

**THE FEASIBILITY STUDY REPORT  
ON  
THE ESTABLISHMENT OF AN AMMONIA PLANT  
IN  
THE REPUBLIC OF ZIMBABWE  
(VOLUME I)**

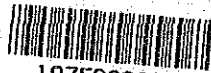
**JUNE 1989**

**INTERNATIONAL COOPERATION AGENCY**

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## PREFACE

In response to a request from the Government of the Republic of Zimbabwe, the Japanese Government decided to conduct a study on the Establishment of an Ammonia Plant and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zimbabwe a study team headed by Mr. Katsuo Adachi of the Japan Consulting Institute from July 29 to August 27, 1988.

The team held discussions with the officials concerned of the Government of the Republic of Zimbabwe, and conducted a field survey in Kwekwe and Hwange area, Zimbabwe. 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 development of the project and to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Zimbabwe for their close cooperation extended to the team.

June, 1989



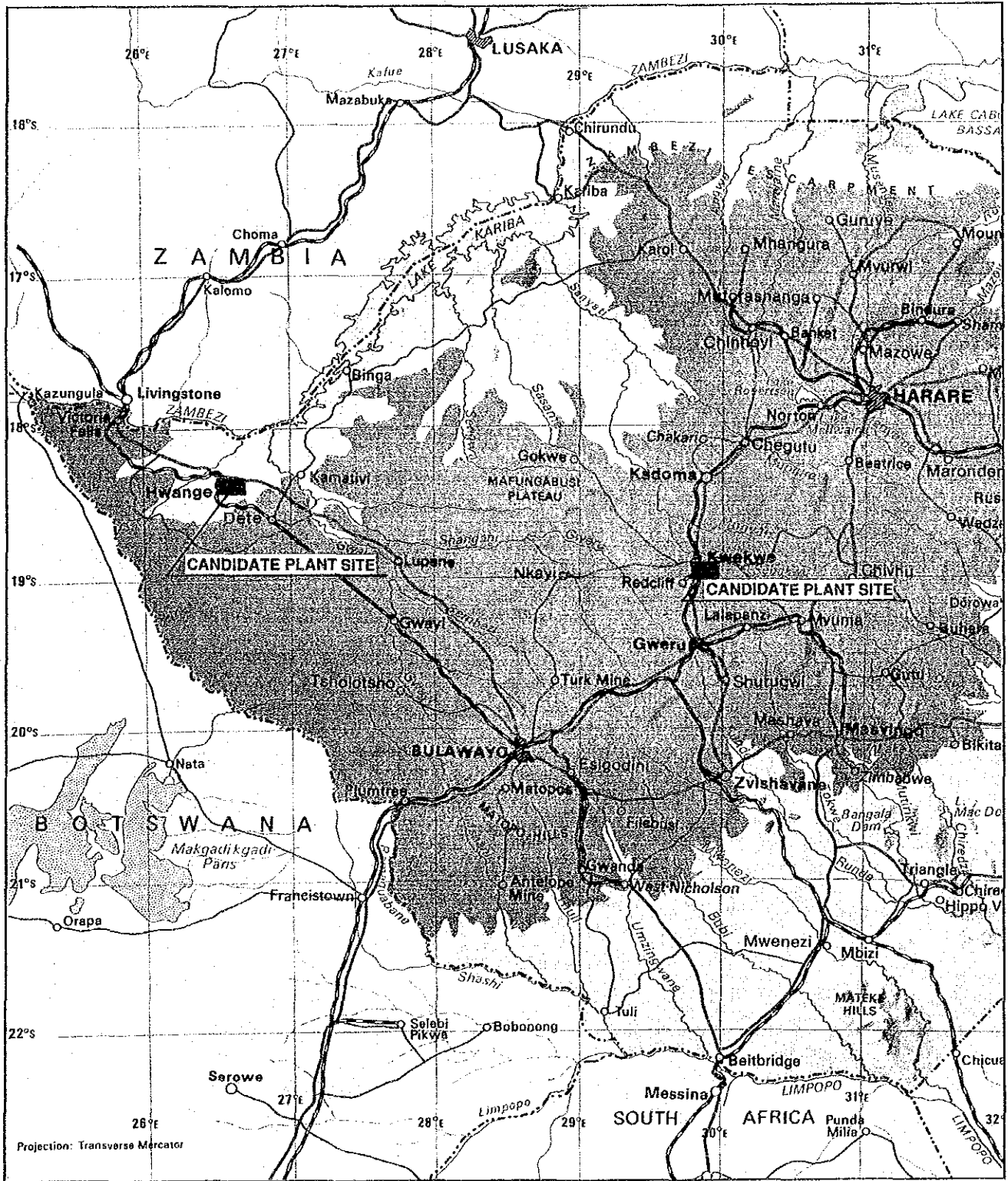
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Kensuke Yanagiya

President

Japan International Cooperation Agency

# PHYSICAL MAP ZIMBABWE



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国際協力事業団

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## LIST OF ABBREVIATION

### 1. Monetary

Z\$	Zimbabwe Dollar
US\$	U.S. Dollar
	Exchange rates for The Study
	August, 1988
	US\$1.00 = Z\$1.80
	= Japanese Yen 130

### 2. Organization

#### (1) Zimbabwean

MIT	Ministry of Industry and Technology
MLARR	Ministry of Lands, Agriculture and Rural Resettlement
MEW	Ministry of Energy and Water Resources and Development
MNR	Ministry of Natural Resources and Tourism
MOF	Ministry of Finance, Economic Planning and Development
MOT	Ministry of Transport
MTC	Ministry of Trade and Commerce
CSO	Central Statistical Office
IDC	Industrial Development Corporation of Zimbabwe Limited
NRZ	National Railways of Zimbabwe
SABLE	Sable Chemical Industries Limited
WANKIE	Wankie Colliery Company Limited
WINDMILL	Windmill (PVT) Limited
ZESA	Zimbabwe Electricity Supply Authority
ZFC	Zimbabwe Fertilizer Corporation Limited
ZIMCON	ZIMCONSULT
ZIMPHOS	Zimbabwe Phosphate Industries Limited
ZISCO	The Zimbabwe Iron & Steel Company Limited

### 3. Unit

#### (1) Length

m	Meter
mm	Milimeter
cm	Centimeter

km	Kilometer
in	Inch (1 in = 2.54 cm)
ft	Foot (pl. Feet) (1 ft = 0.305 m)
(2) Area	
m <sup>2</sup>	Square meter
km <sup>2</sup>	Square kilometer
ha	Hectare (1 ha = 10,000 m <sup>2</sup> = 2.471 Acre)
Acre	Acre (1 Acre = 4.047 m <sup>2</sup> )
(3) Volume	
m <sup>3</sup>	Cubic meter
cm <sup>3</sup>	Cubic centimeter
Nm <sup>3</sup>	Normal cubic meter at 0°C and 1.033 kg/cm <sup>2</sup>
l	Litre
bbl	Barrel (1 Barrel = 159 Litre)
(4) Weight	
g	Gramme
mg	Miligramme
kg	Kilogramme
T	Metric ton
KT	Thousand ton
lb	Pound (1 pound = 0.454 kg)
(5) Time	
sec	Second
min	Minute
H	Hour
D	Day
M	Month
Y	Year
(6) Capacity and Rate	
kg/H	Kilogramme per hour
m <sup>3</sup> /H	Cubic meter per hour
T/H	Metric ton per hour
T/D	Metric ton per day

T/Y	Metric ton per year
l/H	Litre per hour
(7) Pressure	
kg/cm <sup>2</sup>	Kilogramme per square centimeter
ata	Atmospheric pressure in absolute
atg	Atmospheric pressure in gauge
psi	Pounds per square inch
(8) Temperature	
°C	Degree Celsics (Centigrade)
(9) Energy	
cal	Calorie
Kcal	Kilocalorie
MM Kcal	Million kilocalorie
kWh	Kilowatt hour
BTU	British thermal unit (1 Bta = 0.252 Kcal)
HHV	High heating value
LHV	Low heating value
MJ	Mega joule (1 MJ = 238.7 Kcal)
(10) Power	
KW	Kilowatt
MW	Megawatt
KVA	Kilo-volt ampere
<b>4. Economics</b>	
IRR	Internal rate of return
EIRR	Economic internal rate of return
GDP	Gross domestic product
GNP	Gross national product
<b>5. Transportation</b>	
C & F	Cost and freight
CIF	Cost, insurance and freight
FOB	Fee on boad

**Volume I**  
**Part 1**

# **Chapter 1 Introduction**





## Chapter 1 Introduction

### 1.1 Background of This Project

The Republic of Zimbabwe is a landlocked nation in the Central African plateau that has an area of 390,759 km<sup>2</sup>. It is reported that approximately 86% of the territory belongs to people occupied by farming, and about half of farm land is owned by large scale farmers. The estimated present total population is approximately 9 million, showing an average annual population growth rate of about 2.9% for the past ten years. Conversely, at constant price base, the GDP increased from Z\$ 32.24 billion in 1980 to Z\$ 38.94 billion in 1986, showing an average annual increase of 3.2%. The percentage of agriculture to the GDP is approximately 12% and has not changed significantly from the past.

The main economic policy of the government of Zimbabwe is the development of agriculture, progressively pursuing increase of agricultural production by reallocation of land, soil improvement, irrigation, etc.

In terms of demand for fertilizer for increasing agricultural production, Zimbabwe has a substantial agricultural production potential; however, fertilizer dosage per agricultural area and per population are still low on a world-scale. For the supply of fertilizer, Zimbabwe has four fertilizer firms, among which Sable Chemical Industry (SABLE) produces ammonia (200T/D), nitric acid, and ammonium nitrate, and Zimbabwe Phosphate Corporation (ZIMPHOS) produces single superphosphate and double superphosphate. The other two firms, Zimbabwe Fertilizer Co. (ZFC) and Windmill Limited (WINDMILL) purchase straight fertilizers from the two aforementioned companies, blend, granulate, and bag them, and distribute all fertilizers to meet the requirement of the domestic market as either straight or compound fertilizers. Zimbabwe also imports a portion of required ammonia (approx. 100T/D), urea, and potash and utilizes them as raw materials. Therefore, in terms of ammonia, the nation domestically produces two-thirds and imports the remaining one-third. Coal, a raw material in production of ammonia, is reserved in Zimbabwe generally in the Karoo of the Permian period and the Triassic period, and exists in the region of the Zambezi River in the northwest, as well as regions of Limpopo River and Sabi River. Although coal outcrops were discovered in both regions in 1894, Wankie coalfield is the only field excavated commercially since 1903, supplying all the domestic customers.

