1980	(1) 1981	(1) 1982	(1) 1983	(1) 1984	(1) 1985	(2) 1986	(2) 1987	(2) 1988	Average annual growth R. (%)
PRIMARY SECTOR											
Agriculture/ forestry/ fishery	359	404	488	587	607	702	790	908	976	954	11.5%
Growth(%)	-	12.6%	20.7%	20.2%	3.5%	15.6%	12.6%	14.9%	7.5%	-2.3%	
SECONDARY SECTOR											
Extractive industry	33	106	202	263	401	521	630	505	359	353	30.0%
Growth(%)	-	218.7%	90.5%	30.6%	52.2%	30.0%	21.0%	-19.9%	-28.8%	-1.8%	
Manufacturing	102	124	174	247	291	359	422	515	546	519	19.8%
Growth(%)	-	21.8%	40.0%	42.2%	17.8%	23.2%	17.8%	21.9%	6.0%	-4.9%	
Electricity/ gas and water	14	17	18	22	30	35	38	45	48	53	15.5%
Growth(%)	-	17.5%	4.2%	26.9%	35.6%	16.9%	7.1%	19.6%	6.2%	9.6%	
Construction and public works	68	84	103	125	146	193	228	279	265	175	11.1%
Growth(%)	-	24.1%	22.4%	21.0%	16.6%	32.1%	18.2%	22.4%	-4.7%	-34.1%	
TERTIARY SECTOR											
Trade/restau-rants/ hotels	184	202	232	249	311	415	565	658	571	583	13.7%
Growth(%)	-	10.2%	14.8%	7.3%	24.6%	33.5%	36.1%	16.6%	-13.3%	2.2%	
Transportation/ warehouse/ communication	78	90	104	119	129	147	231	249	232	215	12.0%
Growth(%)	-	16.0%	15.1%	15.2%	8.0%	14.4%	56.6%	7.8%	-7.0%	-7.0%	
Bank/insurance/ real estate/ services rendered to undertakings	168	190	248	285	355	397	455	470	491	383	9.6%
Growth(%)	-	13.5%	30.3%	14.9%	24.6%	11.7%	14.7%	3.3%	4.3%	-21.9%	
Furnishing services to community and personal services	11	18	23	28	35	39	46	54	56	59	20.1%
Growth(%)	-	54.9%	30.9%	22.3%	23.2%	13.9%	17.8%	16.6%	4.3%	4.3%	
PUBLIC ADMINI-STRATION	129	175	206	247	314	388	434	453	461	438	14.5%
Growth(%)	-	35.0%	17.7%	20.3%	27.1%	23.4%	11.9%	4.2%	1.9%	-5.0%	
Total	1,146	1,410	1,797	2,173	2,618	3,195	3,839	4,135	4,005	3,732	14.0%
Growth(%)	-	23.1%	27.4%	20.9%	20.5%	22.0%	20.2%	7.7%	-3.2%	-6.8%	
Income/Cp (1,000 F.CFA)	134	168	209	246	289	337	386	395	381	334	10.7%
Growth(%)		25.4%	24.4%	17.7%	17.5%	16.6%	14.5%	2.3%	-3.5%	-12.3%	

Sources: (1) Comtes Nationaux du Cameroun (Version SCN), Resultats 1985/86, Projection 1986/87 et 1987/88, January 1989.

(2) Note Annuelle de Statsitique, 1987/88.

Note: Note:Income/Cp means income per capita.

Table 2.2 GNP and GDP by Industrial Sector

Industrial sector	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Average annual growth ratio
GROSS NATIONAL PRODUCT (GNP) (3											
Current GNP (Billion F.CFA)	1,427	1,800	2,158	2,610	3,060	3,596	3,949	3,818	3,568	3,383	12.1%
(Annual growth ratio)	-	26.1%	19.9%	20.9%	17.2%	17.5%	9.8%	-3.3%	-6.5%	-5.2%	
GNP at 1987 Constant price (Billion F.CFA)	2,513	2,838	3,000	3,235	3,416	3,678	4,025	3,818	3,536	3,425	4.4%
(Annual growth ratio)	-	12.9%	5.7%	7.8%	5.6%	7.7%	9.4%	-5.1%	-7.4%	-3.1%	
Current GNP per Capita(US$) (3	760	900	900	870	820	810	890	920	980	1,000	3.2%
GROSS DOMESTIC PRODUCT (GDP) AT 1980 Constant price											
	(1	(2	(2	(2	(2	(2	(2	(2	(2		
PRIMARY SECTOR (Billion F.CFA)	404	461	497	491	481	459	473	475	433	-	0.9%
(Annual growth ratio)	-	14.1%	7.8%	-1.2%	-2.0%	-4.6%	3.1%	0.4%	-8.8%		
SECONDARY SECTOR (Billion F.CFA)	331	427	504	592	662	722	794	698	671	-	9.2%
(Annual growth ratio)	-	29.0%	18.0%	17.5%	11.8%	9.1%	10.0%	-12.1%	-3.9%		
TERTIARY SECTOR (Billion F.CFA)	478	541	546	568	638	779	850	806	721	-	5.3%
(Annual growth ratio)	-	13.2%	0.9%	4.0%	12.3%	22.1%	9.1%	-5.2%	-10.5%		
PUBLIC ADMINI-STRATION (Billion F.CFA)	197	222	229	250	268	272	277	296	285	-	4.7%
(Annual growth ratio)	-	12.7%	3.2%	9.2%	7.2%	1.5%	1.8%	6.9%	-3.7%		
Total (Billion F.CFA)	1,410	1,651	1,776	1,901	2,049	2,232	2,394	2,275	2,110	-	5.2%
(Annual growth ratio)	-	17.1%	7.6%	7.0%	7.8%	8.9%	7.3%	-5.0%	-7.3%		

Sources: (1) Comptes Nationaux du Cameroun (Version SCN), Resultats Semi-Definitifs 1983/84, Projections 1984/85, May 1985.
(2) Comtes Nationaux du Cameroun (Version SCN), Resultats 1985/86, Projections 1986/87 et 1987/88, January 1989.
(3) World Tables, IBRD, 1991.

Table 2.3 Balance of Foreign Trade

(F.CFA million)

Year	Export	Import	Balance
1970 (1)	64,359	67,241	-2,882
1971 (1)	57,283	69,352	-12,069
1972 (1)	57,673	76,384	-18,711
1973 (1)	81,804	74,486	7,318
1974 (1)	119,272	104,825	14,447
1975 (1)	102,087	128,104	-26,017
1976 (1)	127,283	145,963	-18,680
1977 (1)	179,319	192,401	-13,082
1978 (1)	197,986	237,247	-39,261
1979 (1)	243,699	271,160	-27,461
1980 (1)	290,615	337,607	-46,992
1981 (2)	290,851	364,172	-73,321
1982 (2)	306,314	401,762	-95,448
1983 (3)	407,203	429,466	-22,263
1984 (3)	484,144	462,891	21,253
1985 (4)	834,289	484,867	349,422
1986 (5)	685,968	588,788	97,180
1987 (5)	508,209	558,265	-50,056
1988 (5)	444,550	432,633	11,917

Sources:(1) Annuaire Statistique du Cameroun 1983.

(2) Comtes Nationaux du Cameroun (Version .SCN), Resultats semi-Definitifs 1982/ 1983, March 1984.

(2) Comtes Nationaux du Cameroun (Version .SCN), Resultats semi-Definitifs 1983/ 1984, Projections 1984/1985, May 1985.

(4) Note Annuelle du Statistique 1985-1986.

(5) Cameroon in Figures 1988.

Table 2.4 Balance of International Payment

(F.CFA billion)

Item	1982	1983	1984	1985	1986	1987
1. Goods and Services	(153.7)	(130.5)	(157.2)	40.7	(101.5)	(295.4)
FOB goods	8.1	80.4	85.9	237.6	310.0	36.5
Shipment of merchandise	(31.7)	(23.8)	(19.3)	(23.3)	(16.6)	(41.1)
Transportation/insurance	(2.4)	(6.0)	1.6	6.4	(14.8)	(11.1)
Travel	(2.9)	(5.9)	(12.4)	(24.0)	(49.3)	(65.3)
Interest on capital	(57.0)	(95.5)	(136.8)	(99.0)	(242.8)	(139.4)
Wages	(0.4)	(1.9)	(0.7)	0.8	(3.1)	(2.5)
Other services	(67.4)	(77.8)	(75.5)	(57.8)	(84.9)	(72.5)
2. Official Unrequited Transfers	(4.7)	(1.2)	(2.3)	(17.6)	(17.0)	(33.5)
3. Capital without Reserve	143.3	201.8	135.8	(16.1)	237.0	152.4
A. Investment and long term capital	76.2	180.7	191.3	38.6	80.1	108.8
B. Short term capital	67.1	21.1	(55.5)	(54.7)	156.9	43.6
4. Net Errors & Ommissions	(0.1)	1.0	26.0	11.5	(51.8)	7.4
BALANCE	(15.2)	71.1	2.3	18.5	66.7	(169.1)

Sources:Cameroon in Figures 1984, 1985, 1987 and 1988.

Table 2.5 Government Finance

Government Receipts /Expenditure : (F.CFA billion)

Item	1982	1983	1984	1985	1986	1987	1988	1989(*	1990(*
Budget scale in receipts	310.0	410.0	520.0	620.0	740.0	800.0	650.0	600.0	600.0
1. Expenditures	445.7	638.0	742.5	855.2	897.8	879.5	-	629.4	606.7
Regular and development	445.6	546.7	700.7	813.8	882.1	908.4	-	625.9	605.1
Lending minus repayment	0.1	91.3	41.8	41.4	15.7	(28.9)	-	3.5	1.6
2. Receipts	390.4	671.9	795.4	885.7	923.9	742.8	-	524.7	454.1
Revenue	390.4	612.3	790.5	885.6	919.1	742.8	-	524.7	454.1
Grants	0.0	59.6	4.9	0.1	4.8	0.0	-	0.0	0.0
3. Surplus (+) or Deficit (-)	(55.3)	33.9	52.9	30.5	26.1	(136.7)	-	(104.7)	(152.6)
4. Source of Financing	-	(33.9)	(53.0)	(30.5)	(26.1)	136.7	-	104.7	152.6
Domestic loan	-	(56.5)	(88.7)	(63.4)	(70.0)	73.1	-	6.5	15.6
Foreign loan	-	22.6	35.7	32.9	43.9	63.6	-	98.2	137.0
5. Cash Balance	-	0.0	(0.1)	0.0	0.0	0.0	-	0.0	0.0

Source: International Financial Statistics, September 1989.
(*): Tableau de Bord des Finances Publique, 1988/89, 1989/90.

Note : - Lack of data.
(*) means temporary estimates.

SONEL Revenue /Expenditure (For reference) :

Item	1982	1983	1984	1985	1986	1987	1988	1989	1990
Revenue	28.9	-	38.6	43.1	48.6	54.6	55.6	53.9	61.7
Expenditure	29.1	-	40.0	42.7	47.8	54.4	54.5	56.0	55.8
(% to 1. above)	6.5	(-)	5.4	5.0	5.3	6.2	(-)	8.9	9.2
Cash Balance	(0.2)	-	(1.4)	0.4	0.8	0.2	1.1	(-2.1)	5.9

Source : Compte Rendu de Gestion 1975/76 - 1989/90

Table 2.6 Population Growth in Cameroon

Year	Total population	Working active population	Population in Douala	Population in Yaounde
1971 (1)	6,728,021	...	...	...
1972 (1)	6,896,854	...	...	...
1973 (1)	7,067,206	...	...	...
1974 (1)	7,241,767	...	...	...
1975 (1)	7,420,633	...	...	...
1976 (1)	7,603,924	...	...	...
1977 (1)	7,793,921	...	...	...
1978 (1)	7,988,918	...	...	...
1979 (1)	8,188,916	...	...	...
1980 (1)	8,393,915	...	...	...
1981 (1)	8,603,914	...	...	...
1982 (2)	8,827,909	3,522,000	666,000	456,000
1983 (2)	9,046,000	3,530,000	713,000	488,000
1984 (2)	9,468,500	3,695,000	763,000	522,000
1985 (2)	9,933,823	3,876,588	852,705	583,470
1986 (2)	10,306,447	4,022,001	963,645	633,948
1987 (2)	10,821,746	4,224,390	1,029,731	653,670
1988 (2)	11,181,035	4,363,301	1,196,321	712,089 (*
Annual Population growth ratio	3.0%	3.6%	10.3%	7.7%

Sources:(1) Annuaire Statistique du Cameroun 1983.
(2) Cameroon in Figure 1984, 1987, 1988.
(*) Comtes Nationaux du Cameroun (Version SCN), Resultats 1985/86, Projection 1986/87 et 1987/88, January 1989.
(Note)...:Lack of data.

