Chapter 4 Market of Coal-Chemicals

Chapter 4 Market of Coal-Chemicals

- For Fertilizer, Ammonia, and Urea -

4.1 General Condition of Agriculture in Zimbabwe

4.1.1 Importance of Agricultural Development

Agriculture in Zimbabwe is a key sector producing foodstuffs for nourishing its people and products for export for obtaining foreign currency. Agricultural technologies that efficiently utilize its land, increase agricultural productivity, and benefit agriculture socio-economically are especially important. Among technical measures for agricultural development, investment for agricultural research and utilization of fertilizer and pesticide, expansion of irrigation facilities, and introduction of new varieties chosen for their receptivity to fertilizer are most feasible and effective.

Zimbabwe has a 7,550,000 population (1982 census) on an approx. 390,700 km^2 territory, and is located in the tropical zone of the southern hemisphere. But most of the territory has high altitude and the climate is relatively mild. There is a lot of flatlands and a favorable bases for agricultural, industrial and commercial development.

As described in Table I-4-1, the contribution of agriculture sector to GDP is second highest after manufacturing, amounting to 11.8% in 1984. Agricultural product exportation is also an important source of foreign currency inflow. However, the harvested quantity of maize and other products greatly depends upon rainfall, and in years of drought the quantity of exported products diminishes substantially, decreasing foreign currency revenue and causing instability in the national economy. Therefore, the establishment of stable and highly productive agriculture by utilizing the well-endowed natural environment and installing efficient technology is strongly desirable.

Basic information is provided below necessary in understanding agriculture in Zimbabwe and in predicting the production and demand of fertilizer in keeping with agricultural development in the future.

Table I-4-1 Gross Domestic Product at Factor Cost by Industry of Origin, 1975-1984

Unit: Z$ Million

Item	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
	(at current prices)									
Agriculture and forestry	323	350	334	292	325	458	649	662	592	673
Mining and quarrying	131	152	149	156	226	285	250	217	284	330
Manufacturing	447	480	460	514	623	802	1,016	1,121	1,385	1,565
Electricity and water	50	57	56	62	71	70	78	73	134	161
Construction	94	88	84	68	92	87	133	185	194	203
Finance and insurance	86	92	102	105	123	159	185	228	274	309
Real estate	44	47	47	45	44	43	55	55	59	64
Distribution, hotels and restaurants	258	262	242	356	425	451	603	718	737	791
Transport and communi-cations	145	159	166	178	188	211	306	362	364	403
Public administration	130	163	204	238	269	290	307	357	375	396
Education	65	73	76	86	98	169	215	309	343	423
Health	38	43	49	54	60	71	82	106	109	132
Domestic services	45	49	52	52	53	65	72	85	88	87
Other services, n.e.s	98	105	113	120	136	173	219	277	316	348
Less imputed banking service charges	–52	–56	–65	–69	–82	–108	–121	–146	–173	–199
Gross domestic product (factor cost)	1,902	2,064	2,069	2,257	2,651	3,226	4,049	4,609	5,081	5,686

Source: Statistical Yearbook 1987

4.1.2 Natural Environment

(1) Location and Physical Features of Territory

Zimbabwe is situated in latitude 15 degrees 30 minutes to 22 degrees 30 minutes south, and in longitude 25 degrees to 33 degrees 10 minutes east, and has a total area of 390,759 km^2. Area of each province is shown below.

Provinces	Land area (km^2)
Manicaland	34,870
Mashonaland Central	27,284
Mashonaland East	24,934
Mashonaland West	60,467
Matebeleland North	73,537
Matebeleland South	66,390
Midlands	58,967
Masvingo	44,310
Total	390,759

Source: Statistical Yearbook, 1987

In terms of altitude, Zimbabwe can be divided into the following four regions.

The southwestern to the northeastern part of Zimbabwe is comprised of a savannah with 1,200 to 1,500 m altitude (650 km long, 80 km wide) called "High Veld." This region spans from Plumtree through Gweru and Marondera to Nyanga. This region slopes gently northward to Zambezi River and southward to Limpopo River. The region on both slopes of this highland with 600 to 1,200 m altitude is called the "Middle Veld." Continuous with the Middle Veld, in the Zambezi River basin in the north and in the Sabi and Nuanetsi River basins in the south, is the region with altitude 600 m or less, called the "Low Veld".

All three regions above are plateaus with an undulating physical feature, and is broken up in places by rock formations. There are some extremely large ones; "the Great Dyke", the largest, is 480 km long and 10 km wide.

There is a fourth region called the "Eastern Highland" near the border with Mozambique. This region is situated on the elevated portion of the eastern end of the South- Central African tableland, comprised of a mountain range with many peaks with altitudes exceeding 1,800 m; the highest, Mount Inyangani, is 2,594 m.

The geographic distribution above is described in Fig. I-4-1. Since each region differs in climatic conditions and agricultural configuration, regional divisions are important in understanding agricultural conditions.

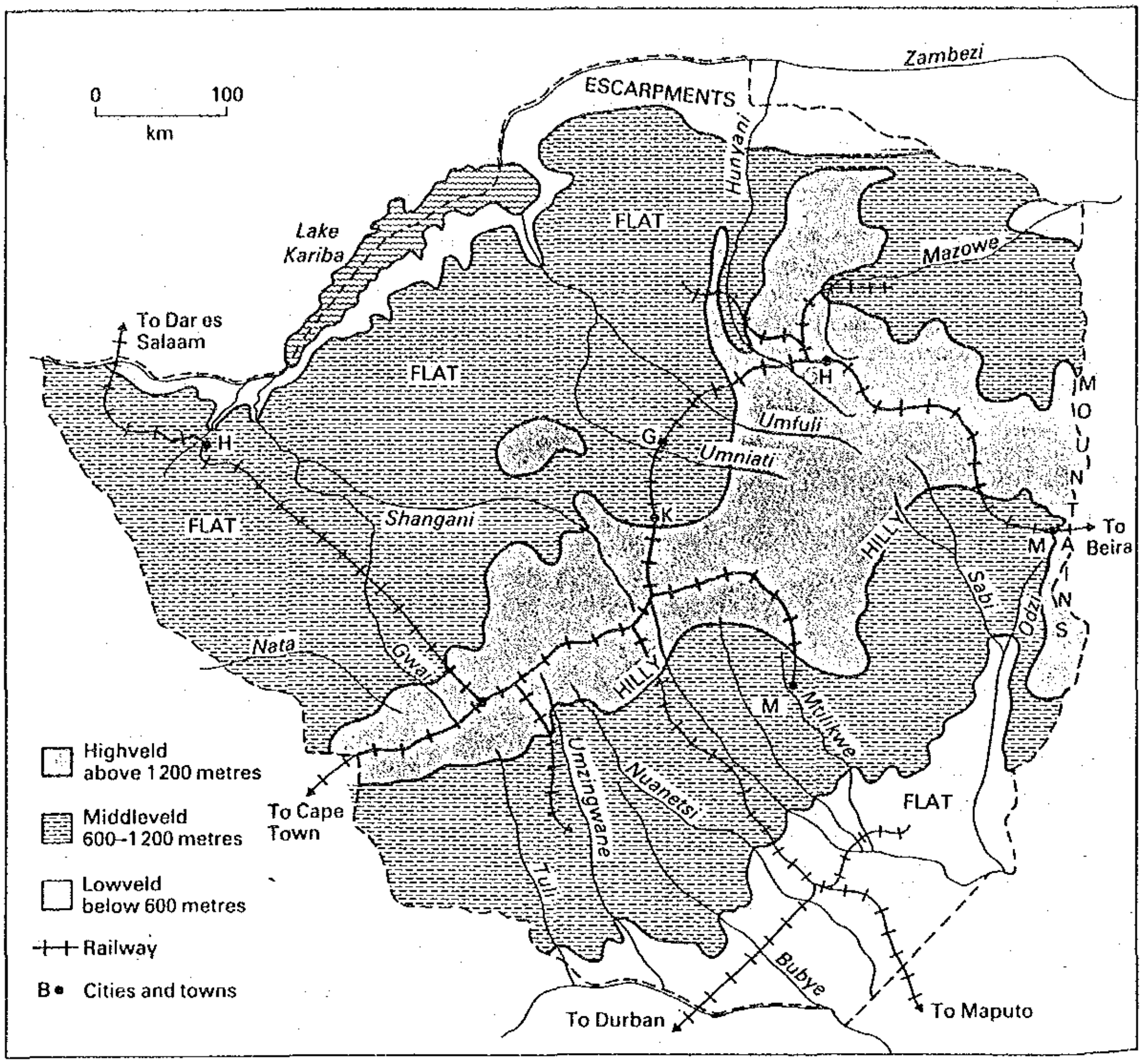


Fig. I-4-1 Topographical Map

(2) Geological Features

In general, the nation has various type of rocks and geological formations and has abundant mineral resources.