With regard to this background, the Government of Zimbabwe requested Japan's technical cooperation in September 1985 for implementing a feasibility study on the establishment of an ammonia plant utilizing domestic coal, for achieving self-sufficiency in fertilizer supply and establishment of a system to supply fertilizer at low cost. In response, JICA formed a preliminary survey team consisted of JICA officials and experts of each field, that was dispatched to Zimbabwe from February 3 to February 19, 1988.

As a result of discussions between the preliminary survey team and Ministry of Industry and Technology and related organizations, the Scope of Work for the implementation of this study was concluded on February 15, 1988 between JICA and its counterpart, Ministry of Industry and Technology. This study was carried out based on this Scope of Work and its results are described in this report.

## **1.2 Objective of Study**

The objective of the study is to investigate the technical and economic feasibility of a plan on the establishment of an ammonia plant in Zimbabwe for producing ammonia from coal and possibly other chemical products with value added as co-products. In relation to the production process, the following four cases are considered.

- The product(s) as
- (1) Ammonia only
  - (2) Ammonia and urea
  - (3) Ammonia (from coke gas) and tar
  - (4) Ammonia and methanol

## **1.3 Scope of Study**

The agreed Scope of Work comprises a detailed market and technical study as well as a financial and economic evaluation, and their contents cover the following categories.

- Background of Project
- Market of Ammonia and Co-products
- Raw Material and Utilities
- Plant Location and Site
- Basic Plans and Conceptual Designs
- Financial Analysis

- Economic Evaluation
- Conclusions and Recommendations

The Scope of Work is provided in the Annex for reference.

On August 25, 1988, the scope of study was confirmed between the survey team and Ministry of Industry and Technology of Zimbabwe, and it was agreed that, for the cases of producing ammonia exclusively and of ammonia and urea being more important, the study should extend to be the estimation of plant cost and the evaluation of the project in views from financial and economic aspects in addition to the process study, while, for the cases of ammonia and tar production as well as of ammonia and methanol production, the project evaluation should be made on the basis of carrying out the process study. The contents are shown in Table I-1-1 in the next page.

#### **1.4 Study Schedule and Study Flow**

As a part of this study, the JICA survey team consisting of team leader Mr. Katsuo Adachi and nine specialists visited Zimbabwe from July 30 to August 25, 1988 and carried out the field survey. Counterpart members for supporting the team were selected from the members of Ministry of Industry and Technology. With their cooperation, the team gathered and analyzed data and information necessary for the work of this study, collected samples of coal, and visited and did surveys in the various regions relevant to the study, such as project site, fertilizer markets, sources of raw materials, and utilities.

The survey team then made a progress report compiling the main results and issues of the field survey as well as the premises and assumptions for the project study, and submitted it to Ministry of Industry and Technology. The results of the discussion concerning this progress report are summarized in the Minutes of Meeting dated on August 25, 1988. The JICA field survey team members, their counterparts, and the organizations that were visited are listed in Tables I-1-2, I-1-3, and I-1-4.

Given a thought to the feature of this scope of study, the study was performed according to the study flow summarized in Fig. I-1-1, with special consideration to nitrogenous fertilizer market survey, the quality of coal as raw material, technical survey on applicable processes and the financial viability of the project. Furthermore, the study flow and methodology are described in detail in the Inception Report issued in July, 1988.

Table I-1-1 Major Items and Extent of Study

Study Work	Case			
	Ammonia Only	Ammonia and Urea	Ammonia from Coke Oven Gas and Tar	Ammonia and Methanol
Evaluation on Test Results of Raw Material	o	o	o	o
Selection of Project Site	o	o	o	o
Process Selection for Ammonia and Co-products	o	o	o	o
Preparation of Basic Plan and Conceptual Design for Ammonia and Co-products Plants	o	o	o*1	o*2
Preparation of Implementation Schedule	o	o	x	x
Preparation of Plant Operation Schedule	o	o	x	x
Estimation of Plant Installation Cost	o	o	x	x
Financial Analysis	o	o	x	x
Evaluation of the Economic Effect upon National Economy	o	o	x	x
Conclusion and Recommendation	o	o	o	o
Status	Second Priority	Top Priority		

Note:-- \*1 Block Diagram and Material Balance (Coal, Ammonia, Coal Tar, Coke) only.

\*2 Process Description and Block Diagram only

o Do x Do not

The report consists of Summary, Volume I and Volume II. In Volume I, the cases for ammonia only, and ammonia and urea are studied and reported. In Volume II, the cases for ammonia from coke oven gas and tar, and ammonia and methanol are studied and reported.

**Table I-1-2 List of JICA Survey Team**

1. K. ADACHI (Leader)  
Supervising and General Manager
2. M. SUZUKI (Assistant-Leader)  
Process and Plant (Coal Gasification and Methanol)
3. Y. FUJIKI  
Process and Plant (Ammonia and Urea)
4. J. SASAOKA  
Process and Plant (Coke and Tar)
5. K. YAMANE  
Raw Materials and Utilities
6. H. SAKO  
Civil Engineering and Environmental Matters
7. M. ITO  
Market and Distribution (Fertilizers)
8. M. MIYAMOTO  
Market and Distribution (Ammonia and Co-products)
9. Y. NODA  
Summarizing of Financial and Economic Analysis
10. A. HASHIMOTO  
Economic Evaluation

**Table I-1-3 Member of Counterpart, Ministry of Industry and Technology**

MR. S. GEZA	: Permanent Secretary
DR. C.C. TAKUNDWA	: Assistant Director
MR. K. NKOMANI	: Assistant Secretary
MR. G. MAULUKA	: Senior Administrative Officer
MR. E.M. SIWELA	: Senior Administrative Officer
MR. Y. SIKWILA	: Senior Administrative Officer
MRS. I. NCUBE	: Senior Administrative Officer
MISS C. CHOGOYA	: Senior Administrative Officer
MR.T. TOGWE	: Assistant Secretary (Bulawayo)
MR. CHIKATE	: Senior Administrative Officer (Bulawayo)

**Table I-1-4 List of Offices Visited**

1. Embassy of Japan in Zimbabwe
2. Ministry of Industry and Technology
3. Ministry of Finance, Economic Planning and Development
4. Ministry of Energy and Water Resources and Development
5. Ministry of Mines
6. Industrial Development Corporation of Zimbabwe Limited
7. Ministry of Transport
8. Ministry of Trade and Commerce
9. Central Statistical Office
10. Ministry of Natural Resources and Tourism
11. Ministry of Lands, Agriculture and Rural Resettlement
12. Zimbabwe Electricity Supply Authority
13. National Railways of Zimbabwe

**Table I-1-4 List of Offices Visited (Cont'd)**

14. Wankie Colliery Company Limited
15. Sable Chemical Industries Limited (Kwekwe)
16. The Zimbabwe Iron and Steel Company Limited
17. F. Issels & Son Limited (Bulawayo)
18. Zeco (Bulawayo)
19. NIMR & Chapman (PVT) Ltd. (Bulawayo)
20. O'Conolly & Co (PVT) Limited (Bulawayo)
21. Hogarths Limited (Bulawayo)
22. Puzzey and Diss Motors (PVT) Ltd.
23. Chemplex Marketing
24. Protea Chemical Services
25. National Oil Company of Zimbabwe (PVT) Ltd.
26. Zimbabwe Fertilizer Corporation
27. Windmill (Private) Limited
28. Zimbabwe Phosphate Industries Ltd.
29. Chemistry and Soil Research Institute
30. Agricultural Marketing Authority
31. Commercial Farmers Union of Zimbabwe
32. Merton Park (PVT) Limited (Commercial Farm)
33. Small-Scale Commercial Farm
34. Chinamora Communal Land
35. Zimbabwe Development Bank
36. Zimconsult
37. Standard Chartered Bank