Table 2.7 Area and Population by Province

Province (capital city)	(1) Area (sq.km)	Population 1975/76	(2) Population 1986/87	Population density per sq.km 1975/76	1986/87	Population growth rate/annum 1976-1987
East (Bertoua)	108,900	366,562	517,198	3.4	4.7	3.18%
Littoral (Douala)	20,220	935,457	1,352,833	46.3	66.9	3.41%
North (Garoua)	67,798	479,306	832,165	7.1	12.3	5.14%
North-West (Bamenda)	17,300	978,030	1,237,348	56.5	71.5	2.16%
West (Bafoussam)	13,890	1,035,920	1,339,791	74.6	96.5	2.37%
South-West (Buea)	24,910	620,709	838,042	24.9	33.6	2.77%
Adamawa (Ngaoundere)	61,992	359,445	485,185	5.8	7.8	2.76%
Central (Yaounde)	68,942	1,177,125	1,651,600	17.1	24.0	3.13%
Extreme-North (Maroua)	34,260	1,395,194	1,855,695	40.7	54.2	2.63%
South (Ebolowa)	47,190	315,297	373,798	6.7	7.9	1.56%
Total	465,402	7,663,045	10,483,655	16.5	22.5	2.89%
Special department (capital city)*						
Wouri(Douala)	886	-	-	-	-	-
Mfoundi(Yaounde)	256	-	-	-	-	-

Sources:
(1) Camerpun Les Enterprises de Production et de Vente, 1985/86-1990/91.
(2) Situation et Perspectives Demographiques du Cameroun(Resume), September 1990.
(*) Population et Supercifie Estimees par Unite Administratif en 1976 et an 1984 Selon le Decoupage Administratif en Vigueur en 1984 et Villes de 5000 Habitants ou Plus par Unite Administratif en 1984.

Note: Total population in both years 1975/76 and 1986/87 is slightly different from that in Table 2.6, which is due to different data sources.

Table 2.8 Working Active Population in Cameroon

(nos:thousand people)

Year	Primary sector		Secondary sector		Tertiary sector		Not occupied		Total	
	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
1982	2,713	77.03%	229	6.50%	475	13.49%	105	2.98%	3,522	100.0%
1983	2,780	78.75%	235	6.66%	486	13.77%	29	0.82%	3,530	100.0%
1984	2,910	78.76%	246	6.66%	509	13.78%	30	0.81%	3,695	100.0%
1985	3,053	78.75%	258	6.65%	534	13.77%	32	0.83%	3,877	100.0%
1986	3,167	78.74%	268	6.66%	554	13.77%	33	0.82%	4,022	100.0%
1987	3,325	78.72%	283	6.70%	582	13.78%	34	0.80%	4,224	100.0%
1988	3,436	78.75%	290	6.65%	601	13.77%	36	0.83%	4,363	100.0%
Rate (*)	4.0%		4.0%		4.0%		-16.3%		3.6%	

Sources:Cameroon in Figures 1984,1988.

Note:(*) Annual growth rate.

Table 2.9 Population Projection by Province (1/2)

(Midium growth)

(1) Population Projection in Cameroon (Base)

Year	High growth	Mid.growth	Low growth
1987	10,483,655	10,483,655	10,483,655
1995	13,419,000	13,366,000	13,333,000
2000	15,723,000	15,404,000	15,224,000
2005	18,541,000	17,721,000	17,329,000
2010	21,889,000	20,283,000	19,553,000
2015	25,882,000	23,081,000	21,775,000
2020	30,684,000	26,128,000	23,962,000

Source:Situation et Perspectives Demographiques du Cameroun (Resume), September 1990.

(2) Population Projection by Province

Province (capital city)	(1) Area (sq.km)	Population projection					
		1994/95	1999/00	2004/05	2009/10	2014/15	2019/20
East (Bertoua)	108,900	544,534	634,416	736,917	850,553	974,734	1,109,673
Littoral (Douala)	20,220	2,336,155	2,752,448	3,233,198	3,773,843	4,373,579	5,035,176
North (Garoua)	67,798	744,957	953,737	1,217,369	1,544,023	1,944,406	2,432,454
North-West (Bamenda)	17,300	1,333,855	1,478,856	1,634,703	1,795,519	1,958,136	2,121,389
West (Bafoussam)	13,890	1,482,448	1,660,150	1,853,578	2,056,423	2,265,248	2,478,812
South-West (Buca)	24,910	952,239	1,087,424	1,238,076	1,400,663	1,573,338	1,755,638
Adamawa (Ngaoundere)	61,992	476,028	543,549	618,786	699,971	786,179	877,178
Central (Yaounde)	68,942	3,052,688	3,547,547	4,110,262	4,732,048	5,409,167	6,142,374
Extreme-North (Maroua)	34,260	2,008,283	2,277,825	2,575,797	2,894,284	3,229,031	3,578,722
South (Ebolowa)	47,190	434,813	468,049	502,315	535,672	567,183	596,585
Total	465,402	13,366,000	15,404,000	17,721,000	20,283,000	23,081,000	26,128,000

Note: Estimated using population projection based on Population Census indicated above and growth ratio of population dansities mentioned in Table 2.7.

Table 2.9 Population Projection by Province (2/2)

(High growth)

(1) Population Projection in Cameroon (Base)

Year	High growth	Mid.growth	Low growth
1987	10,483,655	10,483,655	10,483,655
1995	13,419,000	13,366,000	13,333,000
2000	15,723,000	15,404,000	15,224,000
2005	18,541,000	17,721,000	17,329,000
2010	21,889,000	20,283,000	19,553,000
2015	25,882,000	23,081,000	21,775,000
2020	30,684,000	26,128,000	23,962,000

Source:Situation et Perspectives Demographiques du Cameroun (Resume), September 1990.

(2) Population Projection by Province

Province (capital city)	(1) Area (sq.km)	Population projection					
		1994/95	1999/00	2004/05	2009/10	2014/15	2019/20
East (Bertoua)	108,900	546,693	647,554	771,016	917,900	1,093,023	1,303,169
Littoral (Douala)	20,220	2,345,418	2,809,448	3,382,808	4,072,655	4,904,335	5,913,171
North (Garoua)	67,798	747,911	973,488	1,273,700	1,666,278	2,180,369	2,856,607
North-West (Bamenda)	17,300	1,339,144	1,509,482	1,710,345	1,937,688	2,195,766	2,491,300
West (Bafoussam)	13,890	1,488,327	1,694,530	1,939,348	2,219,250	2,540,148	2,911,049
South-West (Buea)	24,910	956,015	1,109,943	1,295,365	1,511,567	1,764,271	2,061,772
Adamawa (Ngaoundere)	61,992	477,916	554,805	647,419	755,395	881,586	1,030,134
Central (Yaounde)	68,942	3,064,793	3,621,012	4,300,455	5,106,730	6,065,598	7,213,434
Extreme-North (Maroua)	34,260	2,016,246	2,324,996	2,694,986	3,123,452	3,620,891	4,202,752
South (Ebolowa)	47,190	436,537	477,742	525,558	578,086	636,013	700,612
Total	465,402	13,419,000	15,723,000	18,541,000	21,889,000	25,882,000	30,684,000

Note: Estimated using population projection based on Population Census indicated above and growth ratio of population dansities mentioned in Table 3.4.7.

Table 2.10 Agricultural and Agro-Industrial Products in Cameroon

(Ton)

Products	1982	1983	1984	1985	1986	1987	1988	Average annual increasing ratio (%)
AGRICULTURAL PRODUCTS FOR TRADING								
Cocoa in total	114,697	114,156	111,327	121,071	115,082	134,425	135,116	2.8%
Grade I	61,272	33,554	48,948	69,587	75,725	81,600	102,101	8.9%
Grade II	38,791	70,857	47,958	35,144	28,045	34,920	20,206	-10.3%
Sub-standard	14,634	7,950	12,274	14,576	9,098	12,260	10,652	-5.2%
Ungraded	0	1,795	2,147	1,564	2,214	5,646	2,157	-
Coffee in total	97,223	107,182	102,655	106,134	104,855	86,423	112,832	2.5%
Robusta	71,638	87,639	78,112	84,349	87,574	72,895	95,265	4.9%
Arabica	25,585	19,543	24,543	21,785	17,281	13,528	17,565	-6.1%
Cotton	79,819	72,368	94,580	97,500	115,542	122,773	113,699	6.1%
Banana	49,269	49,012	43,285	57,476	55,402	49,395	37,974	-4.2%
Tobacco fillers	915	429	697	580	635	426	591	-7.0%
Tobacco wrappers	1,120	1,331	1,117	1,129	1,539	2,002	1,100	-0.3%
AGRO-INDUSTRIAL PRODUCTS								
Rubber	17,566	15,995	16,413	19,384	19,246	22,506	29,727	9.2%
Palm oil	70,744	72,485	64,586	79,012	102,598	102,960	...	7.8%
Sugar	65,855	67,920	58,655	73,717	74,704	94,182	105,722	8.2%
Oil palm	13,645	15,537	13,238	14,237	14,964	15,754	...	2.9%
Tea	2,133	1,801	2,104	2,279	3,197	2,516	2,564	3.1%

Sources:Cameroon in Figures 1984 and 1988.

Note: (...) Lack of data.

Table 2.11 Cultivation Area for Main Agricultural Products

(sq.km, as of 1987)

Item	East	Littoral	North	North-West	West	South-West	Adamawa	Central	Ex.-North	South	Total
Developed area for cultivation	1,443	1,124	1,504	2,299	2,956	2,449	875	2,895	4,282	1,352	21,179
Modernized cultivated area	20	309	4	8	25	444	45	279	165	207	1,506
Traditional cultivated area	1,345	760	1,496	2,005	1,998	1,892	827	2,562	4,027	1,145	18,057
Traditional non-cultivated area	78	55	4	286	933	113	3	54	90	0	1,616
R(*)	1.4%	27.5%	0.3%	0.3%	0.8%	18.1%	5.1%	9.6%	3.9%	15.3%	7.1%
Applied cultivated area	1,346	987	1,370	1,677	2,194	2,170	780	2,586	3,717	1,164	17,991
Cocoa	390	130	0	9	15	745	0	1,438	0	760	3,487
Coffee (arabica)	0	0	0	424	587	0	0	0	0	0	1,011
Coffee (robusta)	269	312	0	87	337	366	43	120	0	7	1,541
Cotton	0	0	362	0	0	0	0	0	446	0	808
Maize	132	70	106	599	596	71	239	116	102	26	2,057
Plantain	87	27	0	61	61	120	0	132	0	43	531
Sorghum	0	0	621	19	0	0	171	0	2,920	0	3,731
Groundnuts	116	53	281	89	151	19	39	258	249	86	1,341
Cassava	286	51	0	63	29	155	288	179	0	85	1,136
Cocoyams	36	66	0	193	281	254	0	108	0	32	970
Banana	16	59	0	58	102	65	0	45	0	10	355
Oilpalm	14	219	0	75	35	375	0	190	0	115	1,023

Source:Calendrier Agricole de Republique du Cameroun, October 1987.
Note:(*)Modernized ratio.

Table 2.12 Number of Establishments and Employees in Cameroon

Industry group	Number of establishment		Number of employees	
	1987	1988	1987	1988
Agro-industry	3	2	8,047	6,557
Fishery	3	3	373	366
Lumbering	11	11	3,251	2,219
Flour, vegitable and seed	1	1	87	86
Processing of agricultural products	4	5	6,802	8,209
Bakery	3	3	319	316
Other foodstaff industry	2	1	178	78
Soft drink and tobacco	7	7	8,263	7,688
Textile and clothing	12	9	2,773	2,358
Leather and shoes	5	4	1,322	1,163
Wood and timber	5	5	1,635	1,478
Paper	6	5	551	367
Chemical industry	14	12	2,388	1,778
Rubber and plastic	6	6	805	610
Construction material	2	2	729	724
Basic metallurgic industry	3	2	1,350	1,732
Equipment for mechanics and electrics	9	9	1,014	643
Transportation equipment	2	2	401	210
Other type manufacturing	3	3	888	733
Electric, gas and water	2	2	6,673	6,928
Total	103	94 0	47,849	44,243

Source:Note Annuelle de Statistique, 1987/88.