The Tertiary Period sands (Kalahari Sands) spanning from Bulawayo in the west to Victoria Falls, composes 25% of the nation's area. The oldest stratum is a Precambrian schist area (Gold Belt) comprised of andesite and basalt spreading northeast to southwest. This area has large quantities of serpentine with a high content of nickel and chromium. Gold and chromium is also produced in Limpopo Mobile Veld in the south. The Great Dyke mentioned above is comprised primarily of gabbro and pyroxenite. The main rock throughout the nation's territory is granite, in some cases in the form of boulders standing on the ground.

(3) Climate

Zimbabwe is latitudinally located in the tropics but the tropical inland climate is ameliorated slightly by altitude. The plateau in the central area, in particular, has a subtropical climate, with lower temperatures than areas at sea level in the same latitude. The annual climatic distribution is as follows.

- Dry Season: (From April to August. The nighttime temperatures are particularly low with frost forming in some locations)
- Hot Season: (The hottest season in the year, from October to the beginning of November)
- Rainy Season: (From mid-November to March)

Maximum and minimum temperatures of specific locations are described in Table I-4-2, and their annual rainfall (from July to June) in Table I-4-3. The distribution of annual rainfall is described in Fig. I-4-2. As described in the above figure, there is a lot of rainfall in the eastern and northeastern sections, especially in the eastern mountainous region. On the other hand, rainfall is very scarce in the south. Furthermore, long dry spells persist during the rainy season in some years. Annual rainfall and its distribution has an very large consequences for agriculture; not only do they determine production quantity and agrarian economy, but also export of products, so they are significant from the standpoint of national economy. Fig. I-4-3 describes the monthly rainfall and maximum and minimum temperatures of specific locations in 1980/81 and 1982/83. In 1980/81 there was abundant rainfall and a plentiful harvest of agricultural products. The year 1982/83, however was a drought year and many products such as maize were damaged. According to Fig. I-4-3, Beitbridge generally has little rainfall and the rainfall in 1982/83 was only 20% that of 1980/81. Even the rain fall in 1982/83 was approx. 40% of that in 1980/81 in Harare and Mutare, located in a rainy region.

Table I-4-2 Temperature Variations

Station	Altitude (metres)	Annual absolute maximum °C	Annual absolute minimum °C
Beitbridge	457	43.4	-0.6
Bulawayo (Goetz)	1,344	36.7	-3.8
Gweru (Thornhill)	1,429	36.1	-5.8
Harare (Research Station)	1,506	33.2	-3.1
Nyanga	1,878	29.8	-0.9
Kariba Airport	518	40.8	2.7

Source: Climatological Summaries: Zimbabwe, Climate Handbook Suppl. no 5, Department of Meteorological Services.

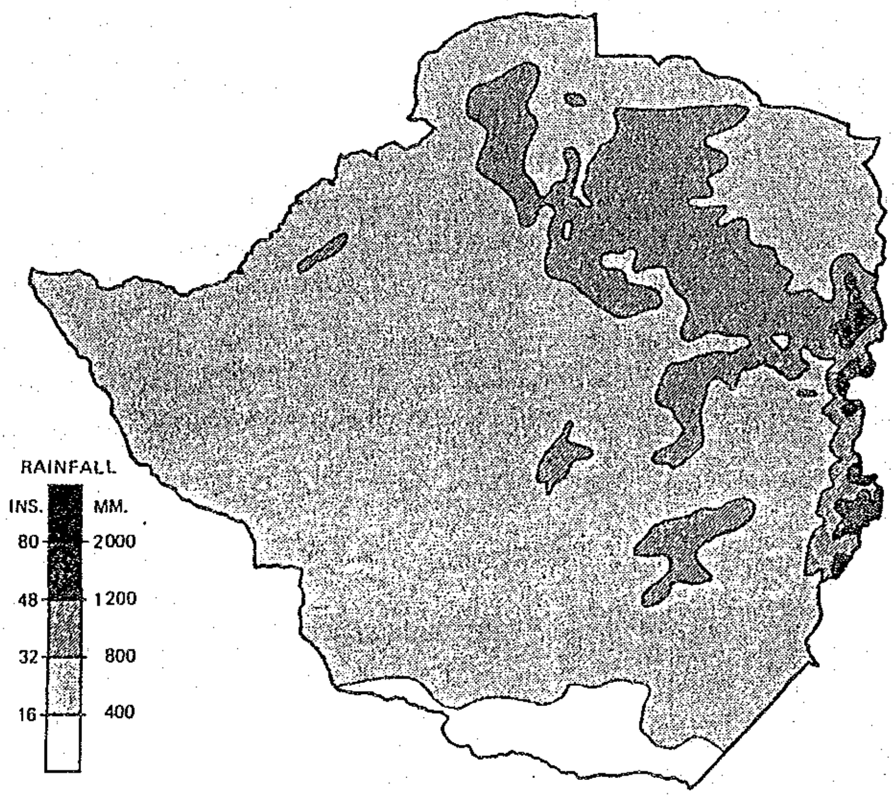
Table I-4-3 Annual Rainfall Totals (1979/80-1984/85)

Unit: Millimetres

Station	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85
Beitbridge	296.4	387.1	280.0	83.3	253.1	393.3
Bulawayo (Goetz)	470.0	833.1	306.5	433.6	432.5	627.4
Gweru (Thornhill)	852.4	825.2	457.3	458.1	501.2	794.7
Harare (Research Station)	817.3	1,106.2	659.5	433.0	694.3	1,033.9
Nyanga	1,011.9	1,882.8	1,140.9	930.6	959.5	1,434.7
Kariba Airport	1,080.6	869.5	694.2	517.1	481.6	739.2

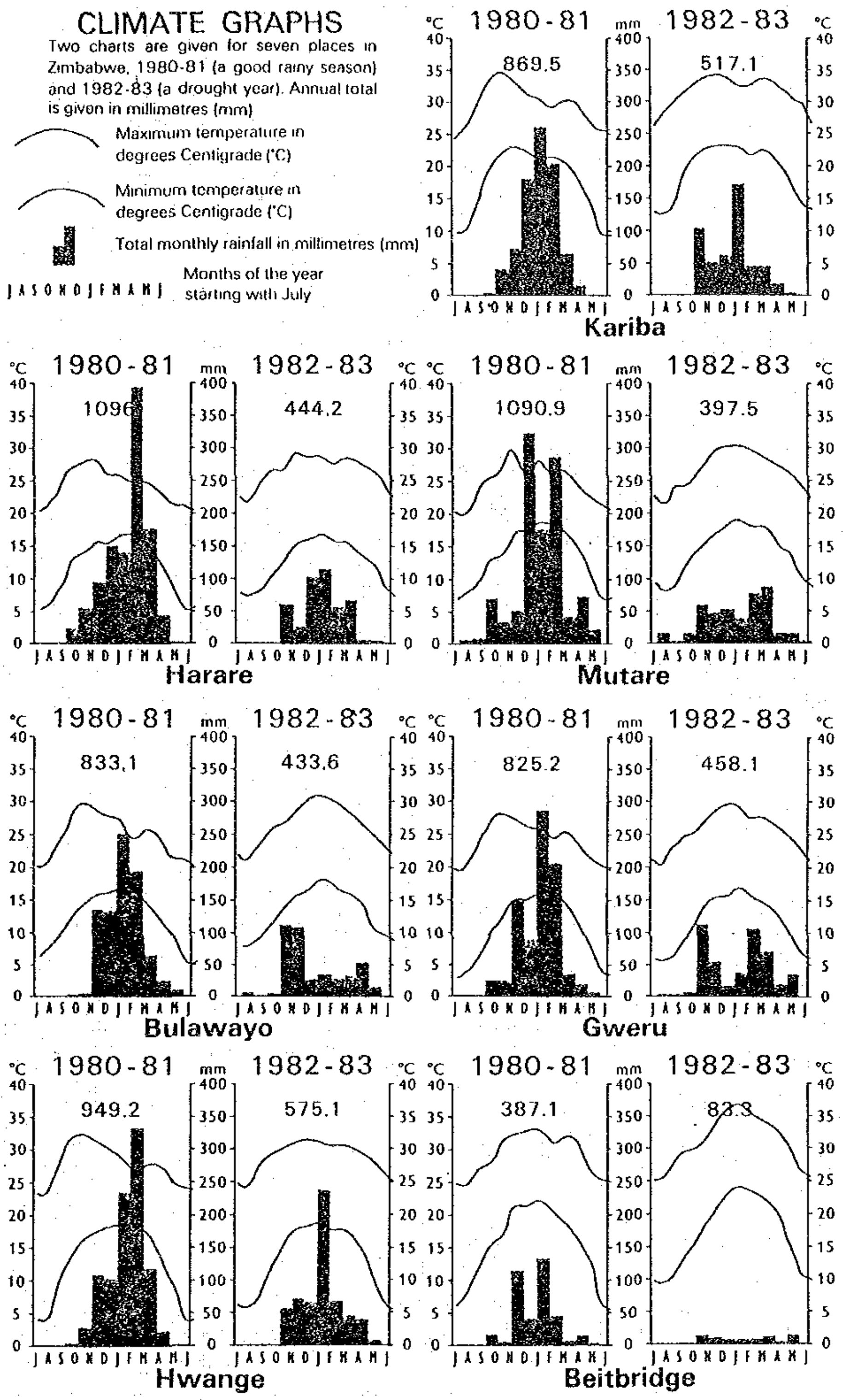
Source: Rainfall Reports, Department of Meteorological Services.