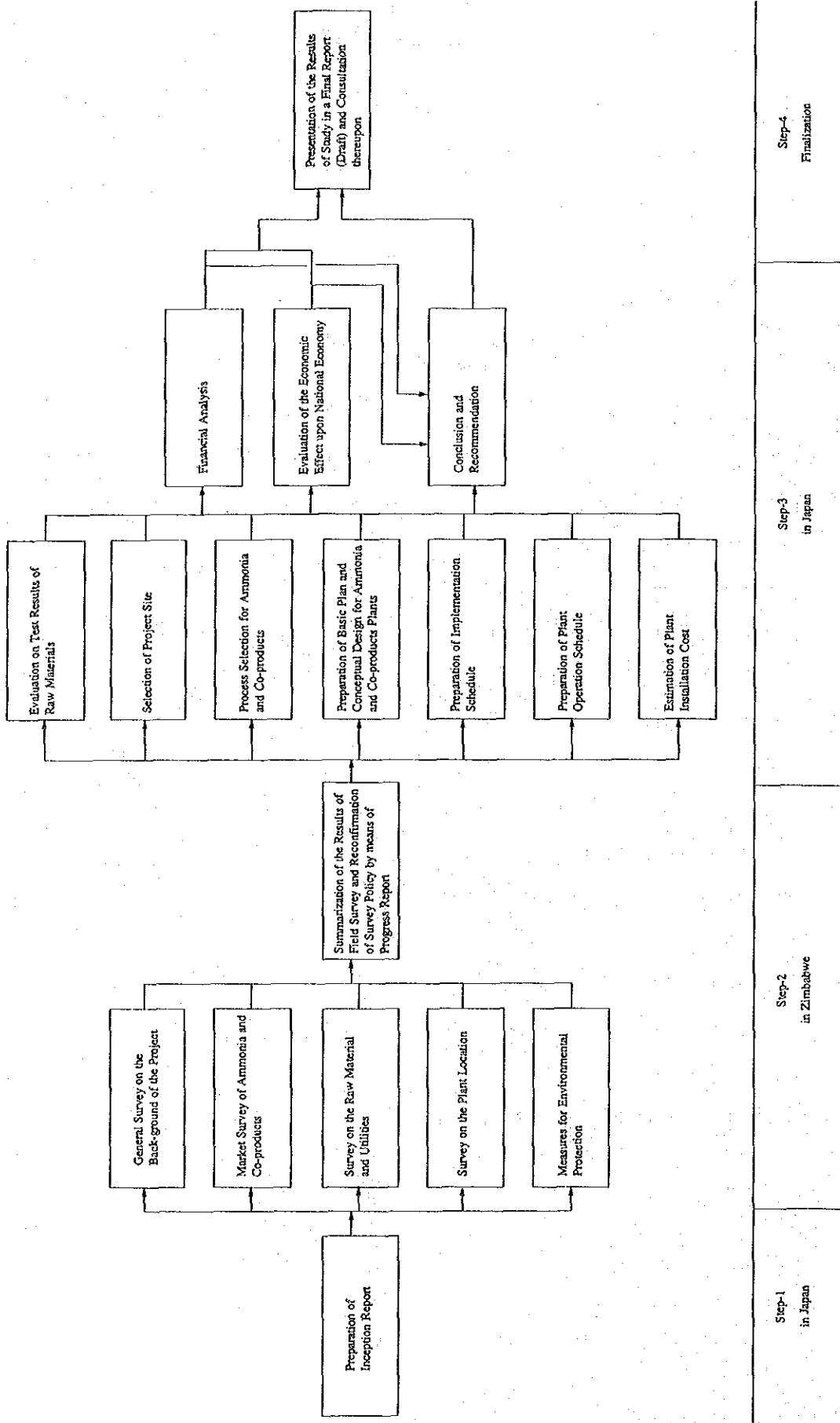


Fig. I-1-1 Overall Study Flow



## **Chapter 2 Social and Economic Conditions of Zimbabwe**



## Chapter 2 Social and Economic Conditions of Zimbabwe

### 2.1 Geographic Characteristics

Zimbabwe is situated in the southern part of the African continent in latitude from about 15 degrees 30 minutes to 22 degrees 30 minutes south and longitude from about 25 degrees to 33 degrees 10 minutes east.

Zimbabwe has borders with Zambia in the north, Mozambique in the northeast and east, South Africa in the south, and Botswana in the west, and is completely landlocked. The nation's main ports for imports and exports are consequently Beira and Maputo in Mozambique; the distances between Harare and Beira is 602 km; for Harare-Chicualacuala-Maputo, 1,269 km; Harare-Beitbridge-Komatipoort-Maputo, 1,480 km; respectively. It thus is disadvantaged from the standpoint of export competitiveness and must rely on expensive imported machinery and equipment.

The area of Zimbabwe is 390,759 km<sup>2</sup>. The geography can be divided into the following regions.

#### (1) High Veld

A High Veld (savannah) from 1,200 m to 1,800 m above sea level spans diagonally like a backbone from Bulawayo in the nation's southwest through Gweru Kwekwe, Harare, and Marondera to Nyanga in the northeast. The nation's major commercial and industrial cities are situated throughout this veld.

#### (2) Middle Veld

A Middle Veld from 600 m to 1,200 m above sea level gently slopes from the High Veld to the Zambezi River separating the nation with Zambia in the north, and to the Limpopo River separating the nation with South Africa in the south.

#### (3) Low Veld

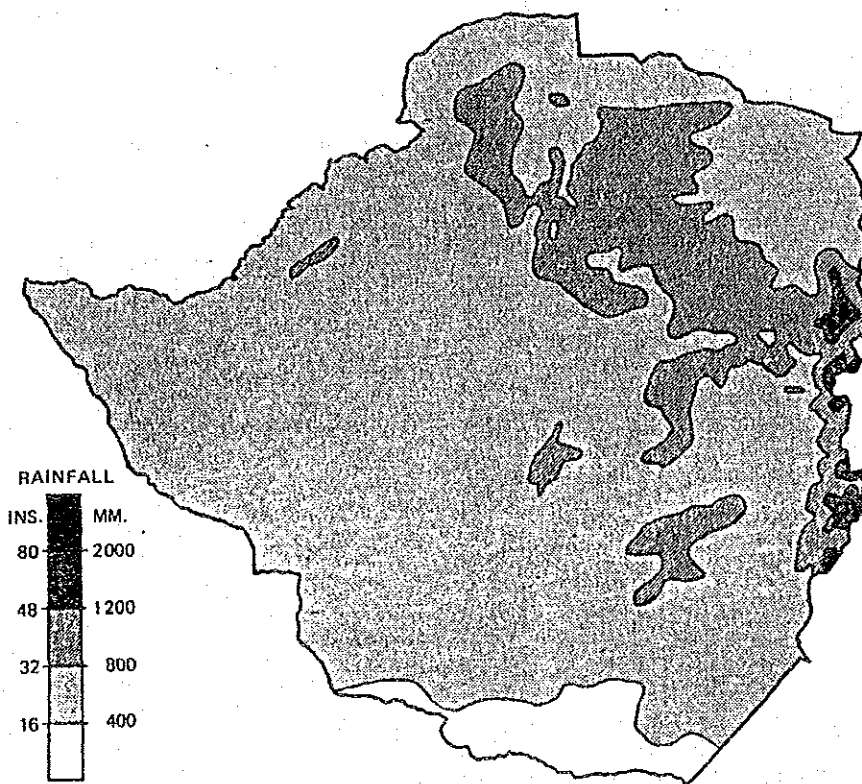
A Low Veld 600 m and less above sea level is situated on the southern bank of Zambezi River, the northern bank of Limpopo River, and both banks of Save River.

#### (4) Eastern Highlands

Eastern Highlands approximately 1,800 m to 2,600 m above sea level span north-south along the border with Mozambique in the east.

The nation has a climate of roughly three seasons in a year. A dry winter lasts from April to August; a hot season from September to the end of October; and a wet season from November to March.

The average annual rainfall, as shown in Fig. I-2-1, is 1,200 mm or more in the Eastern Highlands; 800 mm to 1,200 mm in a region mainly located in the northeastern part of the High Veld; and 400 mm to 800 mm in over half of the nation's territory.



Source: Statistical Yearbook 1987; CSO

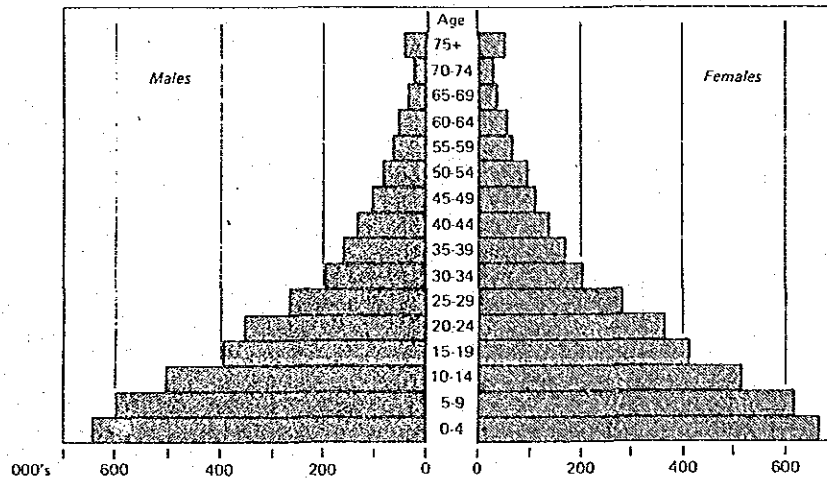
**Fig. I-2-1 Mean Annual Rainfall**

## 2.2 Population

According to a census conducted in August 1982, Zimbabwe's total population is 7,546,071.

The projected population in 1987 and 1992 is 8,640,000 and 9,871,000 respectively.

The population growth rate is 3.06% in 1969-1982 and 2.84% in 1982-1985, and is projected at 2.76% in 1986-1990.



Source: Statistical Yearbook 1987; CSO

**Fig. I-2-2 Population Pyramid 1982**

The population by age and sex, is shown in Fig. I-2-2 and the ratio of younger age population (0 to 14 age) to total population is 47.3%. Since the average younger age population ratio of developing countries is 37.2%, this nation's figure is very high.

## 2.3 Gross Domestic Product

Table I-2-1 shows Zimbabwe's gross domestic product at 1980 constant price. Totals were also provided in current price for reference.

**Table I-2-1 Gross Domestic Product**

Sector	Year	At constant 1980 price Unit: Z\$1,000,000							
		1979	1980	1981	1982	1983	1984	1985	1986
Agriculture and forestry		444	451	515	478	403	496	614	540
Mining and quarrying		292	285	278	284	280	291	288	285
Manufacturing		697	802	881	877	852	809	902	915
Electricity and water		64	70	70	63	68	70	79	108
Construction		89	91	105	101	93	86	64	60
Finance and insurance		147	159	206	239	211	200	216	197
Real estate		48	43	43	43	44	44	44	44
Distribution, hotels and restaurant		339	451	456	451	392	366	410	415
Transport and communications		173	211	221	226	224	226	246	244
Public administration		277	291	339	333	338	364	370	391
Education		127	169	236	284	310	334	355	370
Health		68	71	76	88	89	93	99	106
Domestic service		65	65	63	61	60	59	59	57
Other services		165	173	186	204	215	217	237	252
Less imputed banking services charge		-90	-108	-106	-114	-114	-100	-96	-90
Gross domestic product		2,905	3,224	3,569	3,618	3,465	3,555	3,887	3,894
Gross domestic product (at current price)		2,654	3,224	4,055	4,620	5,236	5,952	7,303	8,232

Source: CSO, Quarterly Digest of Statistics, March 1988

### 2.3.1 Economic Structure

Table I-2-2, Percentage Contribution to GDP (at constant price) is provided, based on Table I-2-1.

Zimbabwe's production sector is comprised of three sections; agriculture and forestry, mining and quarrying, and manufacturing. The ratio of production sector to the gross domestic product is 44.7%.