Table 2.13 Turnover by Industrial Group

(F.CFA million)

Industry group	1986	Rate(*	1987	Rate(*	1988	Rate(*
Agro-industry	1,368	0.4%	12,161	3.3%	7,612	1.8%
Fishery	1,716	0.5%	1,421	0.4%	683	0.2%
Lumbering	2,319	0.7%	15,870	4.4%	15,342	3.6%
Flour, vegitable and seed	5,841	1.7%	3,375	0.9%	3,782	0.9%
Processing of agricultural products	48,782	14.3%	52,695	14.5%	44,868	10.5%
Bakery	2,922	0.9%	3,081	0.8%	2,234	0.5%
Other foodstaff industry	1,104	0.3%	1,870	0.5%	550	0.1%
Soft drink and tobacco	15,050	4.4%	14,935	4.1%	131,801	30.9%
Textile and clothing	25,111	7.3%	22,445	6.2%	20,852	4.9%
Leather and shoes	11,943	3.5%	9,818	2.7%	8,036	1.9%
Wood and timber	6,752	2.0%	8,931	2.5%	6,307	1.5%
Paper	3,151	0.9%	4,316	1.2%	2,512	0.6%
Chemical industry	31,986	9.4%	36,960	10.2%	28,386	6.7%
Rubber and plastic	5,686	1.7%	6,405	1.8%	4,784	1.1%
Construction material	27,793	8.1%	26,777	7.4%	21,673	5.1%
Basic metallurgic industry	66,758	19.5%	62,890	17.3%	49,085	11.5%
Equipment for mechanics and electrics	9,708	2.8%	6,944	1.9%	5,350	1.3%
Transportation equipment	5,698	1.7%	4,311	1.2%	2,547	0.6%
Other type manufacturing	16,331	4.8%	14,437	4.0%	11,484	2.7%
Electric, gas and water	51,745	15.1%	53,693	14.8%	58,803	13.8%
Total	341,764	100.0%	363,335	100.0%	426,691	100.0%

Source:Note Annuelle de Statistique, 1987/88.
(Note) (*:Distribution rate.

Table 2.14 Index of Industrial Production

(1975 = 100)

Industry group	1984	1985	1986	1987	1988	(*) Rate	(**) Rate
Agro-industry	199.0	222.5	274.4	316.4	310.2	9.1%	11.7%
Fishery	61.3	54.5	23.3	15.8	13.5	-14.3%	-31.5%
Lumbering	194.2	226.8	201.9	176.2	145.3	2.9%	-7.0%
Flour, vegitable and seed	239.7	207.7	138.7	86.9	127.6	1.9%	-14.6%
Processing of agricultural products	197.2	228.9	209.4	181.0	247.9	7.2%	5.9%
Bakery	149.9	146.2	154.6	129.1	110.8	0.8%	-7.3%
Other foodstaff industry	1,723.5	1,847.5	2,224.1	1,525.5	1,016.1	19.5%	-12.4%
Soft drink and tobacco	250.9	302.3	331.6	320.3	306.1	9.0%	5.1%
Textile and clothing	173.4	181.5	151.1	126.6	115.8	1.1%	-9.6%
Leather and shoes	95.8	91.0	112.7	89.3	62.5	-3.6%	-10.1%
Wood and timber	135.2	153.3	183.9	169.9	145.3	2.9%	1.8%
Paper	241.9	272.2	279.4	237.8	192.5	5.2%	-5.6%
Chemical industry	234.3	288.7	254.6	247.6	200.1	5.5%	-3.9%
Rubber and plastic	200.8	222.6	284.6	179.5	151.0	3.2%	-6.9%
Construction material	386.7	442.3	517.8	471.5	369.5	10.6%	-1.1%
Basic metallurgic industry	198.7	152.5	157.6	136.6	125.6	1.8%	-10.8%
Equipment for mechanics & electrics	212.2	172.7	192.0	234.1	127.2	1.9%	-12.0%
Transportation equipment	132.5	169.5	192.0	143.0	83.5	-1.4%	-10.9%
Other type manufacturing	668.4	562.0	637.2	486.5	428.9	11.9%	-10.5%
Electric, gas & water	197.3	214.2	222.9	221.7	228.1	6.5%	3.7%

Sources:Note Annuelle de Statistique, 1985/86 and 1987/88.

Note: (*)Annual increasing ratio for the period from 1975 to 1988.
(**)Annual increasing ratio for the period from 1984 to 1988.

Table 2.15 Production of Principal Manufacturing Goods

Products	Unit	1983	1984	1985	1986	1987	1988	Rate(*)
Beer	1000 tons	33	36	42	51	54	54	10.4%
Plywood	1000 cu.m	106	95	122	124	132	56	-12.0%
Rough timber	1000 cu.m	423	463	563	703	478	411	-0.6%
Rubber	1000 tons	16	19	18	17	20	23	7.5%
Cigarette	1000 tons	2	3	3	2	2	1	-12.9%
Cement	1000 tons	585	646	729	798	770	622	1.2%
Soap	1000 tons	23	27	26	28	29	26	2.5%

Sources:Note Annuelle de Statistique, 1985/86 and 1987/88.

Note:(*)Annual increasing ratio for the period from 1983 to 1988.

Table 2.16 Main Export Commodities in Cameroon

(F.CFA million)

Commodities	1982	1983	1984	1985	1986	1987	1988	Rate(*)
Cocoa & its by-products	44,188	57,283	89,201	106,858	96,161	87,757	59,576	5.11%
Coffee & its by-products	45,283	71,183	94,830	111,201	112,949	83,114	60,452	4.93%
Wood and timber	25,365	22,359	18,344	36,118	32,780	24,458	28,030	1.68%
Aluminum & its by-products	10,269	28,328	31,796	33,884	32,269	20,613	22,431	13.91%
Cotton & its by-products	16,753	17,794	19,988	17,177	15,908	16,506	17,708	0.93%
Palm oil & its by-products	1,842	1,039	1,025	2,012	1,113	2,398	2,291	3.70%
Crude oil	127,934	169,209	177,776	461,333	321,304	211,800	189,958	6.81%
Others	34,680	40,008	51,184	65,706	73,484	61,563	64,104	10.78%
Total	306,314	407,203	484,144	834,289	685,968	508,209	444,550	6.40%

Sources:Cameroon in Figures 1984, 1985 and 1988.

Note:(*)Annual increasing ratio.

Table 2.17 Main Import Commodities in Cameroon

(F.CFA million)

Commodities	1982		1983		1984		1985		1986		1987		1988		Rate(*)
Foods, drinks tobacco	20,359	(5.1%)	24,535	(5.7%)	29,146	(6.3%)	40,863	(8.4%)	58,192	(9.9%)	59,326	(10.6%)	51,698	(11.9%)	16.8%
Fuel & lubricants	19,750	(4.9%)	5,942	(1.4%)	6,952	(1.5%)	3,507	(0.7%)	4,003	(0.7%)	4,946	(0.9%)	3,839	(0.9%)	-23.9%
Raw materials of animals & vegitable origin	6,961	(1.7%)	9,316	(2.2%)	11,923	(2.6%)	5,248	(1.1%)	11,269	(1.9%)	12,788	(2.3%)	12,108	(2.8%)	9.7%
Mineral products	17,999	(4.5%)	16,547	(3.9%)	20,034	(4.3%)	18,795	(3.9%)	15,069	(2.6%)	11,766	(2.1%)	9,393	(2.2%)	-10.3%
Semi-manufacturing products	83,761	(20.8%)	89,529	(20.8%)	100,491	(21.7%)	78,515	(16.2%)	91,664	(15.6%)	95,300	(17.1%)	69,936	(16.2%)	-3.0%
Vehicles for transportation & tractors	37,875	(9.4%)	39,755	(9.3%)	44,072	(9.5%)	51,796	(10.7%)	63,782	(10.8%)	59,151	(10.6%)	42,214	(9.8%)	1.8%
Agricultural equipment	1,919	(0.5%)	2,171	(0.5%)	3,174	(0.7%)	2,741	(0.6%)	5,363	(0.9%)	4,797	(0.9%)	4,214	(1.0%)	14.0%
Industrial equipment	73,716	(18.3%)	84,700	(19.7%)	100,806	(21.8%)	114,929	(23.7%)	104,238	(17.7%)	93,274	(16.7%)	70,519	(16.3%)	-0.7%
Consumables for housing	44,895	(11.2%)	51,394	(12.0%)	45,005	(9.7%)	66,278	(13.7%)	86,653	(14.7%)	88,060	(15.8%)	68,330	(15.8%)	7.3%
Consumables for enterprise	94,527	(23.5%)	105,577	(24.6%)	101,288	(21.9%)	102,195	(21.1%)	148,555	(25.2%)	128,857	(23.1%)	100,382	(23.2%)	1.0%
Total	401,762	(100.0%)	429,466	(100.0%)	462,891	(100.0%)	484,867	(100.0%)	588,788	(100.0%)	558,265	(100.0%)	432,633	(100.0%)	1.2%

Sources: Cameroon in Figures 1984 and 1988.

Note: (*) Annual increasing ratio.

( ) Distribution ratio.

Table 2.18 Urban Consumer Price Index
(1966 = 100)

Commodities	City	1982	1983	1984	1985	1986	1987	1988	1989	Rate(*)
Food	Douala	339.2	389.2	410.7	436.4	459.8	444.1	466.0	-	5.4%
	Yaounde	327.4	373.1	390.7	404.8	440.8	439.3	439.1	-	5.0%
Beverage	Douala	249.0	260.0	293.8	324.4	331.6	342.8	405.2	-	8.5%
	Yaounde	247.0	270.2	317.3	338.8	347.5	353.1	414.6	-	9.0%
Housing	Douala	267.4	300.1	333.5	375.4	404.9	415.6	393.0	-	6.6%
	Yaounde	251.0	285.7	323.6	346.3	368.5	371.3	373.0	-	6.8%
Clothing	Douala	505.0	550.8	547.4	575.9	606.0	662.8	680.2	-	5.1%
	Yaounde	376.5	439.6	430.6	448.5	458.9	489.5	516.3	-	5.4%
Transportation	Douala	301.4	331.4	351.7	368.6	389.0	401.1	425.6	-	5.9%
	Yaounde	293.6	329.8	352.1	370.7	392.8	394.7	402.8	-	5.4%
Leisure	Douala	247.2	266.9	223.8	232.6	236.6	238.5	250.7	-	0.2%
	Yaounde	226.0	238.6	256.9	271.3	306.2	355.9	363.9	-	8.3%
Health	Douala	166.9	179.6	288.6	318.9	340.8	339.6	304.1	-	10.5%
	Yaounde	274.4	260.6	261.5	299.8	342.1	347.7	365.1	-	4.9%
Others	Douala	387.9	429.6	450.4	451.2	469.4	580.7	588.5	-	7.2%
	Yaounde	475.9	501.4	562.6	551.5	626.0	682.9	653.2	-	5.4%
General	Douala	308.6	344.6	370.3	395.7	416.5	428.9	443.5	-	6.2%
	Yaounde	305.0	344.3	372.7	388.1	420.2	431.3	439.2	-	6.3%
Imported articles	Douala	318.0	350.3	369.5	401.0	431.7	444.2	459.5	-	6.3%
	Yaounde	318.4	362.7	394.9	411.9	442.8	452.4	471.1	-	6.7%
Local articles	Douala	310.6	351.0	383.9	407.8	421.9	418.9	450.4	-	6.4%
	Yaounde	305.5	351.0	379.8	388.8	409.2	405.9	412.3	-	5.1%
Other services	Douala	276.5	314.9	346.2	356.5	360.8	403.3	382.6	-	5.6%
	Yaounde	264.3	276.8	293.2	316.1	375.0	418.5	397.4	-	7.0%
For reference: Consumer price index in the whole country (base : 1987 = 100)		66.6	77.7	86.5	87.6	94.4	100.0	108.6	108.6	7.2%

Sources:Note Annuelle de Statistique, 1985/86 and 1987/88.
For reference:World Tables, IBRD, 1991.

Note:(*)Annual increasing ratio for the period from 1982 to 1988.