Note: The Meteorological office rainfall year is from July to June.



Source: Statistical Yearbook 1987; CSO

Fig. I-4-2 Mean Annual Rainfall



Source: Ventures Large Print ATLAS for Zimbabwe

Fig. I-4-3 Climate Graphs

(4) Soil

The basic material of Zimbabwe's soil consists of wide range of rocks from granite, which is an acidic rock, to rocks composed of suprabasic materials, nickel and chromium. In addition, various types of soil has been formed by harsh tropical weathering such as high temperature, high humidity, and desiccation.

There have been several studies conducted on soil classification up to now. FAO/UNESCO issued a World Soil Map in 1977, classifying the nations soil into 17 soil groups, which are further broken down in 43 soil units. This was followed by J.G. Thomson's classification of the nation's soil in 1981, below.

SOIL CLASSIFICATION

A: AMORPHIC ORDER

Soils with very feeble development of genetic horizons.

A-1: Regosol group. Deep sands with less than 10% silt + clay above 2 metres; very little or no reserves of weatherable minerals; extremely low silt/clay ratios (mainly Kalahari sands).

A-2: Lithosol group. Very shallow soils, less than 25 centimetres deep, over weathering rock or gravel.

B. CALCIMORPHIC ORDER

Unleached soils, generally with large reserves of weatherable minerals; clay fraction predominantly 2:1 lattice.

B-1: Vertisol group. Moderately deep to deep, dark self-churning clays; clay fractions mainly montmorillonite.

B-2: Siallitic group. Soils in which the clay fractions are predominantly illite or illite-montmorillonoid mixed-layer minerals; with or without calcareous accumulation in the lower solum or underlying material.

C. KAOLINITIC ORDER

Moderately to strongly leached soils; clay fractions mainly kaolinite together with appreciable amounts of free sesquioxides of iron and aluminum.

C-1: Ferisiallitic group. Soils with appreciable reserves of weatherable minerals; clay fractions contain some 2:1 lattice minerals.

C-2: Paraferrallitic group. Mainly sandy soils that have some essentially ferrallitic characteristics, but which are not strictly ferrallitic.

C-3: Orthoferrallitic group. Highly porous, truly ferrallitic soils; very little or no reserves of weatherable minerals; only 1:1 lattice clay minerals present, and, except in the case of some soils formed on Umkondo sandstone, gibbsite always present.

D. NATRIC ORDER

Soils containing significant amounts of exchangeable sodium.

D-1: Sodic group. This includes all soils that have, within 80 centimetres of the surface, horizons in which the exchangeable sodium percentage is greater than 9.

Regions 1-3 in the agricultural region classification consist in many cases of highly fertile calcareous or kaolinite clay, whereas locations classified as regosol and lithosol are infertile with little rainfall, and therefore have low productivity.

4.1.3 Classification of Agricultural Regions

Agricultural regions were classified for the first time in 1960 based on natural conditions and revision was later conducted by FAO in 1982. Five agricultural regions were designated according to natural conditions such as climate, particularly amount of precipitation, soil type, and others. A summary of various regions are the following.

(1) Region 1: Diversified and specialized farming regions

The annual precipitation in this region is over 900 mm in highlands with altitudes 1,700 m or more, and over 1,000 mm in areas with altitudes less than 1,700 m. Forestry, fruit culture, and intensive animal husbandry are the main operations, and in regions where frost doesn't form, plantation crops such as tea, coffee, and macadamia nuts are produced. The area is 7,000 km^2, amounting to 2% of the entire territory of the nation. The percentages of cultivated area in this region by sector are 74% large-scale commercial farmland sector operated by European-descent settlers, 24% communal farmland sector and 2% small-scale commercial farmland sector.

(2) Region 2: Intensive farming region

The annual precipitation is 750 - 1000 mm. Although there is production of various crops and intensive stock breeding in this region, part of the region has a relatively short rainy season or dry spells during the rainy season which result in reduced harvests in some years. The area is 58,600 km^2, amounting to 15% of entire territory. 74% of the cultivated land is large-scale commercial land; 22%, communal land; and 4% small-scale commercial land.

(3) Region 3: Semi-intensive farming region

The annual precipitation is 600 - 800 mm, and the rainy season occasionally has long dry spells. The main forms of agriculture are stock breeding and production of livestock feed, and the region is a marginal area for cultivation of cash crops, such as maize, tobacco, and cotton. The 72,900 km² area accounts for 19% of the nation's territory, 49% of the cultivated land being large-scale commercial land; 43%, communal land; and 8%, small-scale commercial land.

(4) Region 4: Semi-extensive farming region

Annual precipitation is 450 ~ 650 mm, and there are dry spells during the rainy season. Stock breeding and crops resistant to drought are the agricultural products. The area is 147,800 km² amounting to 38% of entire territory. The percentages of the cultivated land are 62% for communal land; 34%, large-scale commercial land; and 4%, small-scale commercial land.

(5) Region 5: Extensive farming region

Annual precipitation is extremely low: 450 mm or less, and the area is not even suitable for production of drought-resistant livestock feed or cereal crops. Therefore, extensive grazing of livestock or hunting are the main operations. The area is 104,400 km², accounting for 27% of nation's territory, 45% of this area being communal land; 35%, large-scale commercial land; and 20%, national park.

Fig. I-4-4 describes the division of the above five regions. Furthermore, as mentioned above, annual variations in precipitation results in serious consequences in cultivation and yield of crops, and also in the quantity of fertilizer consumption. The ranges of precipitation variation differ according to region as described in Fig. I-4-5; with large variations in the southern section and proportionally decreasing variations in locations northward. Agricultural cultivation is stable in proportion to how north the location is. The distribution of highly intensive agricultural regions from the northeast to the north is closely related to this stability of crop cultivation.