**Table I-2-2 Percentage Contribution to GDP at Constant 1980 price**

Unit: %

Year	1979	1980	1981	1982	1983	1984	1985	1986
Sector								
Agriculture and forestry	15.28	13.99	14.43	13.21	11.63	13.95	15.80	13.87
Mining and quarrying	10.05	8.84	7.79	7.85	8.08	8.19	7.41	7.32
Manufacturing	23.99	24.88	24.68	24.24	24.59	22.76	23.21	23.50
Electricity and water	2.20	2.17	1.96	1.74	1.96	1.97	2.03	2.77
Construction	3.06	2.82	2.94	2.79	2.68	2.42	1.65	1.54
Finance and insurance	5.06	4.93	5.77	6.61	6.09	5.63	5.56	5.06
Real estate	1.65	1.33	1.20	1.19	1.27	1.24	1.13	1.13
Distribution, hotels and restaurant	11.67	13.99	12.78	12.47	11.31	10.30	10.55	10.66
Transport and communication	5.96	6.54	6.19	6.25	6.46	6.36	6.33	6.27
Public administration	9.54	9.03	9.50	9.20	9.75	10.24	9.52	10.04
Education	4.37	5.24	6.61	7.85	8.95	9.40	9.13	9.50
Health	2.34	2.20	2.13	2.43	2.57	2.62	2.55	2.72
Domestic service	2.24	2.02	1.77	1.69	1.73	1.66	1.52	1.46
Other services	5.68	5.37	5.21	5.64	6.20	6.10	6.10	6.47
Less imputed banking services charge	-3.10	-3.35	-2.97	-3.15	-3.29	-2.81	-2.47	-2.31
Gross domestic product	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Compiled by JCI

(1) Agriculture and Forestry Sector

Approx. 70% of Zimbabwe's population are affiliated with the agricultural sector. This sector supplies the nation with over 90% of its food supply, and exports products, the amount being approx. 41% of the merchandise export amount. Although the contribution to gross domestic product is only approx. 14%, the sector plays an essential role in the nation's economy.

(2) Mining and Quarrying Sector

Mining is one of Zimbabwe's long-established industries, and although decreasing in recent years, its contribution to the gross domestic product is approx. 7.3%.

**Table I-2-3 Mineral Production and Export**

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Mineral production	238	252	315	415	394	383	470	546	630	699
Export	186	183	236	310	254	301	309	377	464	662
Exports as percent of production (%)	78.2	72.6	74.7	74.7	64.5	78.6	65.6	69.4	73	95

As shown in Table I-2-3, approx. 75% of mining production is exported and the mining sector comprises approx. 27% of merchandise export amount.

The mining sector, in addition, employed approx. 54,300 as of late 1985, constituting 5.2% of the nation's total employment.

However, foreign capital has composed approx. 80% of the mining sector up to now, and consequently the government has established a Mining Development Corporation to raise the indigenous capital ratio.

### (3) Manufacturing Sector

The manufacturing sector is the most important sector in Zimbabwe's economy, with the highest contribution to gross domestic product of approx. 24%.

The breakdown of the manufacturing sector by industrial group is the following, according to Quarterly Digest of Statistics March 1988, compiled by CSO as of 1984: foodstuffs, approx. 23.5%; chemical and petroleum products, approx. 15.4%; metal and metal-products, approx. 16.6%; tobacco and beverage, approx. 12%; and textiles, approx. 11.5%, respectively.

The production amount by region is: Harare (the capital), approx. 47.8%; Bulawayo, approx. 24.4%; and total of Kwekwe, Gweru, Mutare, Kadoma, etc. less than 10%, respectively.

Although the ratio of the manufacturing sector to merchandise exports is becoming significantly high at approx. 46%, approx. 90.6% of merchandise imports is manufactured products, comprising of intermediate products, 53.9%; capital goods, 37.2%; and expendables, 8.9%, respectively.

The ratio of the manufacturing sector's employment to the total employment at approx. 16~17% is second highest after the agriculture sector.



(4) Distribution, Hotel and Restaurant Sector

Due to the labour-intensive character of this sector, it accounts for approx. 7.7% of the nation's total employment and comprises approx. 10.7% of the gross domestic product in 1986.

### 2.3.2 Economic Growth

Based on Table I-2-1 Gross Domestic Product, Table I-2-4 was compiled, which shows annual growth over the previous year.

**Table I-2-4 Real Economic Growth**

Unit: %

Year	1979	1980	1981	1982	1983	1984	1985	1986
Sector								
Agriculture and forestry		1.6	14.2	-7.2	-15.7	23.1	23.8	-12.1
Mining and quarrying		-2.4	-2.5	2.2	-1.4	3.9	-1.0	-1.0
Manufacturing		15.1	9.9	-0.5	-2.9	-5.0	11.5	1.4
Electricity and water		9.4	0.0	-10.0	7.9	2.9	12.9	36.7
Construction		2.2	15.4	-3.8	-7.9	-7.5	-25.6	-6.3
Finance and insurance		8.2	29.6	16.0	-11.7	-5.2	8.0	-8.8
Real estate		-10.4	0.0	0.0	2.3	0.0	0.0	0.0
Distribution, hotel and restaurant		33.0	1.1	-1.1	-13.1	-6.6	12.0	1.2
Transport and communications		22.0	4.7	2.3	-0.9	0.9	8.8	-0.8
Public administration		5.1	16.5	-1.8	1.5	7.7	1.6	5.7
Education		33.1	39.6	20.3	9.2	7.7	6.3	4.2
Health		4.4	7.0	15.8	1.1	4.5	6.5	7.1
Domestic service		0.0	-3.1	-3.2	-1.6	-1.7	0.0	-3.4
Other services		4.8	7.5	9.7	5.4	0.9	9.2	6.3
Less imputed banking services charge		20.0	-1.9	7.5	0.0	-12.3	-4.0	-6.3
Gross domestic product		11.0	10.7	1.4	-4.2	2.6	9.3	0.2

Zimbabwe's economy in 1980 and 1981 grew at a high ten-percent level, triggered by the lifting of economic sanctions, liberalization of the economy, etc., resulting from independence, and for the following reasons.

- (1) Productivity increase due to the repair or replacement of obsolete or damaged production equipment of the manufacturing sector with increased influx of foreign capital.
- (2) Expansion of domestic market after the war.
- (3) Increased agricultural production resulting from abundant rainfall during the 1980 and 1981 wet seasons.
- (4) The reconstruction of the national socio-economic infrastructure after the war.

In late 1981, however, the trade balance became seriously unstable and a foreign capital quota system was commenced.

Due to the drought that began in 1981/82 wet season, the production of the agricultural sector, the main exporting sector, started to decline over the 1982-1983 two-year period, which made the foreign currency situation worse. The manufacturing sector as a consequence had difficulty in obtaining raw materials and parts for production equipment, and the production stagnated for several years. For these reasons Zimbabwe's economy stagnated from 1982 to 1984.

Due to the recovery and expansion of the agricultural sector and the accompanying expansion of domestic demand in 1984 and 1985, and return of favorable exporting conditions resulting from the recovery of the world economy in 1984 and 1985, the economy of Zimbabwe recorded a high growth rate of 9.3% in 1985.

However, the 1986 production of the agricultural sector declined a substantial amount, -12.1% to the previous year, and the demand for the manufacturing sector subsequently decreased, growing stagnantly at 1.4%. This caused the gross domestic product growth rate of Zimbabwe to remain at the 1985 level.

The 1987 gross domestic product is not disclosed by CSO, but the Economic Bulletin, July 1988 of the Standard Chartered Bank reported the growth rate of real gross domestic product was at approximately the same level as 1986.

The average annual growth rate of the gross domestic product at constant price from 1980 through 1987 is 3.8%, a high value compared to 0.8% for above rate from 1981 through 1985 by small-scale developing countries with populations 20 million or less.

## 2.4 Trade

### 2.4.1 Exports

Table I-2-5 shows Zimbabwe's export of principal commodities.

**Table I-2-5 Export of Principal Commodity**

Unit: Z\$ 1,000

Commodity	Year	1981	1982	1983	1984	1985
Food products		130,905	130,309	151,010	167,463	254,397
Beverages and tobacco		224,574	194,796	232,804	287,558	366,253
Crude materials except fuels		166,596	141,876	184,520	243,666	287,820
Mineral fuels, related products and electricity		10,361	12,274	16,459	16,597	15,915
Animal and vegetable oil and fats		1,035	913	651	1,742	1,679
Chemical and related products		11,697	12,198	11,553	23,952	26,666
Manufactured goods classified materials		238,786	230,545	343,342	419,810	501,443
Machinery, transport and electricity equipment		19,244	12,656	11,910	22,396	24,859
Miscellaneous manufactured articles		84,869	71,577	73,458	87,886	66,311
Total		888,067	807,144	1,025,707	1,271,070	1,545,343

Source: Quarterly Digest of Statistics, March 1988

According to records of 1981 through 1985, the percentage contribution by sectors to merchandise exports are agricultural sector, approx. 40%; manufacturing sector, approx. 45%; and mining sector, approx. 15%.

The nation's ten most exported goods are gold, tobacco, ferrochromium, cotton, copper, nickel, asbestos, sugar, edible meat, and corn.

## 2.4.2 Imports

Table I-2-6 shows Zimbabwe's import of principal commodities.

**Table I-2-6 Import of Principal Commodity**

Unit: Z\$ 1,000

Commodity	Year	1981	1982	1983	1984	1985
Food products		15,308	10,572	21,601	83,628	51,611
Beverages and tobacco		2,193	2,054	3,147	2,717	4,305
Crude materials except fuels		33,385	37,946	41,083	38,394	63,829
Mineral fuels, related product and electricity		211,696	178,635	223,598	256,924	344,230
Animal and vegetable oil and fats		8,504	6,924	11,945	10,878	16,202
Chemical and related products		141,992	125,022	150,634	178,111	234,174
Manufactured goods classified materials		196,558	157,332	154,045	177,851	215,353
Machinery, transport and electricity equipment		327,400	439,899	365,260	373,550	418,325
Miscellaneous manufactured articles		80,658	123,403	90,306	78,615	98,500
Total		1,017,694	1,081,787	1,061,619	1,200,668	1,446,529

Source: Quarterly Digest of Statistics, March 1988

According to the records of 1981 through 1985 as shown in Table I-2-6, the percentage contribution of commodities are: machinery, transport and electricity equipment, 33%; mineral fuels, 20.9%; manufactured goods classified materials, 15.5%; and chemical and related products, 14.3%. The nation's importation is characterized by the high percentage of industrial capital goods and industrial raw materials, when the foreign currency quota becomes restricted.