Table 2.19 Prices of Several Daily Articles and Retail Price Index in Yaounde

(F.CFA)

Articles		1982	1983	1984	1985	1986	1987	1988	Rate*
Wheat flour	kg	132	140	151	158	157	131	113	-2.6%
Rice	kg	139	126	131	155	132	107	120	-2.4%
Sugar(local)	kg	235	237	250	275	270	269	265	2.0%
Salt	kg	51	60	68	67	70	65	71	5.7%
Oil sardine	can	94	92	97	113	122	122	116	3.6%
Stockfish	kg	2,651	2,778	2,844	3,027	2,778	2,359	2,743	0.6%
Cooking oil (Brand:Finoline)	ltr	353	351	401	552	551	543	544	7.5%
Wine	ltr	352	363	410	424	443	467	647	10.7%
Beer	btl	110	125	130	133	135	135	141	4.2%
Soap (Brand:Miss Africa)	kg	17,446	18,200	18,102	24,010	24,106	23,450	22,694	4.5%
	pc	182	190	189	250	251	244	236	4.4%
Cement Ordinary	ton	40,674	47,464	50,904	51,567	51,694	51,800	...	5.0%
Iron bar for beton(10mm)	ton	255,928	273,881	283,090	308,550	305,098	309,394	306,921	3.1%
Girder(IPN)	ton	288,649	298,504	360,620	362,816	406,069	424,995	372,841	4.4%
Steel corugated pipe(6/10')	2m	2,645	2,829	3,014	3,623	3,484	3,662	3,689	5.7%
Steel ridge tile	pc	1,237	1,524	1,755	1,968	1,810	2,027	2,098	9.2%
Stengfish lime	kg	166	185	220	225	239	208	228	5.4%
Motor spirit	ltr	142	152	153	158	164	167	184	4.4%
Diesel oil	ltr	124	134	134	134	137	139	143	2.4%
Motor oil (SAE)	ltr	394	425	494	506	529	534	517	4.6%
Grease(MP)		100,856	115,153	141,118	159,232	167,330	167,706	165,135	8.6%
Retail price index on consumption families living in Yaounde(**) (1966=100)		...	392.8	450.5	492.3	553.2	614.3	649.3	10.6%

Sources:Note Annuelle de Statistique, 1985/86, 1986/87, 1987/88.
(**):Cameroon in Figures 1987,1988.

Note:(*)Average annual increasing ratio for the period from 1982 to 1988.

Table 2.20 Production and Consumption of Energy in Cameroon

(1,000 tons in coal equivalent)

Item	1980	1985	1986
Production of Commercial Energy	279,038	324,183	315,080
Solids	30,403	50,742	47,159
Liquids	117,607	119,903	119,678
Gas	95,213	108,794	101,324
Electricity	35,815	44,744	46,919
Change in Stock	1,588	-3,447	1,928
Imports	56,111	37,966	44,817
Exports	78,051	116,549	112,475
Bunkers	5,890	3,148	3,220
Air	1,016	746	796
Sea	4,874	2,402	2,424
Unallocated	-1,801	-5,803	-6,795
Consumption	251,416	251,703	249,070
Solids	29,019	36,559	33,864
Liquids	122,895	98,842	99,408
Gas	67,034	76,511	73,052
Electricity	32,468	39,791	42,746
Per capita (1,000 kg in coal equivalent)	10,437	10,111	9,900
Production of Selected Energy Commodities	7,872	19,357	19,263
Hard coal	0	1	1
Fuelwood	2,657	3,043	3,129
Crude oil	3,856	13,098	12,821
LPG	16	28	30
Aviation gasoline	12	15	28
Motor gasoline	225	622	615
Kerosene	177	457	461
Jet fuel	15	140	143
Gas diesel oil	239	652	660
Residual oil	425	840	920
Lubricants	72	165	162
Electricity	178	296	293

Source:Statistic Year Book 1988, UN.

Table 2.21 Power Production and Consumption in Cameroon

Year	Energy production(GWh)			Energy consumption (GWh)				Loss	
	Hydro-power	Thermal power	Total	High tension	Medium tension	Low tension	Total	GWh	(%)
1971	1,123.8	22.0	1,145.8	931.6	82.2	90.2	1,104.0	41.8	3.6%
1972	1,075.7	36.9	1,112.6	854.6	107.0	102.2	1,063.8	48.8	4.4%
1973	1,069.9	22.7	1,092.6	831.2	120.0	124.8	1,076.0	16.6	1.5%
1974	1,066.9	26.8	1,093.7	826.2	115.3	117.4	1,058.9	34.8	3.2%
1975	1,318.2	63.7	1,381.9	1,049.0	148.3	135.2	1,332.5	49.4	3.6%
1976	1,271.8	75.5	1,347.3	985.4	164.4	148.7	1,298.5	48.8	3.6%
1977	1,239.9	80.6	1,320.5	909.4	188.7	166.4	1,264.5	56.0	4.2%
1978	1,209.9	66.2	1,276.1	807.4	212.7	189.7	1,209.8	66.3	5.2%
1979	1,301.5	74.4	1,375.9	835.8	262.0	220.8	1,318.6	57.3	4.2%
1980	1,305.7	82.2	1,387.9	761.1	279.9	255.5	1,296.5	91.4	6.6%
1981	1,561.1	93.9	1,655.0	962.0	302.8	281.6	1,546.4	108.6	6.6%
1982	2,042.5	105.1	2,147.6	1,353.1	314.3	351.5	2,018.9	128.7	6.0%
1983	2,055.1	105.5	2,160.6	1,265.1	368.2	391.0	2,024.3	136.3	6.3%
1984	2,118.1	38.6	2,156.7	1,186.2	380.3	395.4	1,961.9	194.8	9.0%
1985	2,318.6	62.5	2,381.1	1,285.6	435.9	439.6	2,161.1	220.0	9.2%
1986	2,456.5	41.4	2,497.9	1,296.5	472.2	478.6	2,247.3	250.6	10.0%
1987	2,406.9	52.3	2,459.2	1,174.5	488.8	533.8	2,197.1	262.1	10.7%
1988	2,496.3	60.7	2,557.0	1,240.1	482.0	549.1	2,271.2	285.8	11.2%
1989	2,648.5	41.0	2,689.5	1,368.9	481.8	543.1	2,393.8	295.7	11.0%
Rate*	4.9%	3.5%	4.9%	2.2%	10.3%	10.5%	4.4%	11.5%	

Sources: Compte Rendu de Gestion, 1971/72, 1973/74, 1975/76, 1976/77, 1977/78, 1978/79, 1979/80, 1980/81, 1981/82, 1983/84, 1984/85, 1985/86, 1986/87, 1988/89, 1989/90.

Note: (*) Average annual increasing ratio for the period from 1971 to 1989.
Figures in this table are slightly different from those in Tables 4.4.1 to 4.4.4 due to difference of data sources.

Table 2.22 Sales Amount and Number of Customers in Cameroon

Year	Income (F.CFA million)						Nos. of customers		
	High tension	Medium tension	Low tension	Sub-total	Other revenue	Total	H.T	M.T customers	L.T
1975	1,291	2,206	3,323	6,820	832	7,652	2	334	57,792
1976	1,267	2,515	3,867	7,649	925	8,574	2	386	70,497
1977	1,332	3,531	5,483	10,346	1,599	11,945	2	410	78,427
1978	1,326	3,978	6,304	11,608	1,629	13,237	2	471	91,385 *
1979	1,384	5,146	8,224	14,754	1,950	16,704	3	503	103,572 *
1980	1,509	5,852	9,561	16,922	1,997	18,919	4	570	118,037 *
1981	2,565	6,265	10,614	19,444	3,629	23,073	4	620	132,822 *
1982	4,103	6,717	13,285	24,105	3,898	28,003	4	708	148,028 *
1983	4,248	9,523	16,142	29,913	4,738	34,651	5	822	175,622 *
1984	4,851	10,032	17,611	32,494	5,589	38,083	5	811	181,510 *
1985	5,118	11,505	19,841	36,464	5,861	42,325	5	878	199,392 *
1986	5,320	13,771	23,009	42,100	5,901	48,001	5	941	234,816 *
1987	5,569	14,393	26,156	46,118	6,869	52,987	5	1,013	260,791 *
1988	5,661	14,589	27,596	47,846	5,667	53,513	5	1,121	282,923 *
1989	6,125	14,449	26,889	47,463	4,233	51,696	4	1,127	302,291 *

Sources: Sources:Compte Rendu de Gestion, 1971/72, 1973/74, 1975/76, 1976/77, 1977/78, 1978/79, 1979/80, 1980/81, 1981/82, 1983/84, 1984/85, 1985/86, 1986/87, 1988/89,1989/90.

Note: Other revenue includes connecting services, supplies of materials and sundry services.

(*): Compte-Rendu de Gestion -Statistique Analytique-, 1977/78 -1988/89.

H.T: High tension.

M.T: Medium tension.

L.T: Low tension.

Table 2.23 Power Consumption, Sales Amount and Number of Customers by Region

Year	Low tension					Medium tension				
	Central South East	Littoral West	North Ex.North, Adamawa	South-West	North-West	Central, South, East	Littoral, West	North, Ex.North, Adamawa	South-West	North-West
Power Consumption (GWh)										
78	53.6	115.7	12.2	5.9	2.2	34.9	133.8	35.0	8.5	0.2
79	63.3	132.7	14.8	7.3	2.7	36.5	173.7	41.7	9.0	0.4
80	72.7	153.2	17.2	9.3	3.2	43.9	183.0	42.5	9.9	0.5
81	74.9	171.7	20.3	10.1	5.2	50.0	196.8	45.5	9.8	0.7
82	95.4	216.4	25.4	9.2	4.2	70.4	187.0	46.0	10.4	0.6
83	101.6	244.0	26.2	16.1	6.0	62.7	237.2	54.5	13.2	0.7
84	98.0	238.4	33.4	17.8	7.4	69.3	231.2	66.4	12.5	0.9
85	117.8	259.2	36.8	17.5	8.3	80.7	268.1	74.0	11.5	1.5
86	142.3	265.1	40.3	16.0	10.2	86.8	289.5	80.2	12.9	2.7
87	156.1	295.7	45.6	24.7	11.7	94.6	299.7	76.7	14.3	3.2
88	168.1	303.4	46.0	20.5	12.9	99.2	238.8	76.0	14.2	3.7
89	164.7	295.5	46.6	20.7	15.7	101.5	286.5	74.9	15.3	3.5
R*	10.7%	8.9%	13.0%	12.1%	19.6%	10.2%	7.2%	7.2%	5.5%	29.7%
Sales Amount (F.CFA million)										
78	2,120	3,188	544	321	123	788	2,123	816	245	6
79	2,763	4,165	725	415	155	942	2,826	1,068	298	13
80	3,145	4,864	832	530	186	1,105	3,324	1,101	305	16
81	3,304	5,511	1,005	577	215	1,186	3,557	1,165	314	24
82	4,204	7,045	1,256	531	249	1,399	3,729	1,247	319	23
83	4,898	9,299	1,368	974	363	1,729	4,752	1,048	408	56
84	4,831	9,452	1,707	1,078	432	1,785	4,842	1,758	374	30
85	5,990	10,422	1,895	1,049	500	2,095	5,595	1,946	375	49
86	7,396	11,712	2,147	945	585	2,430	7,068	2,314	401	87
87	8,239	13,370	2,501	1,231	725	3,073	8,231	2,454	505	131
88	9,256	13,686	2,493	1,405	757	3,264	8,328	2,420	426	151
89	8,688	13,507	2,551	1,222	920	3,339	8,027	2,412	532	138
R*	13.7%	14.0%	15.1%	12.9%	20.1%	14.0%	12.9%	10.4%	7.3%	33.0%
Number of Customer (number)										
78	31,047	46,044	6,555	5,392	2,347	95	282	52	35	6
79	33,941	51,988	7,924	6,472	3,247	101	300	52	44	6
80	37,867	59,673	9,227	7,412	3,858	106	362	51	43	10
81	41,860	66,754	10,657	8,658	4,893	116	392	56	45	11
82	46,063	73,949	12,723	9,249	6,044	123	466	58	49	10
83	48,785	90,791	14,602	12,344	9,100	139	532	83	54	12
84	55,418	91,906	16,185	10,190	7,811	150	508	85	50	18
85	60,649	100,189	18,274	11,326	8,945	168	539	86	56	19
86	70,820	110,955	20,941	13,435	12,955	183	586	93	56	27
87	78,830	127,519	25,159	14,669	14,614	204	630	96	56	27
88	85,739	137,428	27,622	15,979	16,155	236	679	115	60	31
89	90,586	146,784	29,785	17,704	17,432	240	678	117	63	29
R*	10.2%	11.1%	14.8%	11.4%	20.0%	8.8%	8.3%	7.7%	5.5%	15.4%

Source:Compte-Rendu Gestion -Statistique Analytique-, 1977/78 - 1988/89.

Note:(*)Average annual increasing ratio.