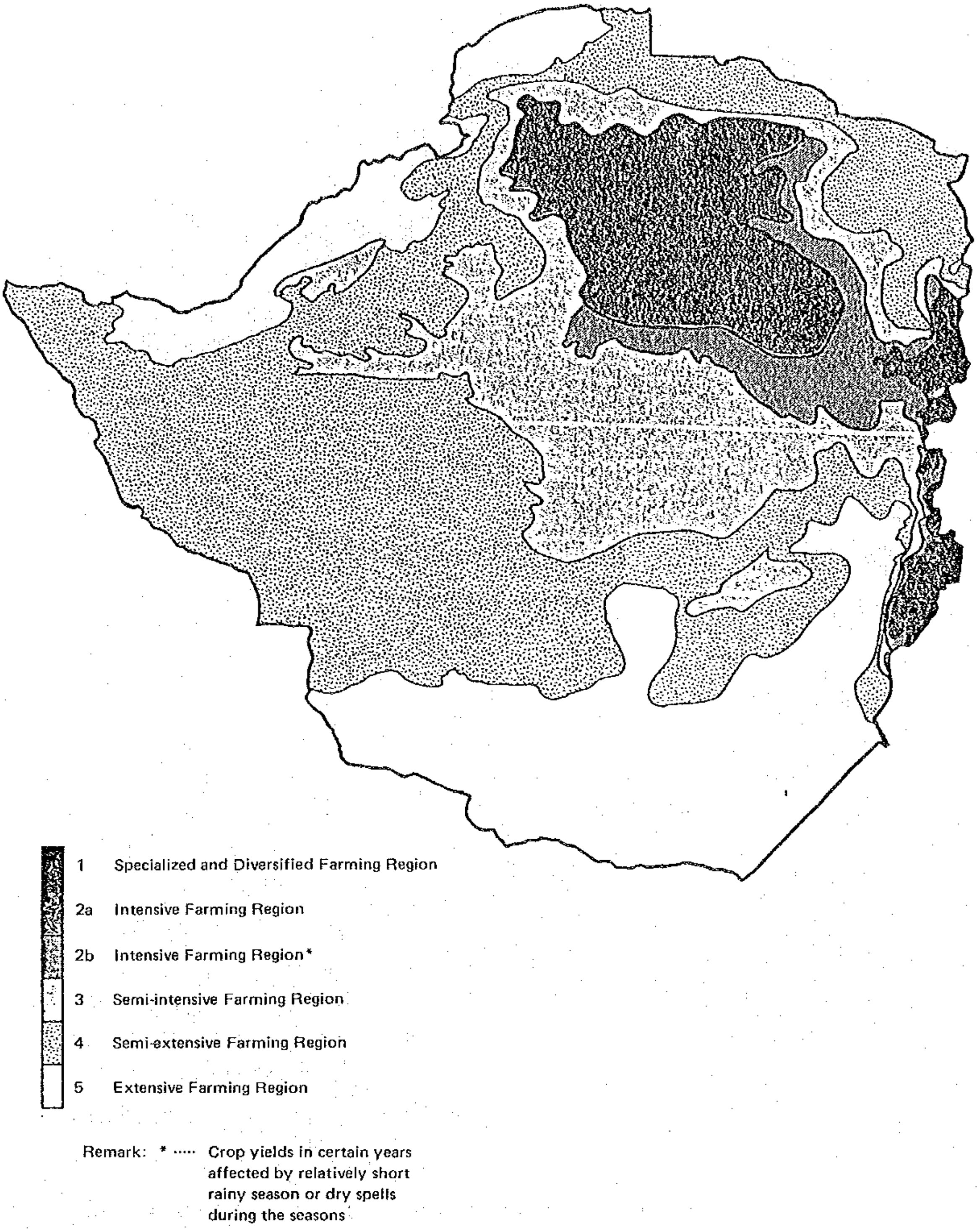
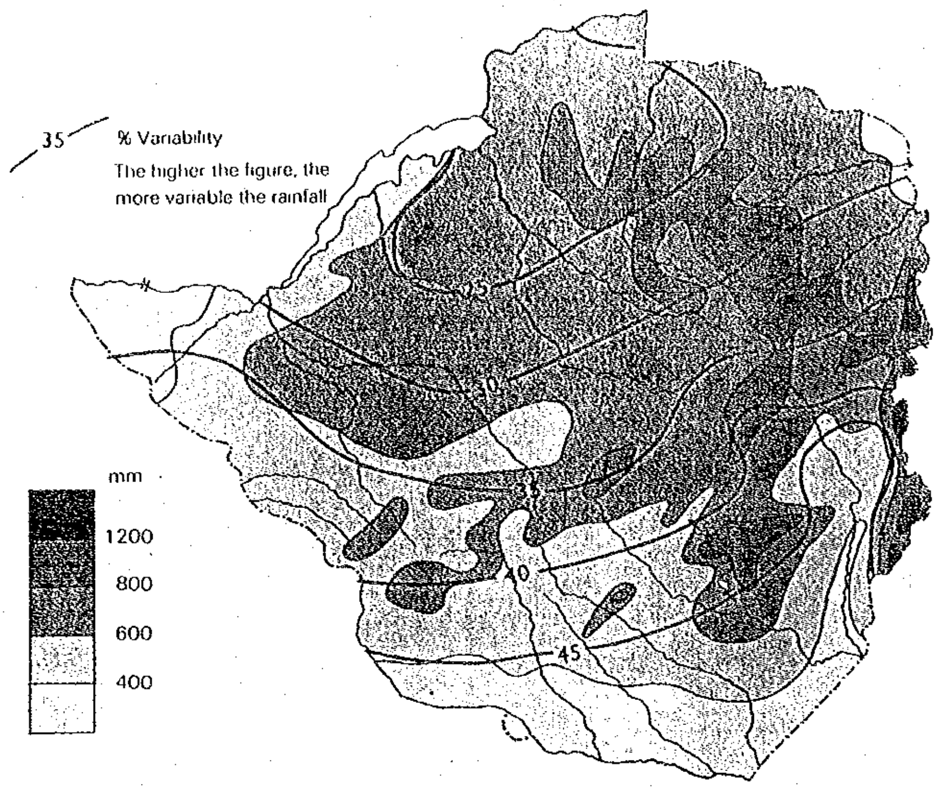


Fig. I-4-4 Natural Regions and Farming Areas



Source: Ventures Large Print ATLAS for Zimbabwe

Fig. I-4-5 Mean Annual Rainfall and % Variability of Rainfall

4.1.4 Organization of Agriculture

Zimbabwe's agriculture has a dualistic character, comprised of management by settlers from Europe and by farmers of African origin. The former is large-scale commercial farming by European descent settlers. The latter consists of small-scale commercial farming by farmers on lands passed on by inheritance, communal farming by farmers on Tribal Trust Lands (TTL), and communal farming on large-scale commercial farmland bought by the government and resettled by peasants from over-populated communal farmlands.

Of the above, large-scale commercial farming accounts for approx. 80% of diversified and specialized farmlands and intensive farmlands (the equivalent of 40% of the nation's territory). It's management is well-organized; it has abundant capital and produces a large proportion of product shipped to market. There are approx. 5,000 farming households and their average cultivation-land area is 2,200 ha, although since gaining independence in 1980 number of households are gradually decreasing.

On the other hand, communal farming accounts for up to 42% of the entire territory, but 75% of this is distributed in regions of low productivity, Regions 4 and 5. 45% of total population, i.e., 4.3 million live on these lands, mostly engaging in subsistence agriculture. Their emergence from slash-and-burn method of agriculture resulting from overpopulation and low agricultural productivity is a major issue. The size of small-scale commercial farming is very small, approx. 1/20 in comparison with large-scale commercial farming.

With governmental guidance, agricultural cooperatives are established in resettled areas and being self-reliantly operated aiming for increased production. Table I-4-4 describes the area of various categories of farmland and national lands including national parks, and their respective proportion to the nation's territory, their respective distribution ratios in Region 1 ~ 3; number of farming households; and farmland area per capita.

Table I-4-4 Land by Type

	Large-scale commercial land 1)	Small-scale commercial land	Communal land	National land (parks,etc.)
Total area, km²	157,000	14,200	163,500	56,200
Total area, %	40	4	42	14
% of land in region 1-3	51	56	26	15
Number of farms	6,000	8,500	–	–
Average size of farm, ha	2,200	125	23	
Population density, ha/person		12	4.5	

74 % of all communal land is located in Region 4 and 5.
75% of all small scale commercial land is located in Regions 3 and 4.
51% of all large scale commercial land is located in Regions 1–3.

1) Including 200,000 hectares urban areas.

Source: Statistical Yearbook 1987

4.1.5 Agricultural Production and Distribution of Agricultural Products

(1) Production of Farm Crops

The nation's main farm crops are maize, tobacco, cotton, wheat, soybean, groundnut, sorghum, tea, coffee, sugarcane, etc. Also, the main livestock are cattle, sheep and hog. Table I-4-5 describes the area planted for main crops in 1980 and 1983.

Table I-4-5 Area Planted

Unit: 1,000 ha

	1980			1983		
	Commerc.	Commun.	Total	Commerc.	Commun.	Total
Maize	228	900	1,128	284	1,050	1,334
Tobacco	64	Nil	64	46	1	47
Cotton	75	15	90	70	65	135
Wheat	33	–	33	21	–	21
Soybean	41	12	53	55	4	59
Groundnut	4	175	179	11	180	191
Sorghum	7	120	127	8	280	288
Tea	4	–	4	4	–	4
Coffee	4	–	4	7	–	7
Sugar	25	–	25	34	–	34
Total	485	1,222	1,707	540	1,580	2,120

Source: UNDP Report, Dec. 1987.

As described in Table I-4-6, the production of crops such maize, sorghum, wheat and groundnut 1983 decreased remarkably compared to that of 1980. This was due to the severe drought in 1983, as mentioned before.

Table I-4-6 Crop Production by Sector

Unit: 1,000T

	1980			1983		
	Commerc.	Commun.	Total	Commerc.	Commun.	Total
Maize	910	600	1,510	624	285	909
Sorghum	16	66	82	7	44	51
Wheat	154	–	154	110	–	110
Groundnut	10	67	77	9	22	31
Soybean	89	8	97	78	2	80
Coffee	5	–	5	8	–	8
Cotton	145	12	157	114	32	146
Tobacco	119.8	0.2	120	93.3	0.6	93.9
Sugarcane	2,528	–	2,528	3,438	–	3,438
Tea	9	–	9	10	–	10

Source: Statistical Yearbook 1987

Information on the area planted for crops by sectors during the period 1980 - 1983, production quantity, and yield per ha are described in A-Table 4-1. Total area, number employed (including both managers and workers), area planted, area of fruit cultivation, irrigation area, production quantity for respective crops, and number of livestock of large-scale commercial farming from 1973 to 1985 are described in A-Table 4-2. According to this table, total area and number employed have been decreasing generally since 1980. However, although there are yearly variations in the production of crops, they generally have not been decreasing. Moreover, the change in crop area by sectors during the past four years are described in Table I-4-7.