### 2.4.3 Trade Balance

Fig. I-2-3, Export and Import of Zimbabwe, was compiled from Tables I-2-5 and I-2-6.

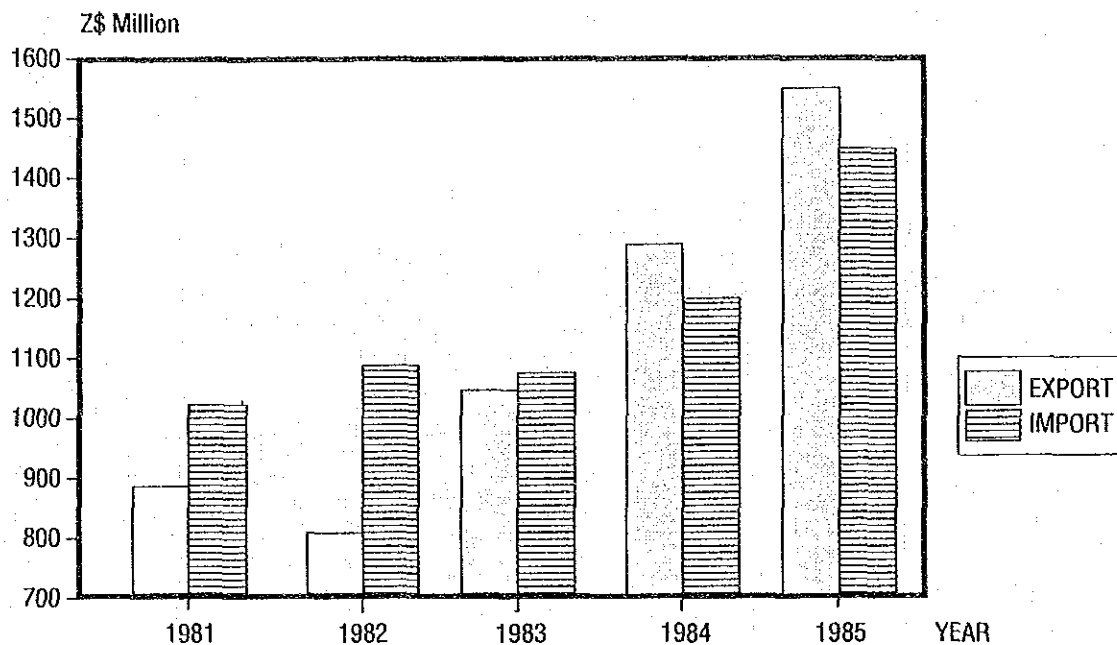


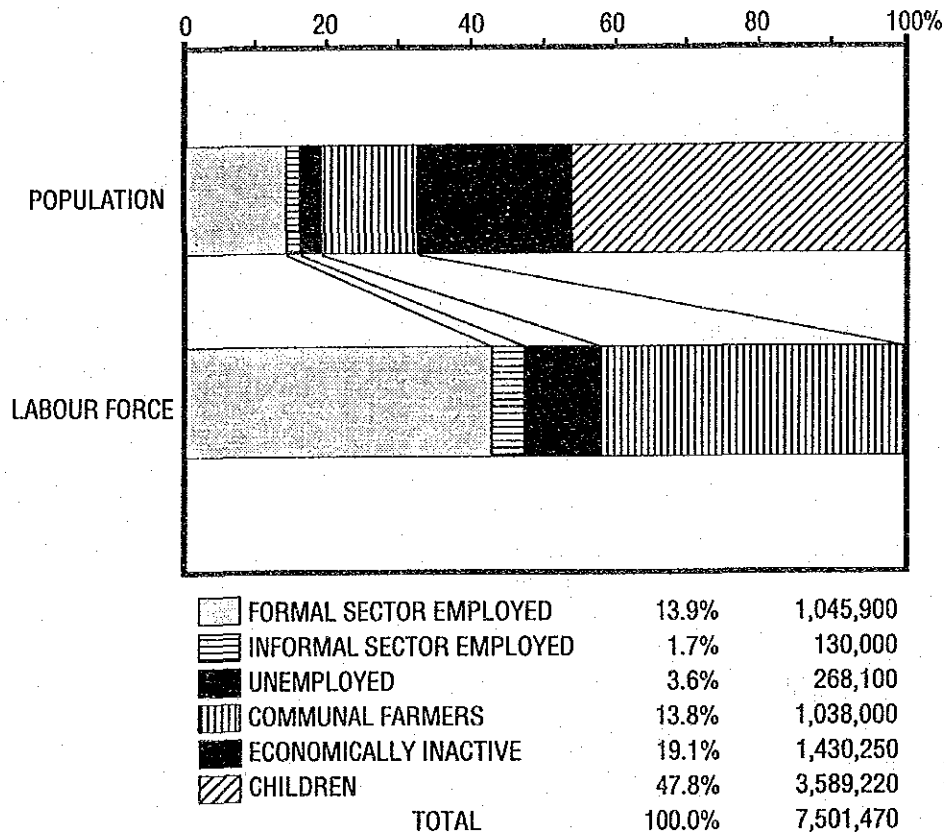
Fig. I-2-3 Export and Import of Zimbabwe

Statistics of 1986 and 1987 are undisclosed; however, according to the *Economic Bulletin* July 1988 of the Standard Chartered Bank, exports exceed imports in that period and the same is expected for 1988.

Therefore, in spite of continued foreign currency regulation, the foreign currency reserve is increasing due to strong exportation.

## 2.5 Employment

The population and labour force in 1982 in Zimbabwe are shown in Fig. I-2-4, which is based on the results of latest census conducted in 1982.



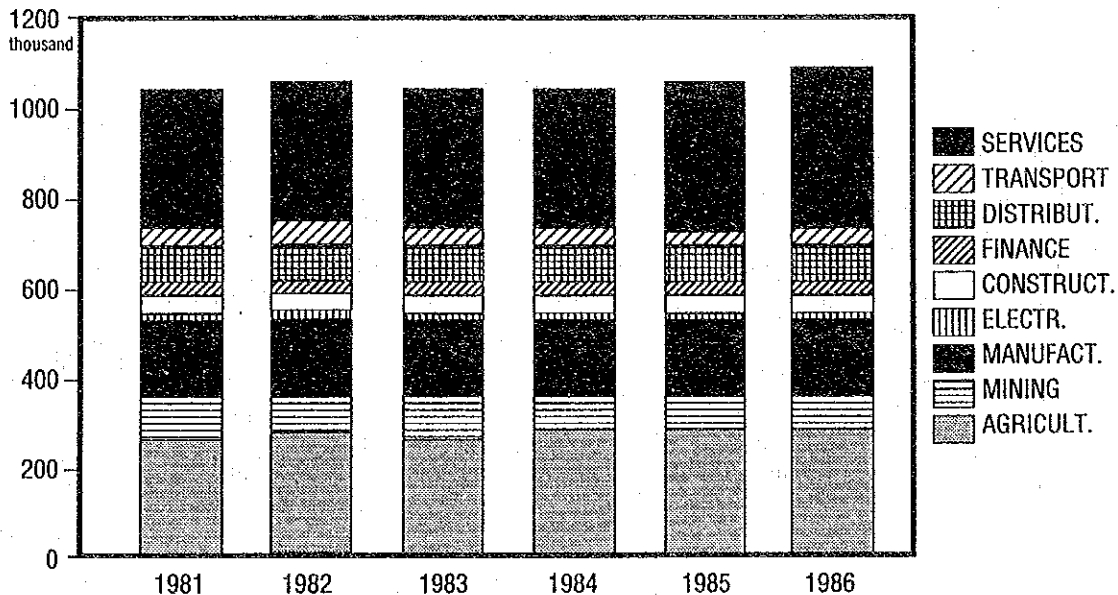
Source: Compiled by JCI

**Fig. I-2-4 Population and Labour Force (1982)**

In 1982, about 47.8% of the population was children of ages 15 years or less, and about 19.1% was students and married women who were economically inactive.

Accordingly, it is concluded approximately 33.1% of total population was the actual labour force.

Fig. I-2-5 shows the employment by industrial sectors based on the report "Quarterly Digest of Statistics March 1988." The employment by the agricultural sector in 1985 and 1986 not reported in the above was estimated at 270,000. According to the data in the report, the total employment by formal sector was approx. 1,040,000, showing very little increase in the period 1981-1986.



Source: Compiled by JCI

Fig. I-2-5 Employees by Industrial Sectors

There is no current data to evaluate employment since no census on population and employment has been conducted since 1982. However, Standard Chartered Bank made estimations of unemployment rates of 12% and 18% in 1984 and 1988, respectively.

The following is a section of a ten-year unemployment forecast in the Economic Bulletin, July 1988 issued by the Standard Chartered Bank.

"It is clear, however, that the unemployment rate will continue to accelerate. Over the next 10 years, only about 120,000 employed people will reach retiring age, implying that the replacement element in the labour force will not be great. During the same period more than 2 mln people will reach the age of 16 and even after allowing for an economically inactive ratio of 25%, there will still be a minimum of 1.5 mln new jobseekers. Even on the most optimistic projections - assuming employment growth averaging 75,000 annually over the next decade - unemployment would still reach 750,000 by 1990 and exceed 1 million by the mid-1990s. The reality is likely to be a good deal worse than this optimistic projection implies."

## 2.6 Wages

Table I-2-7 Earnings by Industrial Sectors shows the only data available for wages of Zimbabwe.