Table 2.24 Finance of Societe Nationale d'Electricite (SONEL)

(F.CFA million)

Year	Revenue				Expenditure					Cash balance
	From sales	From others	From refundble income	Total	Develop-ment	Distri-bution	Other services	General	Total	
1975	...	...	...	...	...	...	...	...	...	...
1976	7,649	0	220	7,869	2,359	109	778	5,216	8,462	-593
1977	10,346	1,561	389	12,296	2,939	127	1,337	6,172	10,575	1,721
1978	11,608	1,546	571	13,725	3,372	128	1,333	7,051	11,884	1,841
1979	14,754	1,827	688	17,269	4,229	142	1,515	8,036	13,922	3,347
1980	16,922	1,802	812	19,536	5,232	184	1,740	9,113	16,269	3,267
1981	19,444	3,310	1,131	23,885	6,976	271	2,327	12,020	21,594	2,291
1982	24,105	3,750	1,009	28,864	8,996	237	2,959	16,899	29,091	-227
1983	...	...	...	...	...	...	...	...	...	...
1984	32,494	4,937	1,138	38,569	7,587	262	5,142	26,983	39,974	-1,405
1985	36,464	5,862	752	43,078	8,159	530	5,889	28,141	42,719	359
1986	42,100	5,901	621	48,622	8,270	416	7,036	32,044	47,766	856
1987	46,118	6,870	1,656	54,644	9,379	395	6,771	37,875	54,420	224
1988	47,846	5,667	2,070	55,583	9,480	329	5,137	39,516	54,462	1,121
1989	47,463	4,233	2,157	53,853	8,742	286	4,362	42,591	55,981	-2,128
1990	...	...	...	61,696	9,111	241	5,082	41,409	55,843	5,853
Rate*				15.85%					14.43%	

Sources:Compte Rendu de Gestion, 1975/76, 1976/77, 1977/78, 1978/79, 1979/80, 1980/81, 1981/82, 1983/84, 1984/85, 1985/86, 1986/87, 1988/89, 1989/90.

Note: 1. Development expenditure means the cost for materials and equipment for development of power stations.
2. Distribution expenditure means the cost for expansion of transmission line.
3. General expenditure means the payment for SONEL's staff and other expenditure for interest, amortization, etc.
4. ... means lack of data.
5. * means average annual increasing ratio for the period from 1976 to 1990.

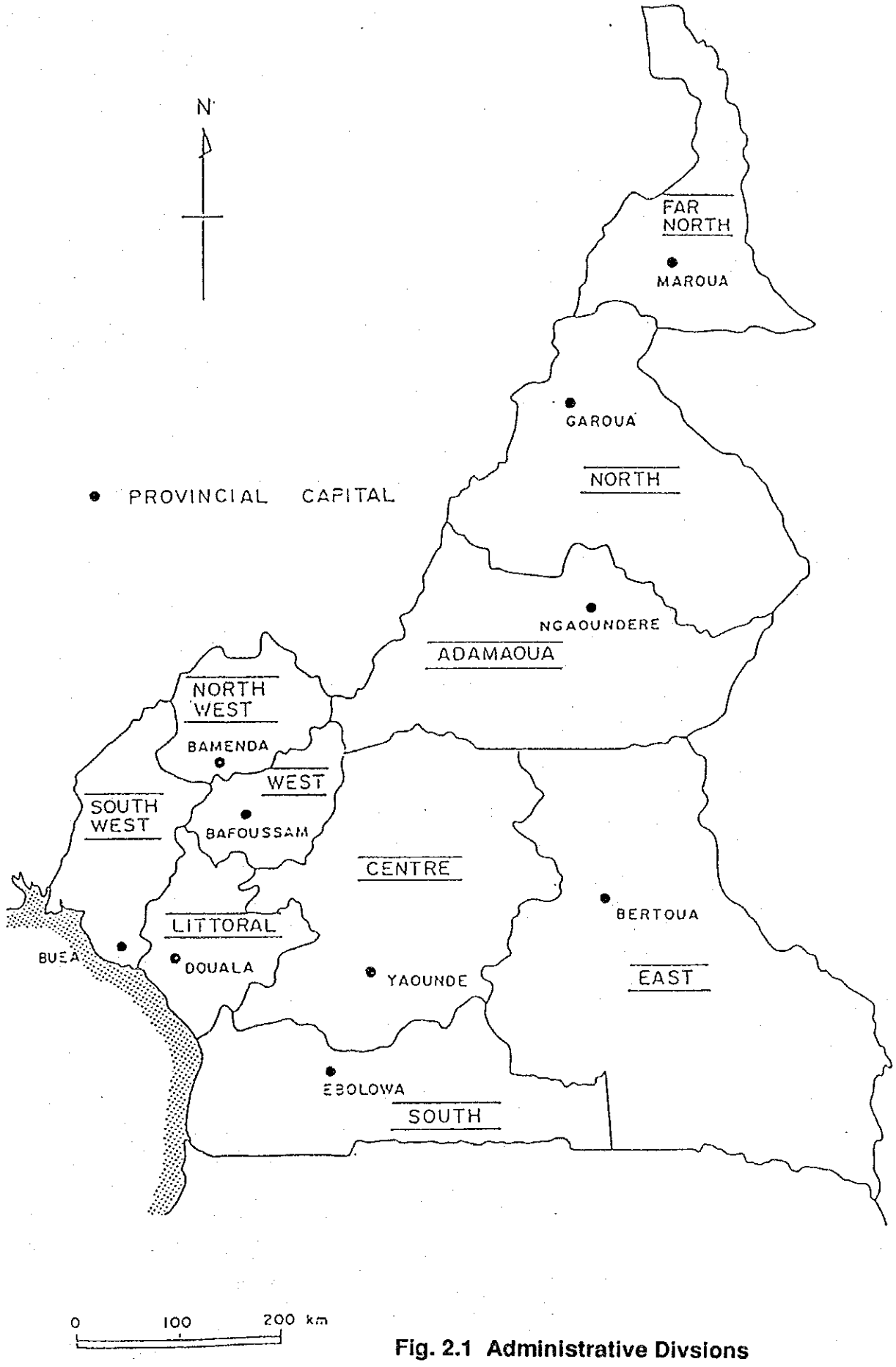


Fig. 2.1 Administrative Divsions

III GENERAL CONDITION OF THE PROJECT AREA

3.1 Topography

3.1.1 Land, Area and Location

The Republic of Cameroon is located at the west end part of Central Africa. It stretches about 1,200 km from Lake Chad as the north bound to the Atlantic Ocean as the south bound. It lies between the latitudes 2 degrees and 13 degrees North and the longitudes 8 degrees and 16 degrees East. The country has a shape of roughly triangular and has a total area of 475,000 km2.

Dorsale Camerounaise (a mountain chain) which divides the country into two parts lies from Mt. Cameroon (4,095 m) in the west to the border of Central Africa Republic in the east. The north of country is of lowlands representative of the area of Lake Chad. The south of country is extensively covered by the South Cameroon Plateau. The west coastal plains bordered on the Atlantic Ocean are relatively narrow.

The Ntem River on which the proposed Memvé Elé site is located, is one of the largest rivers of Cameroon. It drains a catchment area of about 31,000 km2 at the southern edge of the country. In the upper reaches it flows along the border between Cameroon and Gabon and in the lower reaches between Cameroon and Equatorial Guinea. Some of its tributaries originate in Gabon and Equatorial Guinea.

The proposed Memvé Elé site is situated in the lower reaches of the Ntem basin approximately 100 km upstream of the estuary. At this site there is a waterfall, called Memvé Elé falls, with about 35 m head offering favorable site for hydroelectric power development. The catchment area at the falls is 28,300 km2 including two major tributaries; the Ndjo'o and Biwome.

3.1.2 Site Topography

The Memvé Elé waterfalls located immediately downstream of the proposed damsite set up remarkable change in the river characteristics between the upstream and downstream.

At the upstream of the waterfalls, the Ntem river flows slowly and abundantly on its gentle river gradient in the wide flat river sections. Near the waterfalls, the Ntem river spreads into

branches and remains islands among the branches covered with a dense rain forest. Two tributaries, the Ndjo' o and Biwome rivers flow into the Ntem river just upstream of the waterfalls. Downstream of the waterfalls, the Ntem river so-called "Gorges du Ntem", runs rapidly and straight in a succession of short cascades and rapids in south-west direction. The width of the river is around 50 m. A rise of water level due to flood looks to be 5 to 6 m according to the trace of flood on the banks.

Taking a bird' s-eye view of the topography, the damsite is rather flat and looks to embarrass a possibility of creation of a big reservoir. In the north-west part of the right bank of Biwome river, there exist rather high mountains having a height of 600 to 1,000 m.

3.1.3 Topographic Survey

At the beginning of the study, a 1/20,000 map covering the dam-powerhouse area was available. The map was of a limited accuracy, prepared by enlarging from 1/50,000 with adding some additional information interpreted from 1/50,000 aerophotos.

Under this study, a series of topographic survey was carried out for dam-powerhouse area and reservoir area.

(a) Dam-powerhouse area:
- 1/5,000 contour mapping: 2,260 *ha* in area
- 1/1,000 contour mapping: 310 *ha* in area

(b) Reservoir area:
- 1/10,000 contour mapping, covering whole reservoir area below EL. 405 m including the Ndjo' o and Biwome basins.

The work was carried out by a Cameroon survey firm, Société de Topographie et Services (STS), during a period from June 1991 to July 1992. The detail is given in Appendix I.

3.2 Meteorology and Hydrology

3.2.1 Meteorology

(1) General climate

The Ntem river basin is located in the southwest region of Cameroun as shown in Fig. 3.2.1 and spreads out in the range from 1° 30' to 3° in north latitude and 10° to 13° in east

longitude. The basin belongs to the equatorial climate zone and shows four different seasonal patterns as described below.

- rainy season from March to June; relatively frequent rainfall with moderate intensity, high temperature and moderate humidity
- dry season from July to mid-September; relatively low temperature and high humidity
- rainy season from mid-September to mid-December; very frequent rainfall with high intensity, moderate temperature and high humidity
- dry season from mid-December to February; high temperature and low humidity

It is explained that the above patterns depend on the seasonal oscillation of Intertropical Front influenced by the action of high pressures.

As shown in Fig. 3.2.2, annual rainfall range more than 1,600 mm accounts for the entire basin and the west end of the basin is defined as annual rainfall range over 2,000 mm. Annual rain fall in the Ntem river basin upstream of the project site ranges between 1,600 mm and 1,800 mm. In general annual rainfall value is high in the coastal area and declines toward the inland part. Further description and analysis are provided in Appendix III – Hydrology and Meteorology.

(2) Air temperature

Average monthly maximum and minimum air temperature at Ebolowa and Ambam are shown below. Ambam is located in the middle reach area of the Ntem river basin. Ebolowa is located in the northern basin boundary area about 60 km north of Ambam.

Air Temperature

(deg.C)

	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Ambam (El. 560 m)													
Tmax.	28.5	29.3	29.5	29.2	28.2	27.4	26.5	25.8	27.2	27.4	27.8	27.7	27.9
Tmin.	20.6	20.9	20.3	20.5	20.2	20.4	19.6	19.7	19.9	19.9	20.3	20.3	20.2
Tm.	24.6	25.1	24.9	24.8	24.2	23.9	23.1	22.8	23.6	23.7	24.1	24.0	24.1
Ebolowa (El. 603 m)													
Tmax.	28.8	29.6	29.4	29.4	28.7	27.4	26.2	26.2	27.1	27.5	28.1	28.3	28.1
Tmin.	20.1	20.3	20.0	20.0	20.1	20.0	19.7	19.6	19.7	19.7	20.0	20.1	19.9
Tm.	24.5	25.0	24.7	24.7	24.4	23.7	22.9	22.9	23.4	23.6	24.0	24.2	24.0

Tm : (Tmax. + Tmin.)/2

(3) Relative humidity

Average monthly maximum and minimum values of relative humidity at Ebolowa and Sangmelima are shown below. Sangmelima is located outside of the basin boundary about 100 km east of Ebolowa.

Relative Humidity

(%)

	J	F	M	A	M	J	J	A	S	O	N	D	Mean
Ebolowa (El. 603 m)													
Hmax.	97	97	97	97	97	97	96	96	97	97	97	98	97
Hmin.	63	62	64	66	68	71	72	74	72	71	69	65	68
Sangmelima (El. 713 m)													
Hmax.	99	98	99	99	99	99	98	98	99	99	99	99	99
Hmin.	60	56	58	60	64	68	69	68	66	66	65	64	64

(4) Evaporation

Monthly evaporation observed at Ambam, Ebolowa and Sangmelima are shown below. Annual total evaporation is observed to be 694 mm, 683 mm and 650 mm respectively.

Evaporation

(mm)

J	F	M	A	M	J	J	A	S	O	N	DAnnual
Ambam (El. 560 m)											
66.6	67.8	73.6	66.1	51.9	47.8	61.2	56.4	52.5	47.9	48.0	54.2	694
Ebolowa (El. 603 m)											
69.5	70.0	68.4	60.3	54.1	49.3	52.7	53.9	46.8	46.7	50.1	61.4	683
Sangmelima (El. 713 m)											
59.0	69.4	73.0	61.3	53.5	45.3	47.2	51.2	48.0	46.3	46.3	49.6	650

Note : Evaporation is measured using piche.