Table I-4-7 Crop Area Estimates by Sector

Unit: ha

	LSCF* + SSCF**	COMMU***	Reset****	Grand Total
1985/86	603,600	2,271,200		2,874,800
1986/87	552,714	1,811,996	167,570	2,532,280
1987/88	561,900	1,809,420	174,950	2,546,270
1988/89	612,900	1,809,420	184,200	2,606,520

Note : * : Large Scale Commercial Farm
** : Small Scale Commercial Farm
*** : Communal Land
**** : Resettlement

Source: Central Statistical Office

In this table, although the total area of communal farmland and resettlement land is described for 1985/86 but its breakdown is unknown, so comparison with years from 1986/87 onward is not feasible. With respect to the three years from 1986/87 onward, the crop area by commercial farming has been steadily increasing and that by communal farming has been constant in general. Also, although extremely small in scale with other sectors, the area of resettlement has been generally increasing. The estimated crop area of respective crop by sectors from 1985/86 through 1988/89 are described in A-Table 4-3. According to this table, in communal farming land, the area planted with cotton, maize, groundnut, sorghum, as well as rapoko and mhunga is large. Rapoko and mhunga are not cultivated in large quantities in commercial farmland but, as they are suitable for arid areas, farmer households without irrigation facilities cultivate them.

The 1983 statistics of production by commercial farming sector in respective provinces are described in table below.

Table I-4-8 Major Crops of Commercial Farms by Province, Production Area and Yield, 1983

Unit: T, ha and T/ha

		MANICALAND	Mashonaland West	Mashonaland East	Mashonaland Central	Matabeleland North	Matabeleland South	Midlands	Masvingo	Total
Maize	Production	9,914	278,817	107,719	174,344	6,885	2,467	15,202	3,584	598,932
	Area	9,862	121,898	48,457	56,283	2,549	2,305	18,119	12,282	271,755
	Yield	1.005	2.287	2.223	3.098	2.701	1.070	0.839	0.292	2.204
Sorghum	Production	649	4,315	418	1,280	263	22	501	88	7,536
	Area	701	3,210	462	933	346	131	710	1,178	7,671
	Yield	0.926	1.344	0.905	1.372	0.760	0.168	0.706	0.075	0.982
Wheat	Production	18,631	45,202	14,648	23,732	4,400	1,264	694	2,419	110,990
	Area	4,022	8,773	2,542	4,369	844	353	169	475	21,547
	Yield	4.632	5.152	5.762	5.432	5.213	3.581	4.107	5.093	5.151
Groundnuts	Production	198	3,339	4,350	809	250	33	131	43	9,153
	Area	994	2,078	2,920	823	102	221	1,292	2,279	10,709
	Yield	0.199	1.607	1.490	0.983	2.451	0.149	0.101	0.019	0.855
Soybeans	Production	4,150	40,390	16,250	15,070	28	132	1,438	627	78,625
	Area	2,275	31,939	8,732	10,073	31	123	1,298	438	54,909
	Yield	1.824	1.282	1.861	1.496	0.903	1.073	1.108	1.432	1.432
Cotton	Production	13,650	39,270	127	48,769	..	2,277	2,129	7,800	114,022
	Area	5,483	27,695	458	25,085	..	856	4,517	3,881	67,975
	Yield	2.490	1.418	0.277	1.944	..	2.660	0.471	2.010	1.677
Coffee [1]	Production	6,213	1,391	*	214	..	..	*	212	8,234
	Area	4,849	1,576	*	313	..	..	*	103	6,986
	Yield	1.281	0.883	*	0.684	..	..	*	2.058	1.179
Tobacco	Production	6,029	38,262	21,202	27,781	..	..	*	*	93,331
	Area	3,790	19,476	9,511	13,518	..	..	*	*	46,327
	Yield	1.591	1.965	2.229	2.055	..	..	*	*	2.015

*) Suppressed for confidentiality reasons.
1) Productive coffee and relates to large scale commercial farms only.

Source: Central Statistical Office.

As described in this table, Mashonaland West is the province with the largest agricultural production. The three provinces, Mashonaland West, East, and Central are the main production areas of major crops, followed by Manicaland. Although small in area, Manicaland is endowed with natural conditions of Region 1 mentioned above, and is particularly the main producing area of coffee and other products. In contrast with these four provinces above, Matabeleland North and South, comprised of land of Regions 4 and 5, are unsuitable for intensive crop production, and are being utilized for stock breeding. Midlands and Masvingo include areas of Region 3 category, and correspondingly are endowed with far more favorable conditions than Matabeleland North and South. The production by province of the major crops such as maize, sorghum, wheat, groundnut, soybean, and cotton are described in Table I-4-9. These values substantiate the trend of agricultural production by province mentioned above. A-Table 4-4 describes the area of crop and fruit cultivation by province, production quantity and yeild per ha in 1985. Further, the statistics at the end of A-Table 4-4 include values of minor crops not shown on Table I-4-9.

Table I-4-9 Relative Production by Province

Unit: %

	Relative production of					
	Maize	Sorghum	Wheat	Groundnut	Soybean	Cotton
Manicaland	2	9	17	2	5	12
Mashonaland West	46	57	41	37	52	35
Mashonaland East	19	6	13	48	21	..
Mashonaland Central	29	17	21	9	19	42
Matabeleland North	1	3	4	3	..	..
Matabeleland South	..	..	1	..	..	2
Midlands	2	..	1	1	2	2
Masvingo	1	1	2	..	1	7
	100	100	100	100	100	100

Source: Statistical Yearbook 1987

(2) Distribution of Agricultural Products

Among products produced by farmers, milk, cotton, cereal crops, and meat are purchased by the Dairy Marketing Board, Cotton M.B., Grain M.B., and Cold Storage Commission, respectively, which are affiliated with the Agricultural Marketing Authority. The Dairy M.B. packages milk, produces ice cream, cheese, and butter, and sells dairy products domestically as well as exports them. The Cotton M.B. gins and spins cotton, and sells such things as linters and oil seed, the Grain M.B. stores and sells cereal crops. The Cold Storage Commission purchases cattle, sheep, and goat from farming households, butchers them and sells the meat. All four bureaus sell domestically as well as export, and only the foreign currency in the sales is paid to Ministry of Finance.

Commercial and communal farmers are on equal footing in selling products to the AMA. However, communal farmers may sell in its vicinity beside to the AMA, but commercial farmers are not permitted to do so, and must sell to the AMA only.

The determination of regulated prices of agricultural products is under the jurisdiction of Ministry of Trade and Commerce.

The annual sales reserves of major agricultural products made by commercial and communal farming operations from 1970 through 1985 are described in Table I-4-10.

Products have been frequently consumed privately by the communal farmers but recently sales to the Grain Marketing Board of maize in particular have increased remarkably. This is substantiated by the fact that while the sales revenue shown in actual price for the period from 1970 through 1985 increased ten-fold for commercial farming operations, it increased almost hundred-fold for communal farming operations, as described in the table below.

Table I-4-10 Major Crops, Summary of Sales (1970-1985)

Unit: Z$ Million

	Communal	Commercial	Total
1970	2.7	80.9	83.6
1971	6.1	106.1	112.2
1972	12.6	129.5	142.1
1973	8.2	124.9	133.1
1974	15.3	200.4	215.7
1975	14.2	224.2	238.4
1976	18.2	225.4	243.6
1977	15.6	228.6	244.2
1978	17.1	237.0	254.1
1979	12.2	249.2	261.4
1980	22.0	350.1	372.2
1981	63.7	518.2	581.9
1982	65.0	484.7	549.7
1983	45.6	451.1	496.7
1984	103.2	603.5	706.7
1985	224.9	861.5	1,086.4

Source: Central Statistical Office.

Table I-4-11 describes the volume and value of crop sales handled by the AMA. As indicated therein, the sales of maize which is the largest in amount of production showed remarkable decrease in 1983 as a result of the drought.

The proportion of export amount of agricultural products and processed ones to total export amount for 1980 was 29%; 1981: 40%; 1982: 40%; 1983: 38%; 1984: 38%; 1985: 40%, respectively and therefore these items play a significant part in exports.