**Table I-2-7 Earnings by Industrial Sectors**

Unit: Z\$ Million

Year	1982	1983	1984	1985	1986
Sector					
Mining	178.7	186.6	194.0	221.3	243.5
Manufacturing	651.4	709.7	762.7	886.1	1,000.8
Elect. & water	34.2	38.1	46.3	58.0	65.2
Construction	138.2	154.2	160.5	165.5	187.1
Finance	116.2	138.2	151.1	162.6	184.0
Distribution	299.8	335.9	355.0	490.2	443.5
Transport	275.7	279.5	295.2	324.4	377.3
Service	970.7	1,048.1	1,196.1	1,412.5	1,626.6

Table I-2-8 shows the annual percapita earning by industrial sectors.

**Table I-2-8 Earnings Per Head by Industrial Sectors**

Unit: Z\$

Year	1982	1983	1984	1985	1986
Sector					
Mining	2,805	3,093	3,560	4,076	4,468
Manufacturing	3,609	4,093	4,586	5,225	5,629
Elect. & water	5,262	5,522	6,342	7,532	7,855
Construction	2,705	3,128	3,543	3,694	3,842
Finance	7,959	8,747	9,624	10,627	11,948
Distribution	3,757	4,167	4,426	6,261	5,415
Transport	5,470	5,635	5,892	6,488	7,684
Service	2,986	3,131	3,459	3,924	4,305

It should be noted that there are great differences in annual percapita wages among sectors. The wages in the mining, construction and services sectors are low and those in finance and insurance sectors are extremely high.



## 2.7 Price

Fig. I-2-6 shows the retail trade value index formulated from the Retail Trade Value Index by Type of Outlet issued by CSO.

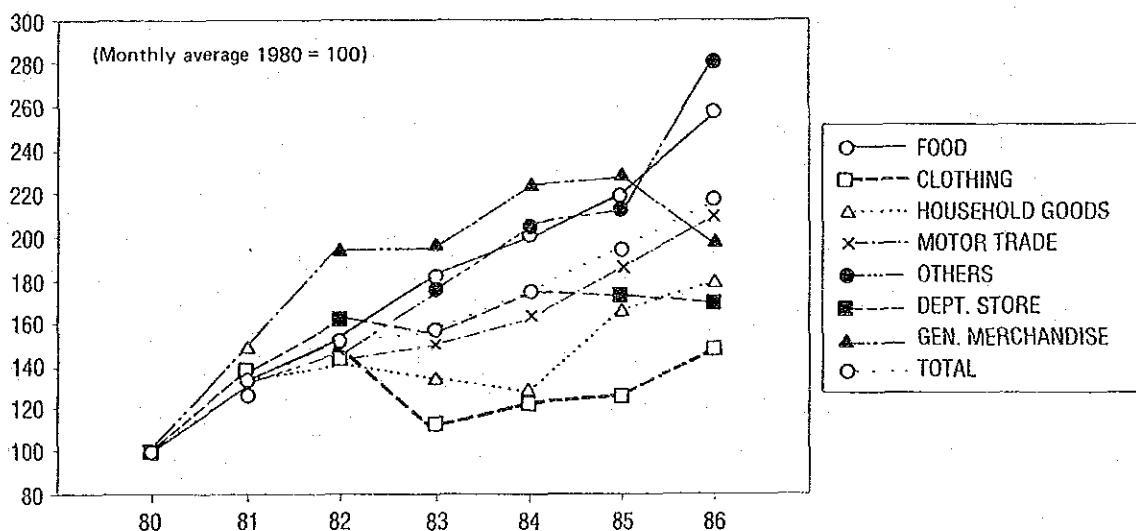


Fig. I-2-6 Retail Trade Value Index

Basing the 1980 average monthly price index at 100, Zimbabwe's 1986 figure is 217.8. This is lower than the 237.4 price index figure for African developing countries for the same period.

The average annual price growth rate from 1980 through 1986 is 13.5%.

## 2.8 First Five-Year National Development Plan 1986-1990

Zimbabwe issued Volume I of the First Five-Year National Development Plan in April 1986 and Volume II in April 1988. This is a long-term plan for the five-year period 1986-1990.

### **2.8.1 Targets of the Five-Year National Development Plan**

The following targets are summarized in the Five-Year National Development Plan.

- (1) Transformation and control of the economy and economic expansion;
- (2) Land reform and efficient utilization of land;
- (3) Raising the standards of living of the entire population, in particular, the peasant population;
- (4) Enlargement of employment opportunities and manpower development;
- (5) Development of science and technology; and
- (6) Maintenance of a correct balance between the environment and development.

To achieve the target growth rate, an investment over a five-year period of Z\$7,126,000,000 in 1985 price-base is required. The equivalent of 63.5% of this amount, Z\$4,513,000,000 is investment by the public sector. The equivalent of 28.2% of this public investment will go to the production sector comprised of agriculture, mining and manufacturing sectors.

It is stated that by this investment, it is possible to achieve the 5.1% GDP growth rate target.

In the period of the First Five-Year Plan, a 7.0% average annual export growth rate and a 6.0% average annual import growth rate are projected. Therefore, in 1990 with relation to commodities and services, the export amount is expected to exceed the import amount.

Assuming a 2.7% annual growth rate in employment, the nation's most important topic, it is stated that 144,000 will be newly employed in the duration of the Five-Year Plan.

### **2.8.2 Agriculture**

The agriculture sector which has been the nation's economic backbone in the past is positioned as the dominant industrial sector in this Five-Year Plan also, and 17.0% of the public investment is allocated to it.

In the period of this plan, a 5.0% annual growth rate for agricultural production, which exceeds the 2.8% population growth rate, is expected. Within the agricultural sector, provisions are made for production growth rates of 7.0~8.0%, 5.0~6.0%, and 3.0~4.0%, by communal-land farming, small-scale commercial, and large-scale commercial, respectively.

To realize this, establishment of an agricultural infrastructure is planned, such as the construction of numerous irrigation systems of various scales, and expansion of arable land area in the traditional communal farming area is also planned.

On the other hand, increased agricultural productivity is also another objective, and the government is making efforts to introduce improved seed, fertilizer and pesticide, as well as modern farming machinery to traditional communal farming.

### **2.8.3 Mining**

Approximately 80% of capital of the mining sector is owned by foreign companies. To promote the restructuring of ownership, the government established the Mining Development Corporation for participating in the development of the mining sector, and the Mineral Marketing Corporation for aiding exportation of minerals.

An estimated Z\$962,000,000 in 1985 prices will be invested in the duration of the Five-Year Plan, Z\$257,000,000 of which will be public investment and the remaining Z\$705,000,000 will be private investment.

The plan aims at increasing export of manufactured goods to enhance the added value of exports.

The Five-Year plan states the following.

“The strategy of the First Five-Year National Development Plan aims at increasing manufactured exports in order to increase the value of exports. In this connection, there are several projects under consideration for beneficiation of minerals such as stainless steel from local chrome, steel and nickel, production of chromium chemicals, production of ammonia from coal and refractory bricks based on magnesite, chrome and kyanite, sheet and plate glass from dolomite, limestone, feldspar and silica sand and production of high grade hydrated lime from local limestone deposits.”

### **2.8.4 Manufacturing**

The manufacturing sector is considered as an important industry for the transformation of Zimbabwe's economic structure and rapid and stable economic growth. Through the Industrial Development Corporation (IDC), Zimbabwe Development Bank (ZDB), and Zimbabwe Development Corporation (ZDC), the government is promoting participation in the capital investment and management of the manufacturing sector.

It is assumed in the Five-Year Plan that in the period of the plan, the manufacturing sector requires an investment of Z\$1,400 million at 1985 prices, of which Z\$381 million will be public investment and the remainder, private investment.

A 6.5% annual growth rate is expected for the manufacturing sector for the duration of the Five-Year Plan, contributing up to 30% of GDP in 1990.

Employment in this sector is also estimated to increase from approx. 169,000 in 1985 to approx. 200,000 in 1990. The following industrial development plans are stated in the First Five-Year Plan, Volume II.

- Ethanol plant construction project
- Chlorine alkali plant construction project
- Coal-base ammonia/fertilizer plant construction project
- Pulp and paper plant construction project
- Steel plant construction project
- Others

## **2.9 Related Regulations**

Zimbabwe appears to have no systematic laws and regulations such as industrial promotion laws and investment laws.

However, it was confirmed that the following points were stipulated concerning tax.

- (1) Corporate income tax is generally 50%.
- (2) In the case of the construction of a plant, however, income tax is exempted until the capital investment necessary for machinery, equipment and construction materials is recovered by taxable income and depreciation (capital investment allowance).
- (3) There is no import customs duty on imported machinery and assets for projects authorized by the state.

Private, ethnic projects also receive long-term, low-interest financing through ZDB established in 1983. On the other hand, public projects receive investment and financing through IDC, which also aids their actualization.

## **Chapter 3 Coal Chemical Industry in Zimbabwe**



## **Chapter 3 Coal Chemical Industry in Zimbabwe**

### **3.1 Overview**

As mentioned in the previous chapter, Zimbabwe is one of the most industrially advanced nations in Africa; its manufacturing sector accounts for approx. 24% of the Gross Domestic Product, approx. 15% of which is accounted by petroleum and chemical related products. Amounting to approx. 45% of exports, industrial products contribute vastly to the nation's economy and trade revenue. However, industrial raw materials account for approx. 90% of Zimbabwe's imports, of which petroleum is approx. 20.9% and chemical-related products, 14.3%.

Zimbabwe designated the manufacturing sector as one of the most important sector for transformation of their economic structure in the First Five-Year National Development Plan, and plans as the main objective to develop and utilize domestic resources as industrial raw material and save foreign currency. Owing to a temperate climate, Zimbabwe produces abundant agricultural products, and is also endowed with large quantities of various mineral resources. Electricity, in addition, is supplied by Kariba hydroelectric power station and Wankie thermal power station. This forms the basis of Zimbabwe's manufacturing sector but unfortunately crude oil and natural gas are not produced domestically and consequently petroleum import amounts to approx. 20.9% of total imports. Also, although nitrogenous fertilizer is produced using hydrogen from water electrolysis, it falls short of demand, and the balance must be imported. Thus, chemical-related products account for approx. 14.3% of imports.

Reducing petroleum and chemical-related product importation would have large effects on Zimbabwe's economy.

Zimbabwe fortunately produces large quantities of coal, the advantages of the production of ammonia, urea, methanol, and coal tar, the objective of this project, were studied, with an introduction to chemical products utilizing coal as raw material.