(5) Wind velocity and direction

Statistic values on wind velocity observed at Ambam, Kribi and Sangmelima are given below. Kribi is located on the coast of the Atlantic Ocean, about 100 km northwest from the

proposed project site. Southwest window dominates in the basin due to the monsoon influencing on this region including the Ntem river basin.

Wind Velocity

(%)

Velocity (m/s)	<= 1	2 to 4	5 to 6	7 to 14	15 to 21	>21
Ambam (El. 560m)	85.02	14.10	0.68	0.20	0	0
Kribi (El. 5m)	57.40	41.00	1.50	0.10	0	0
Sangmelima (El. 713 m)	88.20	11.10	0.60	0.10	0	0

(6) Observed rainfall

According to the existing study report, around 2,000 mm of annual rainfall is observed in the northern basin boundary area and the value declines to 1,600 mm in the southern nation boundary area. In this study twelve stations in and around the Ntem river basin are selected for rainfall analysis considering the data period available and the location. The location is shown in Fig. 3.2.3. Annual rainfall at the stations ranges from 2,030 mm at Oveng to 1,434 mm at Minvoul with the arithmetic mean of 1,710 mm (1934 - 1990).

In order to see rainfall characteristics of the Ntem river basin, monthly rainfall pattern at the twelve stations in and around the basin are compared one another. The rainfall pattern is shown in Fig 3.2.4. The seasonal pattern of rainfall can be explained by one type for the entire basin. This fact might be explained by the topographic feature of basin, that is, there doesn't exist remarkable mountainous regions influencing on the local weather condition in the basin. It is considered that the activity of Intertropical Front produces an effect on the entire basin and the flat topography permits humid air mass to intrude into the inland part from Atlantic Ocean, furthermore the dense tropical forest covering the entire basin regulates the fluctuation of meteorological condition.

Monthly rainfall records at Ebolowa and Djoum are given below. Ebolowa is located in the northern basin boundary area and while Djoum in the most eastern area of Ntem basin about 150 km east of Ebolowa. Relatively large difference of annual rainfall is found between these 2 stations.

Rainfall

(mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
Ebolowa (El. 603 m, 1951-1990)												
37	93	192	216	234	167	59	78	230	322	189	47	1,866
Djoum (El. 684 m, 1934-1982)												
38	54	129	184	194	146	78	88	216	252	130	47	1,566

The difference of annual rainfall between both stations is 300 mm, but similar trend is found in the seasonal variation. Major rainfall peaks are observed in May and October and the lowest value in January. Sum of rainfall in the rainy seasons (March - June and September - November) accounts for 80 % of annual rainfall. The above values are illustrated in Fig. 3.2.4.

(7) Estimate of basin rainfall

In the existing hydrological analysis, basin rainfall of the Ntem river basin upstream of Nyabessan has been estimated to be 1,600 mm to 1,800 mm. In this study annual mean basin rainfall is estimated applying Thiesen Method to observed rainfall data at the selected twelve stations.

Mean annual basin rainfall of the Ntem river basin is estimated at 1,738 mm and this value is quite close to the arithmetic mean of observed point rainfall at the same stations.

Through the same process, the basin rainfalls of the Ndjo' o river basin and the Biwome river basin are estimated to be 1,808 mm and 1,679 mm respectively. In this study stage, basin rainfalls of the Ndjo' o and Biwome river basins are reviewed including the data at Méfo because possibility of the underestimate was pointed out in the previous study stage. Estimated basin rainfall for the three basins are given in Table 3.2.1.

3.2.2 Hydrology

(1) Basin condition

The Ntem river basin is located in the southwest region of Cameroon and the southern 40 % of the entire basin extends to Gabon and Equatorial Guinea. The catchment area is 26,350 km2 at Nyabessan (proposed dam site) and 18,100 km2 at Ngoazik locating in about 150 km

upstream of Nyabessan. Furthermore two tributaries with the total catchment area of 1,800 km2, Ndjo' o and Biwome rivers, join the Ntem river near the proposed dam site. In the previous study report the catchment area of the Ndjo' o river basin is identified to be 373 km2, however as a result of the review in this study using 1/50,000 scale maps, it is assumed that the Ndjo' o river basin has at least 550 km2 of the catchment area and the Biwome river basin has 1,250 km2.

The Ntem river originates in the northern part of Gabon and flows west toward the Atlantic Ocean. Length of the main river stretch from Nyabessan to the origin is about 360 km and the river profile consists of two parts, that is, one is a mild slope stretch with the mean slope of about 1/1,800 from Ma' an 50 km upstream of Nyabessan to the origin and the other is a steep slope stretch with the mean slope of about 1/300 from Ma' an to the river mouth. The entire basin is generally characterized by the flat topography and the most upstream areas of main stretch and tributaries are characterized as inundation prone area or marsh. There are some rapids in the river stretch between middle reach and the proposed dam site and the river water flows down into the Ntem Gorge through Memvé Elé falls at just downstream of the proposed dam site. From the aspects of vegetation the entire basin is covered with dense and humid evergreen forest.

On the other hand the basin of the Biwome and Ndjo' o rivers spreads out in the northern mountain range of the proposed dam site. The mean slope of river stretch is about 1/300.

(2) Flow rating curve

Flow rating curves at the following sites are derived on the basis of the existing measured data and the data obtained through measurement works conducted in this study. The location is shown in Fig. 3.2.3 and Fig. 3.2.5.

Flow rating curve at Nyabessan on the Ntem river

$$Q = 217.888 - 3.496*H + 0.015*H^2$$

(applicable to the range more than H = 120 cm)

Flow rating curve at Ngoazik on the Ntem river

$$Q = 25.139 + 0.052*H + 0.008*H^2$$

Flow rating curve at Abem on the Ndjo'o river

$$Q = -0.713 + 0.04*H + 0.0015*H^2$$

Downstream power station site in the Ntem gorge

$$Q = 33.991 + 0.153*H + 0.00154*H^2$$

Upstream power station site in the Ntem gorge

$$Q = 0.653 - 0.228*H + 0.0009*H^2$$

where H: reading of staffgauge (cm), and
Q: daily runoff discharge (m3/sec).

As shown in Figs. 3.2.6 to 3.2.10, the above curves are drawn in order to get a better fit with the measured data. From the above study result, it can be said that discharge measurement works and flow discharge data have enough reliability for hydrologic analyses.

In the Biwome river basin neither a staff gauge was installed nor discharge measurement had been conducted before start of this study for the Memvé Elé project. In this study the flow discharge is estimated on the basis of the discharge of the Ndjo'o river.

(3) Mean annual runoff

Ntem river (at Nyabessan)

In order to verify the discharge data of the Ntem river at Nyabessan, a runoff double mass curve between Nyabessan and Ngoazik is prepared as shown in Fig. 3.2.11. The relation of accumulated annual runoff depth between both stations is almost linear and it shows that there exists consistency between the discharge data at the two stations.

Runoff characteristics of the Ntem river is described below on the basis of the discharge data from 1957 to 1988 at Nyabessan. Annual daily mean discharge varies from 218 m3/sec to 588 m3/sec and the mean value is 398 m3/sec. Annual total runoff depth varies from 261 mm to 704 mm and the mean value is 476 mm(12.6 billion m3/year).

Ndjo'o river (at Abem)

The availability of daily discharge data at Abem is very limited (actually for 2 years from 1981 to 1982). For the purpose of data generation, a rough estimate of flow runoff for the period from 1957 to 1988 was attempted applying correlation with the Ntem discharge data in this study.

Furthermore, the above estimate is checked by applying the water balance condition in the Ntem river basin, that is, it is assumed that total rain loss including evapotranspiration and infiltration into the ground is almost same between the two basins. Total rain loss of the Ntem river basin is 1,262 mm, which is calculated by the basin rainfall, 1,738 mm and the total runoff depth, 476 mm. Considering this rainloss, total rain loss of the Ndjo' o river basin is roughly assumed at 1,200 mm. Annual runoff depth of the Ndjo' o river basin is thus calculated to be approximately 600 mm.

On the basis of the above assumption, the mean annual runoff is calculated to be about 11 m3/s.

Biwome river (at Nyabessan ferry point)

There is no availability of discharge data in the Biwome river basin. Therefore the daily discharge was estimated by prorata to the estimated discharge of the Ndjo' o river(on the basis of basin area)assuming the similarity of basin conditions such as topography, vegetation and meteorological conditions between the two basins. The estimated mean annual runoff is about 24 m3/s.

Mean annual runoff at Nyabessan on the Ntem river is provided in Table 3.2.2 and the values of other basins are summarized below.

Mean Annual Runoff

Location	River	Drainage Area (km2)	Mean Annual Runoff (m3/s)	(mm)	(10^6 m3)	Specific Discharge (m3/s/km2)
Nyabessan	Ntem	26,350	398	476	12,565	0.0151
Abem	Ndjo'o	550	11	625	347	0.0200
Nyabessan	Biwome	1,250	24	603	757	0.0192

However, discharge values estimated as above, especially for the Ndjo'o and Biwome rivers, should be verified and modified using data to be obtained through the future measurement works.

(4) Annual runoff pattern

Monthly runoff depth and annual runoff pattern of the Ntem river, Ndjo'o river and Biwome river are analyzed as below using observed runoff records of the Ntem river and estimated runoff of the Ndjo'o and Biwome rivers as illustrated in Figs. 3.2.12, 3.2.14 and 3.2.15 respectively.

Monthly Runoff Depth

(mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
Nyabessan (Ntem river)												
18	13	20	35	50	43	23	15	34	86	95	45	476
Abem (Ndjo'o river)												
20	11	34	33	73	43	20	11	90	150	110	30	625
Nyabessan ferry point (Biwome river)												
18	11	33	32	71	41	17	11	85	148	106	30	603

As shown in Fig. 3.2.12, two flood periods and two low flow periods are observed in the Ntem river. The first flood period is generally from April to June and the second one is from October to November. On the other hand the first low flow period is from January to February and the second one is from July to August. Sum of runoff volume in the two flood periods accounts for about 65 % of total annual runoff. Annual maximum flood is generally recorded in November, while August and February are drought months.

As given in Fig. 3.2.13, the similar feature of runoff pattern is observed also in the Ndjo'o river. As it is, however, clear from the Figure, rising time and recession time of the flood hydrographs are rather short compared with those of the Ntem river. Especially during the first flood period, many flood peaks with short duration time are observed.

The hydrographs show that there exists a remarkable difference of the runoff characteristics between the Ntem river basin and the Ndjo'o, Biwome river basins. The runoff pattern of the respective basins would be mainly dependent on the difference of catchment area and topographic conditions between the two basins.

(5) Runoff ratio

Mean runoff ratio of the Ntem river is calculated to be about 0.27 as below and variation of the value over 30 years is provided in Table 3.2.3. While runoff ratios of the Ndjo'o and Biwome rivers were calculated to be about 0.35 using estimated daily runoff data.

Runoff Ratio of the Ntem River Basin

River Name	Annual Basin Rainfall (mm)	Annual Runoff (mm)	Runoff Ratio
Ntem	1,738	476	0.27
Ndjo'o	1,808	625	0.35
Biwome	1,679	603	0.36

(6) Flow duration curve

As shown in Fig. 3.2.16, flow duration curve of the Ntem river at Nyabessan was prepared in order to clarify the flow condition. The curve is drawn using runoff data observed in 1957 to 1991. Serial method is applied to the preparation of the above curve.

Flow discharge values corresponding to time series are summarized below and given in Table 3.2.4.

Flow Duration Curve(at Nyabessan on the Ntem river)

Time(%)	Discharge(m3/s)	Time(%)	Discharge(m3/s)
10	872	60	229
20	631	70	178
30	482	80	142
40	371	90	105
50	291	100	15

Annual mean daily discharge corresponds to around 40 % discharge of flow duration.

The flow duration curves for the Ndjo'o and the Biwome rivers are also provided in the same way using estimated data from year 1957 to 1988. The results are shown below and Tables 3.2.5, 3.2.6 and Figs. 3.2.17, 3.2.18 respectively.

Flow Duration Curve(at Abem on the Ndjo' o river)

Time(%)	Discharge(m3/s)	Time(%)	Discharge(m3/s)
10	25	60	6
20	18	70	4
30	13	80	3
40	9	90	2
50	7	100	1

Flow Duration Curve(at Nyabessan on the Biwome river)

Time(%)	Discharge(m3/s)	Time(%)	Discharge(m3/s)
10	57	60	14
20	41	70	9
30	29	80	7
40	18	90	5
50	16	100	3

The flow duration curve after confluence of the Ntem, Ndjo' o and Biwome rivers is provided in Table 3.2.7 and Fig. 3.2.19. The curve shows that the runoff pattern at the proposed dam site depends on that of the Ntem river because the runoff volume of the Ntem river dominates the total runoff volume of the three rivers.