Table I-4-11 Crop Sales to/through Marketing Authorities (Volume and Value 1970-1984)

Unit: 1,000 T and Z$ Million

		1980	1981	1982	1983	1984
Maize	Volume	819	2,014	1,391	617	952
	Value	72	240	166	74	131
Unshelled Groundnuts	Volume	17	20	16	9	6
	Value	5	5	4	3	2
Sorghum	Volume	18	30	19	5	20
	Value	2	3	2	1	3
Soybean	Volume	94	65	84	74	90
	Value	15	11	17	19	26
Coffee	Volume	6	5	7	10	11
	Value	12	7	12	21	32
Wheat	Volume	163	201	213	124	99
	Value	22	35	40	27	25
Cotton	Volume	182	201	158	167	250
	Value	71	77	79	83	138
Flue-cured Tobacco	Volume	123	70	87	94	120
	Value	97	128	146	178	247
Burley Tobacco	Volume	2	2	4	5	5
	Value	2	3	6	7	8
Sugar	Volume	..	..	..	..	..
	Value	77	82	78	94	114

1) Figures refer to intake year, which is from April to March.
Source: Central Statistical Office.

4.1.6 Agricultural Promotion, Subsidy and Financing System

The agricultural extension service programme of Zimbabwe is under the jurisdiction of Department of Agricultural Technical and Extension Services (AGRITEX) of MLARR. AGRITEX has an extention service section and a technical section; extention service agencies have been established at the province, district, ward, and village levels for diffusion which give guidance and advice to farmers. On the other hand, with respect to technical service, a total of eight sections including crop production, stockbreeding, agricultural engineering, irrigation, research and training, and management provide technical instruction materials to transfer the results of research in the respective fields to farmers.

Agricultural finance is managed by the Agricultural Finance Corporation (AFC). The major financing schemes are the following.

(1) Small Farm Credit Scheme (SFCS)

(2) Resettlement Loan Fund (RLF)

In loan scheme (1), farmers receive loans through agricultural cooperatives, purchase fertilizer, and make repayments by deduction from product sales amount. This policy is managed well and the rate of repayment is reported to be almost 90%.

Subsidy with respect to fertilizer is currently discontinued.

4.2 Overview of Nitrogenous Fertilizer

4.2.1 World Supply and Demand

The world supply and demand of nitrogenous fertilizer for 1986/87 is described in Table I-4-12; growth during 1985/86 and 1986/87 is described in Table I-4-13.

Table I-4-12 World Nitrogen Fertilizer Supply/Demand Balance

Unit: 1,000 TN
Preliminary

	1984/85	1985/86	1986/87
Production	74,751.4	73,295.9	75,603.0
Available supply	72,508.9	71,097.1	73,335.0
Consumption	70,586.9	70,338.2	72,032.3
Balance	+1,994.0	+758.9	+1,302.7
Trade	15,901.4	14,732.3	16,990.2

Source: Statistical Supplement, Nitrogen 1987

Table I-4-13 Changes in Production/Consumption Levels (1986/87 v 1985/86)

Unit: 1,000 TN

	Production	Consumption
Western Europe	–319.8	+354.3
Eastern Europe	+1,048.8	+328.7
USSR	+996.0	+525.0
North America	–85	–212.7
Middle East	+158.1	+111.6
Asian CPEs	+52.9	–341.6
South and East Asia	+1,460.5	+1,316.8
China P.R.	+147.9	–298.0
India	+1,088.8	+830.0
World	+2,307.2	+1,706.5

Source: Statistical Supplement, Nitrogen 1987

The conditions regarding fertilizer market were favorable in 1986/87 compared with 1985/86; increase in production was 2.3 MMTN (3.1%); consumption, 1.7 MMTN (2.4%); and trade, 2.3 MMTN (15%), respectively. A similar trend is seen for phosphatic fertilizer and potash fertilizer as described in Table I-4-14 and I-4-15, respectively.

Table I-4-14 World Phosphate Fertilizer Supply/Demand Balance

Unit: 1,000 TP_2O_5

	1984/85	1985/86	Preliminary 1986/87
Production	35,519	33,525	37,286
Available supply*	34,453	32,520	36,167
Consumption	34,163	32,961	34,489
Balance†	+290	–441	+1,678
Trade	8,819	7,410	8,419

Source: Statistical Supplement Phosphorus and Potassium, 1987

* Available supply equals production, minus losses incurred by transport, bagging and handling operations, estimated at 3% of world production

† Balance equals notional stock change.

Table I-4-15 World Potash Fertilizer Supply/Demand Balance

Unit: 1,000 T K_2O
Preliminary

	1984/85	1985/86	1986/87
Production	28,923	28,439	28,114
Available supply*	27,477	27,017	26,708
Available supply for fertilizers†	26,103	25,666	25,373
Consumption	25,951	25,572	25,687
Balance†	+152	+94	–314
Trade	18,400	18,060	18,412

Source: Statitical Supplement Phosphorus and Potassium, 1987

* Available supply equals production, minus losses incurred by transport, bagging and handling operations, estimated at 5% of production.

† Available supply, less industrial sales (estimated at 5% of total)

† Balance equals notional stock change.

It is obvious from these 3 tables that the world fertilizer market is recovering to its stable condition.

The middle and long range supply demand records and forecasts of nitrogenous fertilizer are summarized below.

A-Table 4-5 describes production and consumption of nitrogenous fertilizer by product and by region for the period 1984/85 ~ 1986/87. It has been shown that most of the nitrogenous fertilizer increase in 1986/87 is a result of urea increase, while the other nitrogenous fertilizer consumption is constant or generally decreasing. A-Table 4-6 describes the production and consumption by various nations during the same period. A gradual decrease is indicated for Western Europe and Northern America, particularly notable is a decline exceeding 2 MMTN in the U.S.A. This can be inferred as closely related to surplus in agricultural production.

In addition, estimates of future supply and demand is described in A-Table 4-7, This table shows that nitrogenous fertilizer will be in short supply in 1990/91, even in advanced countries except North America expected to be in long supply. Estimates of developing regions are discussed. The Middle East is expected to continue increasing exporting capacity but the region is generally expected to have a nitrogenous fertilizer deficiency in 1990/91 which exceeds that in 1985/86. Although an approx. three-fold supply increase is expected in Africa during the same period, the supply shortage is not significantly ameliorated. The demand growth rate until 1991/92 is estimated 3.7%. Planned economy regions such as USSR and Eastern Europe are expected to continue exporting to the rest of the world as a result of their excess supply capacity. In general, due to decreased plant construction resulting from the low price of nitrogenous fertilizer, the present fertilizer surplus is expected to continue until 1989/90, however, the supply is expected to just break even or be short in 1990/91, and run a shortage in 1991/92. If the supply and demand of agricultural products continues to be in surplus, the application of nitrogenous fertilizer will decrease, and as a result the coming of a supply shortage may be postponed.

Nitrogenous fertilizer trade statistics are described in A-Table 4-8. Total world trade volume in 1986/87 increased 2.3 MMTN from the previous year, and in particular, import increase in Western Europe, India, and China, and export increase in Eastern Europe and North America are notable. Importation increased more than 50% in 1985/86 over the previous year in Africa; however, which nations this originated from is not determinable in these statistics.

A-Fig. 4-1 ~ 4-6 describe the monthly international price fluctuation of ammonia, urea, ammonium sulphate, and compound fertilizer (15-15-15) for the period 1982 ~ 1988.

4.2.2 Fertilizer Distribution in Zimbabwe

As mentioned earlier, agriculture is the nation's key industry. Consequently, the government has paid the greatest attention to the production and supply of agricultural materials, especially fertilizer. Although it aims to produce nitrogenous and phosphatic fertilizer domestically as much as possible, a portion of raw materials and finished product of fertilizer must be imported because of the large demand, and a large allotment of foreign currency is made for this purpose.

The private sector produces and markets fertilizer: SABLE produces ammonium nitrate; ZIMPHOS produces single superphosphate (SSP) and triple superphosphate (TSP), and these fertilizers are sold to ZFC and WINDMILL. The latter two firms manufacture and sell compound fertilizer as well as sell such single fertilizers as ammonium nitrate, double superphosphate (manufactured from SSP and TSP), and potash fertilizer directly to farmers, and in part to agricultural cooperatives. Furthermore, items such as urea imported as fertilizer are similarly sold by these two firms.

The flow of raw materials and final products of fertilizers are described in A-Fig. 4-7. Imported urea and potassic salt is directly transported to either ZFC or WINDMILL and utilized in compound fertilizer manufacturing or sold as straight fertilizer.

Fertilizers currently marketed are thirteen brands of compound fertilizer (A, B, C, D, J, L, M, P, S, T, V, X, and Z); straight fertilizers such as nitrogenous fertilizer (ammonium nitrate, urea, and sodium nitrate), phosphatic fertilizer (single superphosphate and double superphosphate), and potash fertilizer (potassium chloride and potassium sulphate); and gypsum as a supply source for sulphur. In addition, ammonium sulphate, etc. are also utilized in small quantities. Sulphur content is described in the composition of fertilizers, in consideration of applying sulphur as fertilizer. There are also compound fertilizers comprised of boron and zinc. The major brands of fertilizer and their composition percentages are described in A-Table 4-9.