### **3.2 Chemical Products with Coal as Raw Material**

Until 1940, most of organic chemical products were produced with coal tar as raw material, but since around 1940, with the development of petrochemical technology, chemical products are produced from petroleum as raw material.

Petroleum resources are limited, however, and after the oil shock the research for the production of organic chemicals based on coal as raw material resumed.

Fig I-3-1 describes organic chemical products produced from coke, tar, and coke oven gas which are products from coke oven.

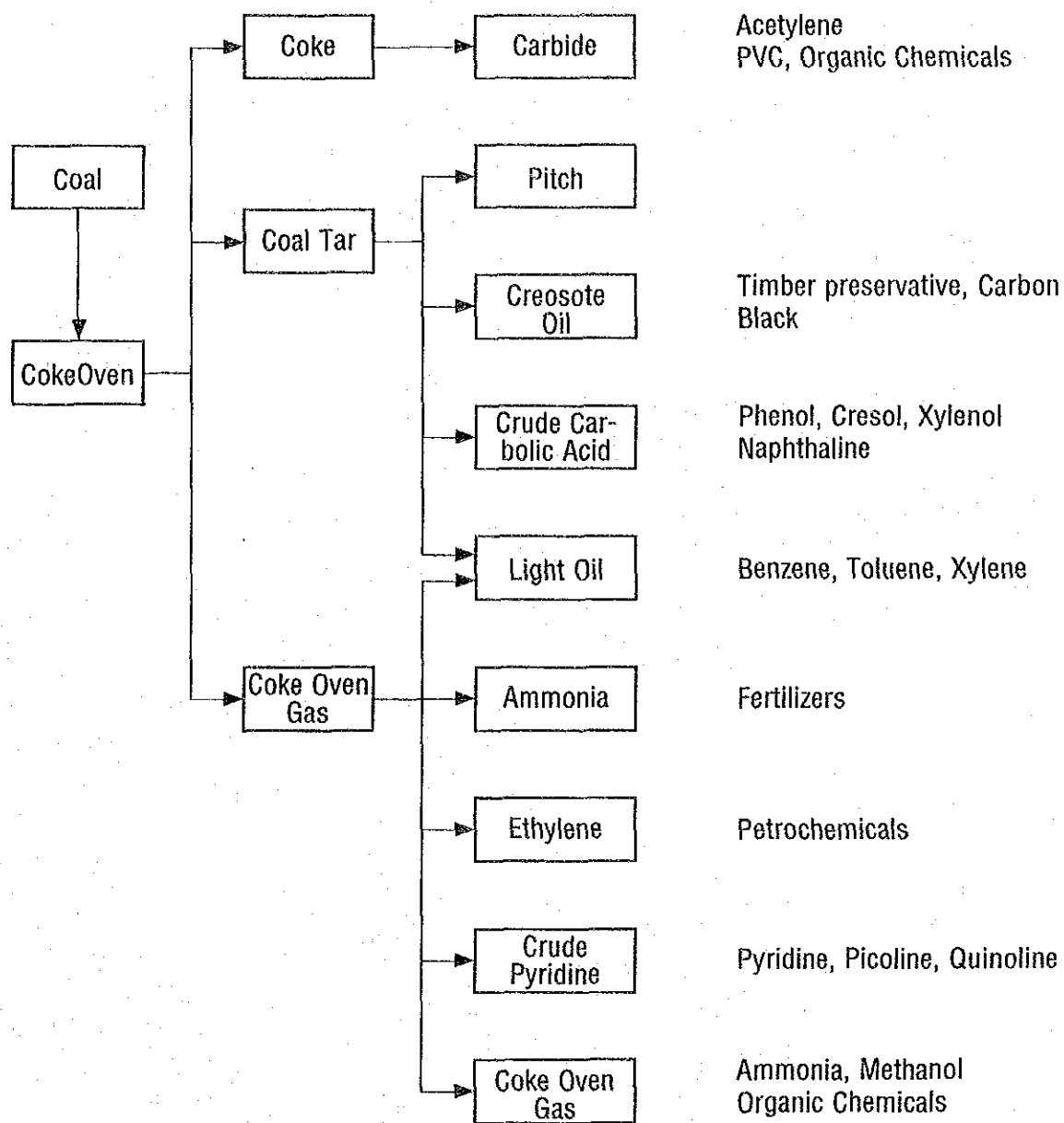
- (1) Calcium carbide is generally produced from high-quality anthracite, but when it is difficult to obtain, coke is used. In the past, vinyl chloride, vinyl acetate, acetylene, acetic acid, and esters were manufactured from acetylene produced from calcium carbide, but now they are produced using ethylene, produced from steam cracking of naphtha or natural gas, as raw material. However, the steam cracking of naphtha or natural gas produces propylene, butylene, and aromatics as by-products besides ethylene, thus making necessary the simultaneous construction of various plants which consume these by-products as raw materials. In the case where only one kind of acetylene derivative in small scale is to be produced, the production process using acetylene from carbide is in certain circumstances more advantageous.
- (2) Coal tar is distilled into the fractions described in Fig. I-3-1 and further processed into phenol and aromatic products. If the scale is small, distillation and refining of products from coal tar will be done by collecting coal tar from several coke-oven plants and centrally distilling and refining it, since coal-based products produced in small quantities are not competitive to petroleum-based products.
- (3) After removal of gas oil, ammonia, and sulphur, coke oven gas is utilized to heat coke ovens, and the rest of the gas is utilized for iron manufacturing and town gas.

Ammonia is recovered as ammonia water and ammonium sulphate is produced although in small quantities, as by-product. Also, even though ethylene exists in the coke oven gas, since its content is low, separation is uneconomical.

Fig. I-3-2 describes organic chemicals produced from synthesis gas from coal as feed stock. With the exception of ammonia and methanol, the manufacturing methods of these organic chemicals are still in the research stage.

- (1) The production methods of ammonia are classified by the production method of hydrogen as raw material. There are three methods: water electrolysis, steam reforming of natural gas or naphtha and coal gasification. Ammonia production using water electrolysis is feasible only if electricity is extremely low-priced.





**Fig. I-3-1 Organic Chemicals from Coke Oven Gas**

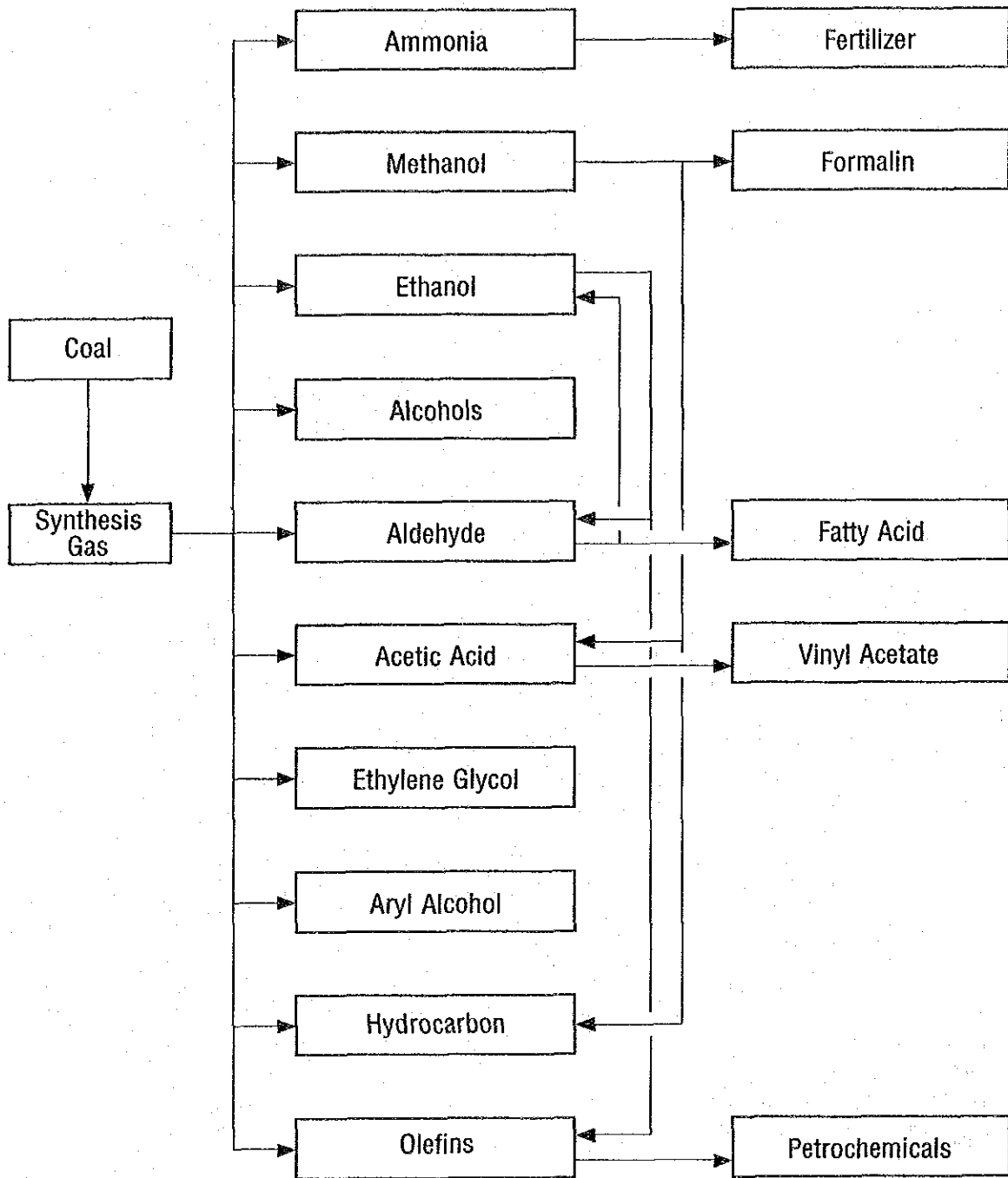


Fig. I-3-2 Organic Chemicals from Synthesis Gas

The production of ammonia using coal or hydrocarbon as raw material differs in the process of producing synthesis gas ( $\text{CO} + \text{H}_2$ ) for the production of hydrogen, but are the same in the rest of the processes. The case of utilizing coal as raw material is costly compared to the case of utilizing hydrocarbon as raw material in facilities up to and including the synthesis gas production process, and is therefore disadvantageous. In areas deficient in hydrocarbon resources and where low-priced coal is available, there are cases in which the production of ammonia using coal as raw material is advantageous.