(7) Flow distribution around the proposed dam site

As shown in Fig. 3.2.5, the Ntem river furcates mainly into three streams just upstream of the proposed dam axes and then forms a bladed channel which consists of many small streams between the Memvé Elé falls and the first furcation part. In this study the flow distribution in main channels is roughly estimated on the basis of spot flow measurements. Schematic diagrams of the flow distribution are shown in Fig. 3.2.20. Most of the river flow discharges into sections A2 and SD4 both in the flood season (October) and the dry season (August). Especially in the dry season, nearly 60 % of the total discharge is observed at section A2.

Flow distribution values obtained here will be applied to hydraulic calculation for the project design including the diversion facilities, the inlet structure and the spillway.

(8) Runoff pattern of the Sanaga river

Sanaga river basin at Nachtigal Hydropower Project site has a catchment area of 76,000 km2 and the daily mean runoff is 1,067 m3/sec. Monthly mean runoff of the Sanaga river at Nachtigal is given below to compare with that of the Ntem river at Nyabessan. The hydrographs are shown in Fig. 3.2.21.

Runoff Pattern of the Sanaga River at Nachtigal

(m3/sec)

J	F	M	A	M	J	J	A	S	O	N	D	Mean
Sanaga (Nachtigal, 1952-1982))												
434	276	235	298	485	729	1,154	1,571	2,343	2,796	1,722	759	1,067
Ntem (Nyabessan, 1957-1988)												
177	138	196	365	487	442	239	143	337	848	969	437	398

(9) Frequency analysis on annual maximum flood

On the basis of the existing data from 1957 to 1991(35 years) at Nyabessan, examination on probable flood of the Ntem river was conducted. Further, flood records at Ngoazik in the middle reach of the Ntem river is also collected in order to verify the reliability of flood records. These flood records are given in Table 3.2.8 and recorded maximum flood at Nyabessan on November 9 in year 1970 is given in Table 3.2.9 and summarized below.

Recorded Maximum Flood of the Ntem river

(November 9, 1970)

Station	Drainage Area (km2)	Peak Flow (m3/s)	Specific Discharge (m3/s/km2)
Nyabessan	26,350	2,111	0.080
Ngoazik	18,100	1,379	0.076

Flood frequency analysis are made on the annual maximum floods applying three types of probable distribution, that is, Log-normal distribution (Iwai' s method), Log-Pearson Type III

distribution and Extreme value distribution (Gumbel's method). The distribution condition of observed data and theoretical distribution are given in Fig. 3.2.22 and calculation results are given below.

Probable Flood Discharge of the Ntem river at Nyabessan
(Catchment area 26,350 km2 at Nyabessan) (m3/sec)

Return period(year)	Iwai	Log-Pearson III	Gumbel
2	1,270	1,240	1,250
5	1,520	1,500	1,530
10	1,680	1,670	1,720
20	1,830	1,830	1,900
100	2,160	2,210	2,300
200	2,300	2,370	2,480
1,000	2,620	2,760	2,880
10,000	3,090	3,370	3,450

The above analysis was made for combined flood peak data at the proposed dam site (just upstream of Memvé Elé Falls) including the Ntem, Ndjo'o and Biwome rivers. The result is given below and the theoretical distribution is shown in Fig. 3.2.23.

Probable Flood for the Combined Discharge at the Proposed Dam Site
(Catchment area 28,150 km2 at Memvé Elé Falls) (m3/sec)

Return period(year)	Iwai	Log-Pearson III	Gumbel
2	1,340	1,310	1,320
5	1,610	1,580	1,620
10	1,790	1,760	1,820
20	1,960	1,940	2,000
100	2,360	2,340	2,430
200	2,530	2,510	2,620
1,000	2,930	2,930	3,040
10,000	3,550	3,590	3,650

Estimated floods by Gumbel method indicate the maximum values of the above three methods and these floods are applied to further study so as to be on a conservative side.

In order to verify the propriety of flood scale estimated above, they are compared with the probable floods adopted for the other hydropower projects in Cameroon. The comparison is made using Creager' s coefficient as given below, which is an index for flood scale independent on the peak discharge and the catchment area.

$$Qp = 46\ C * A^{\alpha}$$
$$\alpha = 0.894 * A^{-0.048-1}$$

where, C : Creager's coefficient
A : Catchment area in square-mile
Qp : Specific discharge in square-feet/sec/mile2

As provided in Fig. 3.2.24, Creager' s coefficient (C) of most extraordinary floods estimated in the past ranges between 10 and 25. From this result, it is considered that the probable floods estimated here would be reasonable.

(10) Shape of typical flood hydrograph

As shown in Fig. 3.2.12, a flood event which brings out an annual maximum flood occurs in the second flood season from September to December. The flood pattern is simple and it could be explained by one type of step-up single peak. The hydrograph starts to rise up in early September and reaches the peak in the end of October or early November repeating small oscillation. After reaching the peak, it recesses up to base flow in early January repeating small oscillation.

The hydrographs of some floods recorded at Nyabessan on the Ntem river are shown in Fig. 3.2.25. In general the hydrograph has a rising time of two months and a recession time of two months.

The hydrographs of probable floods of the Ntem river are derived by enlarging or reducing the hydrograph of the recorded maximum flood. The conversion factor is provided as a ratio of the respective probable flood peaks to the recorded maximum flood peak. The hydrographs thus obtained are given in Fig. 3.2.26 and Table 3.2.10.

(11) Identification of the maximum flood for the project

Estimate of probable maximum flood (PMF) is often carried out for a project design, but since the availability of daily rainfall data in and around the Ntem river basin is insufficient,

the estimate is not made in this study. On the while 10,000 year probable flood is adopted as the maximum flood for a project in existing hydropower project reports and that, the concept of PMF is not introduced to existing studies. From this viewpoint, 10,000 year probable flood is applied to the maximum flood for the Memvé Elé Project.

(12) Suspended load rating curve

A suspended load rating curve is generally approximated by a straight line on a full-log-paper as shown in Figs. 3.2.27 to 3.2.28. These lines can be expressed by the following formula.

$$Q_s = a * Q^b$$

where, Q_s = suspended load transport in ton/day

Q = flow runoff in m3/s
a, b = parameters depending on the basin characteristics

The two pairs of parameter are obtained for the two sites respectively, that is, one is calculated as constants of the least square formula and the other is calculated as constants of the envelope line for the observed data. The parameters are given below.

Parameters of Suspended Load Rating Curve

Location	River	Mean Runoff (m3/s)	Parameters "a"	"b"	
Nyabessan	Ntem	398	0.624	1.21	(LSA)
			1.0	1.21	(Env.)
Abem	Ndjo'o	11	1.595	1.10	(LSA)
			2.23	1.20	(Env.)

Note :
LSA : Parameters by least square approximation
Env : Parameters of an envelope line for observed data

In this study the parameters obtained as constants of the envelope line are applied to the suspended load rating curve so as to be on a conservative side because of uncertainty of the data and assumption used in estimation of sediment inflow. Therefore, the above parameters should be verified and modified including the data observed in the future.

(13) Sediment inflow into proposed dam site

Ntem river

Suspended load transport of the Ntem river is computed to be 1,500 ton/day based on 32 (1957 - 1988) years' daily runoff records at Nyabessan applying the suspended load rating curve obtained above. Its monthly summary is given in Table 3.2.11.

Furthermore the specific sediment inflow including bed load into the proposed reservoir is estimated to be 19.2 m3/km2/year (or 25 ton/km2/year) applying a bed load ratio of 20 %.

Ndjo'o and Biwome rivers

Suspended load transport of the Ndjo'o river is computed to be 42 ton/day applying the suspended load rating curve obtained above to the estimated daily runoff data. Its monthly summary is given in Table 3.2.12. The specific sediment inflow into the proposed reservoir is estimated to be 27 m3/km2/year.

The Ndjo'o river has a catchment area of 550 km2 and it is much smaller than that of the Ntem river, nevertheless the capacity of sediment yield per unit area is about 1.4 times as large as that of the Ntem river.

In the Biwome river basin, observed data enough to the analysis is not collected. Considering the similarity of basin topography, vegetation and meteorological conditions to the Ndjo'o river basin, mean annual specific sediment inflow of the Biwome river is assumed to have the same value as that of the Ndjo'o, 27 m3/km2/year.

Furthermore 100 % of the trap efficiency of sediment inflow by reservoir is adopted.

On the basis of the above study, the total sediment deposit volume after 100 years operation of the reservoir is estimated to be around 56 million m3 as shown below.

Summary of Sediment Study Result

Location	River	Drainage Area (km2)	Sediment Inflow (m3/km2/yr)	(mm)	Sediment Volume after 100 years (10^6 m3)
Nyabessan	Ntem	26,350	19.2	0.0192	51.0
Abem	Ndjo'o	550	27.0	0.027	1.5
Nyabessan	Biwome	1,250	27.0	0.027	3.4
Total		28,150			55.9

Sediment volume transported by the Ntem river accounts for over 90 % of the total sediment volume to be deposited in the reservoir.

Evaluation is conducted to examine the propriety of the above analysis result based on the existing sediment study for the entire land area of Cameroon. Sediment yield of the Ntem at Nyabessan (25 ton/km2/yr) is less than that of the Sanaga (28 ton/km2/yr at Nachtigal and 44 ton/km2/yr for the whole Sanaga basin). The evaluation result is provided in Appendix III.

(14) Composition analysis of sediment

The diameter distribution of particles and composition of suspended solid and river bed material taken in the project area are analyzed for the purpose of clarifying the influence on generating equipment and the design of project components. The analysis results are given below.

Suspended solid

The analysis for the suspended solid is conducted for two samples taken at Nyabessan gauging point on the Ntem river. The result is summarized below.

Composition of Suspended Solid of the Ntem River

(%)

Material	Sample Number No. 1	No. 2
Quartz	27.9	38.7
Opaque mineral	61.8	49.1
Black mica	3.8	6.7
Fibriform glass	6.5	5.5
Total	100	100

Note: Samples No. 1 and No. 2 are taken at different points on the same river section.

It is generally recognized that hard materials exceeding 0.2 mm in diameter such as quartz produce an unfavorable influence on generating equipment. Although quartz occupies around 30 % of the material, the diameter distributes between 0.03 mm and 0.19 mm. Most of the particles of other materials also distribute in the range less than 0.2 mm in diameter.

As mentioned in the previous section, sediment from the Ntem river accounts for over 90 % of the total sediment volume. Therefore unfavorable effect on generating equipment by suspended solid would not be so serious.

River bed material

Diameter distribution is analyzed for river bed materials. Sampling of river bed material is carried out at the following 5 points.

P1 : Nyabessan(Ntem river)
P2 : Nyabessan(Ndjo' o river)
P3 : Nyabessan(Biwome river)
P4 : Meyontem(Ntem river)
P5 : Ma' an(Mvila river)

The analysis result is given below.

Diameter Distribution of River Bed Material

Diameter (mm)	Sampling Point P1	P2	P3 (%)	P4	P5
D > 2	0.4	0.0	5.0	5.2	0.4
0.2 < D <= 2	63.5	46.0	21.1	32.8	24.4
0.05 < D <= 0.2	35.1	48.4	62.1	48.4	63.4
0.02 < D <= 0.05	0.0	0.6	2.1	1.7	0.7
0.002 < D <= 0.02	0.0	0.9	2.0	1.0	1.3
D < 0.002	0.8	2.9	7.2	10.3	5.0

Note : excluding moisture content
"D" denotes diameter of riverbed material

The above table presents that most of the particles distribute between 0.05 mm and 2 mm in diameter. Especially the share of diameter between 0.2 mm and 2 mm is large compared to that of suspended solid.

(15) Water quality

The chemical analysis for the water of the Ntem, Ndjo'o and Biwome rivers were conducted to assess the water quality. Water samples were taken at the gauging points as well as those for the suspended load. The laboratory test was carried out in the Laboratory of the Hydrologic Center in Yaoundé.

The result of the laboratory test are provided in Table 3.2.13. It is generally recognized that the water may has adverse effect on generating equipment and metal structures if its pH value is less than 4.5. As shown in the table, pH value of the river water of the above three rivers ranges between 6.3 and 7.7. Accordingly it is judged that the river water is sufficiently usable for the hydropower purpose. Assessment result on the river water from the aspects of other water use would be mentioned in Appendix IV on the study from health environmental aspects.

3.3 Geological Study

3.3.1 Outline of Geology in the Vicinity of the Project Site

As shown in Fig. 3.3.1 "Regional Geological Map" the project site in located in south Cameroon is widely composed of pyro-xene hornblend gneiss and granitic gneiss that sedimentary rocks (sandstone, argillaceous stone and calcareous stone in origin) of Precambrian period was underwent metamorphosed. Immediately downstream of the site, the waterfall called as Chute Du Memvé Elé with some 35 m in head is located. The downstream of the waterfall forms very steep cliff and the gorge called "Gorges Du Ntem". The direction of flowing down (gorge) stream is from NE to SW.