The recommendation of application of above compound fertilizers are specified by crop respectively, and in particular, application of chlorides to tobacco is restricted as much as possible.

A summary of the application rates of fertilizer for respective crops in large-scale commercial farming is described in Table I-4-16.

Table I-4-16 Zimbabwe Fertilizer Application Rates Large-Scale Commercial Sector

Crop	Basal Applications (Kg Compounds/ha)	Top Dressing (Nitrogen as AN kg/ha)
Tobacco - Virginia	700	75
- Burley	800	300
Maize (incl. seed)	360	380
Cotton	325	150
Sorghum	125	75
Groundnuts	300	–
Wheat	650	450
Barley	700	200
Edible Beans	200	–
Soybeans	250	–
Sunflowers	300	100
Potatoes	1,800	150
Coffee	1,100	300
Fruit	400	150
Sugar Cane	300	475
Tea	600	220
Vegetables	1,200	1,000

Source: World Bank Report No. 6349; an industrial sector memorandum (1987)

As explained above, specified compound fertilizers are utilized for basal application, and straight fertilizers for top dressing. Moreover, the applied amount of nitrogen is described by product volume of ammonium nitrate.

As mentioned already both ZFC and WINDMILL sell fertilizers, and under a mutual agreement, sell to farmers. The farmers take soil samples from their crop field to these fertilizer firms, determine the fertilizer application rate according to results of analytic diagnosis, and purchase fertilizer from those firms.

Fertilizer prices have increased as described in Table I-4-17 (1) and (2).

Table I-4-17 (1) Domestic Fertilizer Price for the Years 1975 to 1986

Unit: Z$/T

YEAR (MAR-FEB)	Straights									
	Nitrogen				Phosphate		Potash		Ground	
	AN	Urea	Nitrate of soda	Sulphate of ammonia	Double supers	Single supers	Sulphate of potash	Muriate of potash	Dolomite	Gypsum
1975/76	127.4		156.2		92.8	43.8	143.4	118.4	14.4	21.8
1976/77	116.4		153	75	117.6	57.4	130.6	99.2	13.4	23.4
1977/78	129.4		170.2		138	63	119.6	89.8	14	25.2
1978/79	138.8		163.4		149.8	67.6	125.4	91.6	14	26.2
1979/80	141.6		214	113.8	173	76.2	166.2	121.6	15.6	29
1980/81	168.2		220.4		204.4	90.4	201.8	155.2	16.2	34.2
1981/82	187.2	249.6	257.6	167.6	230.4	117	238.6	183	18.8	38
1982/83	206.8	275.6	302.2		267.4	143.6	267.4	193.8		44.2
1983/84	206.8	275.6	302.2		267.4	143.6	267.4	193.8		44.2
1984/85	306.4	408.6	516.6		376	198.4	376			52.4
1985/8	406	541.4	609.8		479.6	256	536.4	351.8		55.4
1986/87	406	541.4	609.8	293.2	479.6	256	536.4	351.8		55.4
1987/88	406	541.4	609.8	293.2	479.6	256	536.4	351.8		55.4

Source: Central Statistical Office

Table I-4-17 (2) Domestic Fertilizer Prices for the Years 1975 to 1986

Unit: Z$/T

Year (Mar-Feb)	Compounds							
	A	B	C	D	L	M	S	Z
1975/76	100.2	107	94	91.4	94.4	98.2	88.8	109.2
1976/77	110.8	117.2	105	99.4	102.2	95.2	100.4	116.4
1977/78	114.6	122.4	126.6	106	92.2	99	106.8	123
1978/79	123.2	131.6	136	114.2	98.8	108.4	114.8	126.6
1979/80	146	155	158.6	128.2	112.2	117.8	130	140.2
1980/81	175	185.8	190.4	154	135	141.2	154	165.4
1981/82	201.6	211.4	214.4	168	188.8	166.2	180	181.6
1982/83	230.6	241.2	243.4	189.4	214.2	184.6	206.6	203
1983/84	230.6	241.2	243.4	189.4	214.2	184.6	206.6	203
1984/85	327.8	344	347.6	265.2	304.6	258.6	337.8	280.6
1985/86	443.2	465	467.8	355.6	404.1	350.8	448	371.2
1986/87	443.2	465	467.8	355.6	404.1	350.8	448	371.2
1987/88	443.2	465	467.8	355.6	404.1	350.8	448	371.2

Source: Central Statistical Office

The latest fertilizer prices issued in September 1988 with price increases are described in Table I-4-18.

Table I-4-18 Fertilizer Price-Increase

Unit: Z$/T

Fertilizer	Price
Compound A	525.00
Compound B	546.60
Compound C	547.20
Compound V	525.60
Compound D	416.60
Compound J	466.80
Compound L	492.80
Compound M	404.20
Compound P	449.60
Compound S	530.80
Compound X	483.80
Compound Z	435.00
Compound T	507.80
Urea	553.80
Ammonium Nitrate	415.40
Nitrate of soda	821.20
Sulphate of ammonia	388.60
Muriate of potash	400.80
Sulphate of potash	600.20
Single superphosphate	317.00
Double superphosphate	586.00
Gypsum	83.60
Colemanite	1,401.40
Borate	1,202.40

Source: The Herald 23nd Sept. 1988

The annual fertilizer sales records for the period 1980/81 to 1987/88 are described in A-Table 4-10. The ratio of compound fertilizer to straight fertilizer is in the range between 55:45 and 58:42. The quantity of the former is large to some extent, with fluctuations from year to year; moreover, the total quantity is between 400,000 and 500,000 tonnes. A summation of fertilizer sales records for the same period by nutrient is described in A-Table 4-14.

Table I-4-19 Fertilizer Sales by Nutrient

Unit: T

	85/86	86/87	87/88
COMP. N	20,925 (23)	18,993 (23)	18,067 (25)
STR. N	71,119 (77)	61,962 (77)	55,513 (75)
TOTAL N	92,044 (100)	80,955 (100)	73,580 (100)
COMP. P_2O_5	41,650 (91)	38,531 (90)	34,676 (89)
STR. P_2O_5	4,109 (9)	4,300 (10)	4,439 (11)
TOTAL P_2O_5	45,759 (100)	42,831 (100)	39,115 (100)
COMP. K_2O	26,391 (85)	25,318 (84)	18,560 (82)
STR. K_2O	4,528 (15)	4,740 (16)	4,094 (18)
TOTAL K_2O	30,919 (100)	30,058 (100)	22,654 (100)
Total Nutrients	168,722	153,844	135,349
Total N/Total Nutrients	0.55	0.53	0.54

The monthly sales quantity peaks in the April-May period and the August-September period (according to WINDMILL). The destinations of fertilizer by province are described in Table I-4-20 and A-Fig. 4-8; three provinces, Mashonaland West, Mashonaland Central, and Mashonaland East, account for 71% of total fertilizer quantity. These three provinces account for 77% of the fertilizer destined to the commercial farms, however they account for 59% of the fertilizer destined to the communal sector showing that much fertilizer is destined to other provinces also. Although this information was provided by WINDMILL, it summarizes the total amount handled by ZFC and WINDMILL and the sales amount by region for the entire nation can be discerned from it. Of the total 430,000 tonnes sales quantity, 310,000 tonnes and 120,000 tonnes are forwarded to the commercial farm and communal farm, respectively. Moreover, 56% of the total is compound fertilizer; 38%, ammonium nitrate; 4%, superphosphates; 2%, potash fertilizers, respectively, consequently the proportion of ammonium nitrate is significantly large.

Table I-4-20 Market Distribution over Various Agricultural Areas

Unit: %

	A	B	C
Mashonaland West	34	40	18
Mashonaland Central	24	26	21
Mashonaland East	13	11	20
Manicaland	5	6	11
Midlands	8	6	13
Masvingo	10	9	13
Matabeleland	6	2	4
Total	100	100	100
Tonnes	430,000	310,000	120,000

A : Total Zimbabwe market for all fertilizers.

B : Market for commercial farmers.

C : Market for communal farmers.

Note: The market is made up of approximately:

NPK Compounds	56%
Ammonium Nitrate	38%
Super Phosphate	4%
Potash	2%
	100%

Source: ZFC & WINDMILL

The relative fertilizer consumption by crop is described in Table I-4-21; 61% is by maize which is markedly high, followed in order by winter cereals, tobacco, cotton, etc.