- (2) Methanol can be produced using synthesis gas ( $\text{CO} + \text{H}_2$ ) obtained from hydrocarbon or coal. In this case, as in the production of ammonia, the methanol production using natural gas at the producing site is generally advantageous.
- (3) With respect to hydrocarbon, direct liquefaction of coal, synthesis from synthesis gas ( $\text{CO} + \text{H}_2$ ), and synthesis from methanol are being studied.

Although synthesis of hydrocarbon from synthesis gas, and that from methanol are being executed commercially in the Republic of South Africa and New Zealand, respectively, since currently the price of crude oil is falling, they are becoming less competitive.

- (4) Olefins (ethylene, propylene, butylene, etc.) are basic raw materials for the production of petrochemicals, and are at present being produced from naphtha or natural gas. Researchers from various nations around the world are studying how to manufacture olefins from coal, but have not yet succeeded in developing an economically viable manufacturing method. However, if it is possible to produce low-priced ethanol, ethylene is easily produced from ethanol as described in Fig. I-3-2. Manufacturing olefins from hydrocarbon or coal as raw material, as mentioned before, requires a large-scale complex process and a large investment. Therefore, if only a small quantity of one kind of ethylene derivative is necessary, ethylene production from ethanol is advantageous under certain circumstances.
- (5) Research in the development for the production of other organic chemicals using coal as raw material described in Fig. I-3-2 is in progress; all these products are currently produced from hydrocarbon. In the future, as the research now in progress of the technology with coal as raw material is completed, selection will be made for various projects after comparing the economic aspects of utilizing hydrocarbon or coal as raw material.

### 3.3 Chemical Products from Coal in Zimbabwe

#### 3.3.1 Present State

In Zimbabwe, the following three companies are producing coal related chemicals.

(1) Sable Chemical Industries Ltd. (SABLE)

The products and capacities of SABLE are as follows.

Ammonia	70,000 T/Y
Nitric acid	164,000 T/Y
Ammonium nitrate	215,000 T/Y

SABLE is Zimbabwe's only producer of nitrogenous fertilizer; it produces ammonia using hydrogen produced by water electrolysis, and in turn producing ammonium nitrate using this ammonia as raw material. The firm thereby supplies the domestic market with nitrogenous fertilizer. There are, however, the following issues.

- 1) SABLE's ammonia plant based upon water electrolysis was installed to use the low-priced excess electricity of Kariba hydroelectric power station when the station was constructed. However due to the subsequent economic expansion of Zimbabwe, balancing of the supply and demand of electricity became difficult, and with the increase of electricity tariff, the cost of fertilizer increased.
- 2) At present, in order to produce ammonia at 200 T/D, approx. 100,000 kW of electricity is consumed, accounting for 10% of Zimbabwe's requirement of electricity.
- 3) Currently, the 100 T/D shortage of ammonia is imported; this exerts pressure on Zimbabwe's foreign currency balance.
- 4) Zimbabwe has made improvement of agricultural industry as a policy, and to achieve this goal, twice the current use of nitrogenous fertilizer is expected in 1995. In order to meet this increase of fertilizer, a large amount of electricity will be required in case of ammonia production based on water electrolysis, and in light of future increases of electricity tariff, the supply of low-priced fertilizer is impossible. Furthermore, explanation of SABLE will be made in detail in Chapter 7.

(2) Wankie Colliery Company Ltd. (WANKIE)

WANKIE is presently the only coal mining company; it supplies Zimbabwe's total coal demand as well as operates coke oven and produces coke and tar products. Its outline is as follows.

Coke	18,000 T/M
Tar	612 T/M
Crude benzol	60 M <sup>3</sup> /M

Coke is distributed domestically and for export. Tar produced by WANKIE is not distilled and partially used for pavement, but otherwise has little demand, and is used as fuel.

Crude benzol too has no use other than as additive for gasoline.

(3) Zimbabwe Iron Steel Co. (ZISCO)

ZISCO is the only iron manufacturing company in southern Africa with the exception of such companies in the Republic of South Africa; it has an annual capacity of one million tonnes. It supplies the nation's demand and exports most of production, contributing to obtaining foreign currency. All the coke for steel production is produced in the company's own coke ovens using the coking coal purchased from WANKIE.

At present, the firm has a coke capacity of 45,000 T/M. By-product tar and crude benzol, as in the case of WANKIE, are not distilled and refined, so are used as fuel.

### 3.3.2 The New Plan of Zimbabwe

Zimbabwe is promoting various plans for substituting with replacements the intermediate material imports which currently amounts to 51.5% of total imports.

(1) Expansion Plan of Triangle Ethanol Plant

At present, ethanol is produced from sugar cane and molasses and mixed with motor gasoline in order to reduce petroleum imports. In this plan, production of ethanol will be increased, and the mixing ratio with gasoline will be increased from the present 16% to 20%.

Zimbabwe is currently consuming plastics from ethylene at approx. 40,000 T/Y. If low-priced ethanol production is made possible by the expansion of production capacity, it would be possible to produce ethylene from ethanol and to produce plastics.

(2) Plan of Chlor-alkali, Calcium Carbide, and PVC Production

The demand for caustic soda is large in developing countries generally, but because the chlorine co-produced by salt electrolysis is in smaller demand, it is difficult to develop a chlor-alkali industry in many cases. In this plan, hydrochloric acid will be produced from by-product chlorine, and vinyl chloride monomer will be produced by a reaction of the hydrochloric acid and acetylene produced from calcium carbide, which in turn is processed into polyvinyl chloride. Caustic soda and polyvinyl chloride which are currently imported will be produced domestically.

The price of polyvinyl chloride produced from carbide is more costly than that produced in large quantities from hydrocarbon; however, this is a good project in which three products, caustic soda, carbide, and polyvinyl chloride, will be simultaneously produced. This can also be considered as one field in coal-processing technology.

(3) Plan of Expansion for Fertilizer Production

Nitrogenous fertilizer is at present produced by SABLE, which is used for domestic demand, but as will be discussed in Chapter 7, 100 T/D of shortage of ammonia is imported. The demand in 1995 is projected to increase two-fold from the present, so it is necessary to increase fertilizer production.

(4) Plan of Crude Tar and Crude Benzol Refining

Presently, by-product tar and crude benzol produced from coke oven of WANKIE and ZISCO are unrefined and consequently have no special usage, so most of each is consumed as fuel. In this plan, crude tar and crude benzol produced in WANKIE and ZISCO will be collected at ZISCO and refined to produce final products.

Crude tar and crude benzol refining is a basic coal-chemicals technology and is an important plan which increases the added value of products, creates demand, and as advances technology.

### 3.3.3 The Effect of the Present Project to Zimbabwe's Industry

In order to study the feasibility of a project to produce ammonia from coal as raw material in Zimbabwe, further consideration is made for plans to co-produce urea, tar, and methanol. Therefore, a short description of the effects of ammonia, urea, tar, and methanol production to Zimbabwe's industry will be provided.

#### (1) Ammonia

At present, ammonia is produced at SABLE from hydrogen by water electrolysis, and ammonium nitrate is produced from the ammonia. However, problems discussed in section 3.3.1 above exist.

In the present project ammonia will be produced from coal which is abundant in this country, and the following benefits are expected.

- 1) By substituting ammonia produced by water electrolysis with that produced from coal, it is possible to supply low-priced nitrogenous fertilizer, regardless of future increase of electricity tariff. This is very important to Zimbabwe's agricultural policy and makes a major contribution to the economy.
- 2) SABLE is presently consuming approx. 100,000 kW of electricity in order to manufacture 200 T/D of ammonia. By substituting to ammonia produced from coal, this electricity will become available for other purposes, and will make a significant contribution to the electricity supply and demand situation in Zimbabwe, especially in the Kwekwe region where demand is expected to continue increasing.
- 3) 100 T/D of ammonia, which is imported by SABLE to meet the shortage of internal requirement, will be replaced by the domestically produced ammonia in case that the present project is realized. As a result of replacement, foreign currency will be saved.
- 4) The demand for nitrogenous fertilizer in Zimbabwe will grow steadily in the future. The nitrogenous fertilizer production by means of water electrolysis will have disadvantages considering the expected electricity price hike and shortage of electricity supply. However, the production will be much easier by the ammonia production from coal.

5) Coal gasification facilities and technology are required to produce ammonia in case of ammonia production from coal, and this coal gasification technology is one of the basic coal-chemical technologies. The technology of the coal gasification process transferred from industrially advanced countries will be a milestone in the development of coal chemical industry in Zimbabwe.

(2) Urea

Ammonium nitrate and sulphate have been domestically produced and small volume of urea has been imported in Zimbabwe. Urea, although a comparatively recently developed fertilizer in comparison with ammonium nitrate and sulphate, is widely used in the world as a nitrogenous fertilizer due to its superior characteristics. When the domestic production of urea is realized, the Zimbabwe farmers can enjoy large benefit by application of urea since the production cost of urea is cheaper than that of ammonium nitrate.

(3) Methanol

Methanol is being produced for mixing with gasoline or diesel oil to decrease imports of petroleum products. The technology of methanol synthesis is proven, therefore, if realized the application of gasoline and diesel oil mixed with methanol will contribute significantly to the economy of Zimbabwe in view from the foreign currency saving.

However, modification of engines is required in case that the gasoline or diesel oil is mixed with methanol. In particular, the application technology of methanol-mixed diesel oil is not commercially proven yet. Accordingly, the methanol production should be planned for when the engine modification applicable to mixed fuel is developed.

(4) Tar

Important organic intermediates can be produced from tar and crude benzol which are by-products of coke production. However, tar and crude benzol are not utilized and consequently are not refined and consumed as a fuel at present. In the future, when the economy and industry are further developed, the products from tar will be in demand. Recommended as the first stage of development is transformation of the crude tar and benzol produced by WANKIE and ZISCO into manufactured products.