The geological feature in the site is characterized by the development and distribution of fault and scistocity in the same direction of the gorge (Fig. 3.3.2 - Interpretation of Linearment).

3.3.2 Geology of the Project Site

There found out no unstable geological phenomenon such as landslide. In case of FSL = 392 m (corresponds to dam crest EL. 395 m) was selected in the site, several places of the existing road will be submerged. A re-settlement or embanking at the places lower than 395 m is needed. Also the lowest ridge of the southwest most area is an altitude of some 405 m only. Since the ridge is composed of silty fine sand deposits at the depression zone accompanied a fault, a construction of a blanket or cutoff trench shall be required (Fig. 3.3.3 - Geological Map of the Reservoir Area).

The geological reconnaissance, seismic exploration of 17 km, drilling campaign of 17 holes (490 m in total), and test pits etc., were conducted at the site. As a result, it is clarified to be the biggest problem in the project that an existence of the fault is running in the direction of NE-SW. The two main faults are identified by the study result. One fault is located along the Gorge Du Ntem. The other one is parallel running at the south east side of the former one, which has a depression zone. They are hinge faults that the east side of the fault is inclined to NE and the west side of the fault is inclined to SW, respectively (Fig. 3.3.4 - Geological Map of Dam Sites). It was impossible to find out the fact from the site whether they are active or stable. The result of seismicity analysis shows that the three events only had affected to the site during past some 300 years. The earthquake coefficient (k) for the site for return period of 100 years is calculated as $k = 0.01\ G$. No geological reference

regarding the faults is available at present.

The possible dam sites and waterways for the project are 5 alternatives for the dam site and 2 alternatives for the waterway route respectively (see Fig. 3.3.4 for locations of the alternatives). The result of the geotechnical interpretation is as follows;

The comparative study(geotechnical analysis) was done for the 5 alternative dam axes of ***1***, ***2***, ***3***, ***4***, and ***5*** in descending order from the upstream one (Table 3.3.1). It is resulted that Alternative ***4*** is suitable. The alternative axis 4 is located at the place where the fault is not likely affected to the axis, and the geological conditions are relatively in stable. In addition, the site is topographically expected to be able to design by minimum scale for the volume of an earth fill dam. Construction planning is also moderately easy compared with the other sites of earth fill dam (Fig. 3.3.5 - Geological Profile of Axis 4).

The comparison study on the possible two alternatives of the up-stream and the downstream waterways reveals that the downstream one has much better than the upstream one, because the seismic survey result shows that the low velocity zone of 20 m wide indicating a fault is running at the point along the route just before reaching the Gorge Du Ntem in the upstream one.

While the downstream one is some 1 km longer than that of the upstream one. However, the route can be expected to have a larger head by 7 to 8 m, and it has also a favorite topography for a pondage on the way of the route.

3.4 Construction Material Survey

3.4.1 Soil, Sand and Gravel Materials for Core, Random Zones and Fine Concrete Aggregates

In the vicinity of the alternative dam sites of 1, 2, 3, 4, and 5, the earth fill material of laterite and residual soil reaching to the depth of 10 m to 35 m is abundantly found out, especially in the right bank side. The soil up to the depth of 5 m is homogeneous, not contained gravel, rather low moisture content due to above G/W/L. As the soil in deeper portion near a basement rock is contained gravels, it shall be utilized for random zone material. These soils have the moisture contents which is several percent higher than that of the optimum; therefore, the earth work in dry season with control of moisture, and water draining on the dam foundation of river bed is very important.

There is a sand deposit immediately upstream of the Nyabessan boat station. The sand obtained is relatively coarse having low uniformity coefficient. For the purpose of fine concrete aggregate, this river sand shall be passed through rod mill in an aggregate production plant so as to improve gradation. There are underwater sand deposits at many locations in further upstream reaches, though the quantity at each location appears to be relatively small. The deposits may still be the sources of sand material by means of recuperation by manpower (local people) in the dry seasons.

Coarse concrete aggregate including coarser particles of sand materials shall be produced by quarry rock at the aggregate production plant. Filter material will be mixed the river sand with aggregate passing through a secondary jaw crusher.

The location of each construction material is shown in Fig. 3.4.1. Table3.4.1 to Table 3.4.3 show evaluated parameters for the preliminary design, the available sites for the respective dam site, and their exploitable quantity.

3.4.2 Rock Quarry

As shown in Fig. 3.4.1, the available and possible rock quarry sites of R 1, R 2 and R 3 only are found out. The rock test result for the samples taken from R 1 and R 2 reveals that the rock is suitable for the material and good quality in terms of strength, durability and stability.

3.5 Environment

3.5.1 Activities Carried Out

Studies on the socio-environmental aspects of the project was commenced in May 1991 when the Study Team's Environmentalist was first assigned to Cameroon. He carried out the initial environmental examination (IEE) and also prepared the Terms of Reference for the environmental impact analysis (EIA) to be carried out by SONEL.

SONEL intended to carry out the EIA survey by employing Cameroonian survey agencies. As the result of tender, SONEL selected two survey agencies; one is SEDA (Societe d'Etude pour le Developement de l'Afrique) for socio-environmental survey and the other is CUSS (Centre Universitaire des Science de Sante) for the health survey.

In March 1992, the Study Team despatched the Study Team's Environmentalist to provide

guidance to SEDA and CUSS at the beginning of their survey activities. However, actual commencement of the SEDA/CUSS's survey was delayed until October 1992 due to delay in contract signing (effected in June 1992) and further due to difficulty of financial mobilization on the part of SEDA and CUSS.

SEDA/CUSS's provisional reports were submitted in the end of January 1993. The Study Team's Environmentalist, after arrival in Cameroon in February 1993, discussed with SEDA/CUSS for reviewing and upgrading the survey outputs. The final reports by SEDA/CUSS were submitted in June 1993.

3.5.2 Initial Environmental Examination (IEE)

The Study Team's Environmentalist carried out an initial environmental examination during his assignment in 1991/92. This initial survey identified potential socio-environmental issues related to the proposed project and proposed two lots of the surveys:

(a) Study on public health and impacts on it due to the proposed project
(b) Study on economic activities, habitation and infrastructures

The major issues were foreseen to be (i) resettlement of people and (ii) health problem due to creation of water impounding reservoir.

3.5.3 Environmental Impact Assessment (EIA)

Details of the environmental aspects including the environmental impact assessment are described in Appendix IV - Environmental Aspects with its annexes. The results of the environmental impact assessment are summarized hereinafter and in Table 3.5.1.

(1) Pollution (Deterioration of water quality)

Appraisal for negative impact: None

Besides the obstacles remained in the reservoir such as trees and grasses, decay of submerged biomass will lead a sensitive change in the water quality. However, the water quality in the reservoir and the downstream can be diluted and kept clean by circulation of reservoir water in a short period (2 to 3 days) because of the run-of-river type development.

(2) Natural Environment

i) Effect on ecology by development of project

Appraisal for negative impact: Small

The project site is located near the Campo fauna reserve. The impact to this zone is small because the reservoir created by the dam construction is far away from the said zone, as the small scale development damming up Ntem river only is adopted. The reservoir has an area of 19 km2. Water rise due to the dam is about 10 m. A part of equatorial forest will be submerged and animals living in this area will be ridded to the surrounding.

In the swamp zone sharing large part of the submerged area, there are many wild palm trees and few marketable trees. As to the marketable trees growing on higher land, following measures are conceived.

1) Allocation of felling/cutting of marketable trees in the reservoir area to forest exploiters.
2) Having contracts with peasant woodcutters for opening and clearing hauling roads.

To protect the animals in the reservoir area from drowning and being isolated in small islands, it is recommended to carry out beating drums and gun shots in the air regularly for many days before impounding the reservoir.

ii) Effect on landscape

Appraisal for negative impact: Small

Memvé Elé waterfalls having a height of 35 m exist just downstream the proposed dam site. It is considered that the discharge passing through the falls become small due to diversion of water for power generation. There are two tributaries, the Ndjo' o and Biwome, joining with the Ntem river between the dam site and Memvé Elé falls. The average discharge of both the Ndjo' o and Biwome 35 m3/sec can be used as a compensation flow. Furthermore, river outlet facilities will be provided for the dam body.

The dam site located at the very remote area and the transportation means are poor. Thus, the tourism for this area is not popular now.

(3) Socio-Economic Environment

i) Effect on historical and cultural heritage

Appraisal for negative impact; None

The influence zone close to the project possesses little historical and cultural heritage.

ii) Effect on existing infrastructures

Appraisal for negative impact: None

There is no specific infrastructure to be affected by the project development.

iii) Resettlement

Appraisal for negative impact: Small

Numbers of houses affected are only 9. The cost of resettlement is estimated at F.CFA 7.5 million. The compensation cost for the cultivated lands and agriculture is greater than that of resettlement and estimated at around F.CFA 80 million.

It is very important to make efforts to realize smooth and successful resettlement because the resettlement is essential to the Project. A land-to-land based compensation to the inhabitants is highly recommended as one solution of the resettlement operation. That is, no compensation money is paid to the inhabitants but new equivalent land with more modernized infrastructures is offered to them. By the land-to-land based compensation, the Project will have more chance to receive inhabitant's accord to the successful resettlement. The new lands have therefore to be prepared in advance.

iv) Effect on traffic means

Appraisal for negative impact: Small

The public road connecting Ma'an with Nyabessan will be cut of by submergence at two bridges, near Alen II and between Nemeyong and Alen I. The formation height of road near the bridges may be elevated by embankment and replacement of the bridges (span is less than 10 m) will be required.

The transportation mean to cross the Ntem river is carried out by a canoe at present. The dam crest road can be utilized for communication between Nyabessan village and villages at the opposite bank after the completion of the project.

v) Effect on downstream water utilization

Appraisal for negative impact: None

Water used for the power generation is put back to the Ntem river at the tailrace outlet about 4 km downstream of the dam. There is few private house along the river course between the dam site and the tailrace outlet. As the project is of run-of-river type, the flow condition downstream the tailrace outlet will not change remarkably but be a little regulated.

vi) Occurrence of diseases such as malaria caused by insects or water

Appraisal for negative impact: Small

The entomological investigation assesses the existence of notable vectors, simulium of human onchocerca (creeping disease), anopheles of malaria and tse-tse flies of sleeping sickness (trypanosomiasis) from the view point of medical and veterinary interest.

Considering the fact that malaria infection already reaches high level in the project zone in all seasons, the intensity of transmission of this decease will not be generally modified.

The absence of onchocerca presently in the project site and relatively far distance to the nearest homes will minimize the risk of outbreak of this parasitic disease.

As to the sleeping sickness, owing to the fact that there will be intensive mobilization of population following construction of the dam, the proximity of breeding area at Campo keep permanent danger.

It is important to envisage an adequate anti-vector campaign program based on local strategies. While hygienic measures and health education are also important to the population.

(4) Others

i) Effect on environment during construction period

Appraisal for negative impact: Small

As there is few private house around the construction site, noise and vibration by construction will not affect on the residents. However, it is expected that vehicle for transportation of construction materials and equipment will cause noise and vibration and affect on the residents living along the existing road. The road will be improved by grading and widening, and speed limitation should be considered before the commencement of

construction.

ii) Environmental monitoring

Appraisal for negative impact: Small

In general it has been assessed that impact on the environment is not serious in comparison with other hydropower projects because of the run-of river type development. However, the monitoring for the health problem due to creation of water impounding reservoir is very important for the project.

3.6 Further Investigation / Study

3.6.1 Topographical Survey

1/1,000 scale mapping was carried out for the alternative dam axes and waterway routes in the beginning of field investigation stage. The proposed dam axis and waterway in the feasibility design stage is partially beyond the survey area by the 1/1,000 scale mapping. The additional survey area along the dam axis and waterway by 1/1,000 scale mapping is around 120 *ha*. The associated cost is estimated to be F. CFA 1,020 million.

As to the detailed design of open concrete structures such as the intake, spillway, penstock intake, powerhouse and tailrace outlet, 1/500 scale mapping will be required for the area of around 60 *ha*. The estimated cost to the 1/500 scale mapping is again F. CFA 1,020 million.

Cross sectional surveys of the river are also necessary along the dam axis, cofferdam axis and near the water level gage stations at Nyabessan and downstream the tailrace outlet. The associated cost is estimated to be F. CFA 508 million.

Note that the estimated costs above are based on the Study Team's experience in Cameroon and also on the past actual costs of similar works worldwide.