Table I-4-21 Relative Fertilizer Consumption of Principal Crops in Zimbabwe

Unit: %

Maize	61
Winter Cereals	8
Tobacco	8
Cotton	6
Coffee and Tea	4
Sugarcane	4
Potatoes and Vegetables	3
Soybeans	2
Others	4
Total	100

Source: World Bank Report No. 6349-21H; an Industrial Sector Memorandum (1987)

If farmers are guaranteed the purchase of crops and are able to obtain effective fertilizer at low cost, the growth of future fertilizer demand and increased production will be expected.

4.3 Ammonia

Supply and demand situation of ammonia is examined in the following.

4.3.1 World Production and Consumption

The statistics studied by the International Fertilizer Industry Association on the production, domestic demand, and export of major producing nations excluding those in the planned economy region for the period 1985-87 are described in A-Table 4-11.

"Ammonia" in this context refers to anhydrous ammonia, produced for industrial use, nitrogenous fertilizer production, and direct application as fertilizer. This does not include by-product ammonia obtained in the production of coke, caprolactam, etc. "Domestic demand" refers to that captively consumed or domestically transacted for the manufacture of industrial products and for the fertilizer directly applied. "Export" refers only to shipment as anhydrous ammonia, and excludes aqueous ammonia and nitrogenous fertilizer. Export by USSR, a giant exporting nation in world trade, can be referred to in export-import statistics provided later.

According to the above statistics, the 1987 ammonia production was 40 MMTN, of which 5.4 MMTN was exported. Among these exporting nations, Trindad and Tobago and Bahrain have export-oriented production configurations exporting almost all of production; also in terms of quantity, North America is relatively large.

As a middle and long range forecast, the actual operating capacity (maximum supply capacity) of ammonia plants in Table I-4-22, and total ammonia demand forecast in Table I-4-23 are provided, compiled from FAO/UNIDO statistics.

Table I-4-22 Forecast of Actual Operating Capacity for Ammonia

Unit: 1,000 TN

	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	%
Developed countries	31,301	30,617	30,905	31,275	31,453	31,523	31,675	0.20
Developing countries	17,378	18,429	19,135	20,619	21,652	22,414	23,465	5.13
Planned economy countries	41,918	42,734	43,756	44,498	44,733	45,005	45,215	1.27
Total	90,597	91,780	93,796	96,392	97,838	98,942	100,135	1.71

Source: FAO/UNIDO/World Bank Fertilizer Working Group, June 1987

The actual operation capacity (maximum supply capacity) of ammonia plants which was 90 MMTN in 1985/86 have been increasing at an average annual rate of 1.71% and is expected to reach 100 MMTN in 1991/92, and planned economy region including USSR, Rumania, and People's Republic of China is expected to have almost half the world's total capacity in 1991/92 as in the present. The average annual growth rate of developing region in Africa is estimated approx. 17.9%, but this value is questionably high.

Table I-4-23 Forecast of Ammonia Demand in Total

Unit: 1,000 TN

	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	%
For fertilizer use	69,980	71,190	73,460	75,740	77,920	80,110	82,300	2.74
For industrial use	10,278	10,412	10,554	10,645	10,788	10,931	11,074	1.25
Loss, etc.	7,033	7,167	7,358	7,608	7,738	7,836	7,961	2.09
Total	87,291	88,769	91,372	93,993	96,446	98,877	101,335	2.52

Source: FAO/UNIDO/World Bank Fertilizer Working Group, June 1987.

Approximately 80% of the total world ammonia demand is for fertilizer and at an approx. average annual growth rate 2.52% it is expected to reach 101 MMTN, including 82 MMTN for fertilizer, in 1991/92, which is higher than actual operating capacity.

The forecast of increases in the world's ammonia facility capacity and its breakdown by region are described in Fig. I-4-6 and Table I-4-24.

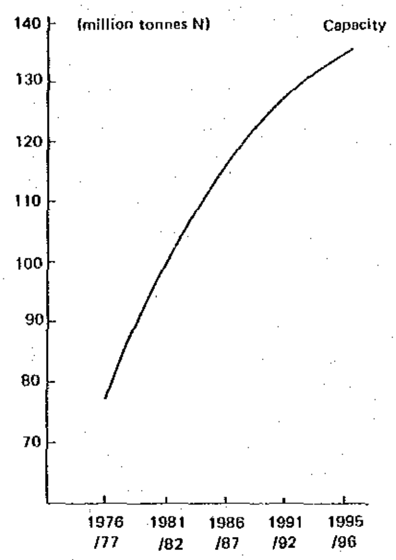


Fig. I-4-6 World Ammonia Capacity

Table I-4-24 Ammonia Capacity by Region

	1986/87	1990/91	1995/96
Western Europe	14,893	15,402	15,717
Eastern Europe	38,439	39,535	40,636
Africa	3,416	3,916	4,554
North America	17,338	17,656	17,656
Central America	3,875	5,143	5,143
South America	2,154	2,726	3,576
Asia	37,016	41,858	47,132
Australia and Oceania	581	606	1,461
World Total	117,712	126,842	135,875

Source: NITROGEN No.167, May/June 1987

An 18 MMTN increase is forecast in the ammonia plant capacity for the entire world from 1986/87 to 1995/96, and 10 MMTN, or over half of the increase is by the Asian region including India, People's Republic of China, Saudi Arabia, and Qatar. The plant capacity increase in Africa for sufficing the region's demand increase is estimated 1.1 MMTN, at an annual growth rate of 3.2%, according to this reference. This is based on expansions in Algeria, Egypt, and Nigeria, which, excepting Algeria, are oriented for the domestic demand with downstream plants.

In view of the entire balance of ammonia supply and demand, the world ammonia production capacity and market which grew rapidly from the mid-1970s to the mid-1980s is presently at a turning point. That is, due to the supply surplus and price drop of products resulting from Eastern Europe, Middle East, and Asian nations entering the market, the plant capacity since 1979/80 had to be cut by 5% in Western Europe, 17% in the U.S.A., and by over one-third in Japan. Consequently, a 5 MMTN capacity reduction had to be implemented. Installation of new plants has been slower than the annual 4% rate of the 1970s, and even if all new plants planned by 1991/92 are realized, the growth is expected at only a low rate of 2% annually. Considering the above rate of completion, the estimated net increase of ammonia production capacity for 1991/92 is 1 MMTN/Y.

Further, the installation of export oriented ammonia plants for the export of ammonia has decreased recently. For instance, six ammonia plants were commissioned in the world in 1987 and the total plant capacity increased 2,080 KTN/Y. Of this, only 407 KTN/Y of NAFCO of Saudi Arabia was for export; plants in Netherland and Algeria were substituting for plants shut down; 271KTN/Y of NAFCON of Nigeria and plants in China and India are part of comprehensive plans for furnishing downstream products, urea and NPK fertilizer, respectively. Similarly, although 4 plants were scheduled for commissioning with total capacity 1,362 KTN/Y in 1988, only the Trinidad and Tobago plant of 359 KTN/Y is export-oriented and the two plants in India and one in Bangladesh were provided with downstream urea plants.

The forecast on ammonia capacity increase by 1991/92 resulting from new plants is 5 MMTN/Y; Asia accounts for a large proportion with 2.4 MMTN/Y in China and 2.2 MMTN/Y in India, and downstream production are planned in both nations. Restructuring including plant shutdowns are expected to continue in Western Europe and the U.S.A.; however quantitative estimates are difficult to establish from data which do not reflect long-term plans. USSR have no plans of installing new plants. However, there are plans to modernize (increase capacity by renovation) existing facilities over the next two years, resulting in an estimated 4% increase of installed capacity and approx. 1.1 MMTN/Y increase. This is seen to slowdown the export momentum of the USSR and induce the recovery of the ammonia market.

On the other hand, in view of ammonia consumption, even if the recovery of fallowed crop land in North America is impossible, a stabilization of consumption is foreseen. Further, a forecast cannot be made for Western Europe because of the EEC agricultural controversy, and a steady consumption growth is generally forecast for a number of years in Asia including India and China. A description from NITROGEN, No. 170, 1987 follows.

"Overall, nitrogenous fertilizer consumption is forecast by the FAO to grow by about 3% a year, with high rates of growth in Asia and Eastern Europe, offset by more moderate growth in Latin America and Oceania, and scarcely increased demand in North America and Western Europe".

Consequently, FAO forecasts that the global balance of nitrogen supply potential and consumption will change from the present 2.7 MMTN/Y surplus to a 700 KTN/Y shortage in 1991/92. The world ammonia production pattern is expected to continue shifting, from the current 27% ratio for total capacity in North America and Western Europe, and 32% ratios for Eastern Europe and Asia, respectively, to a change as described in Fig. I-4-7.

Africa, in particular, is expected to steadily increase production capacity.

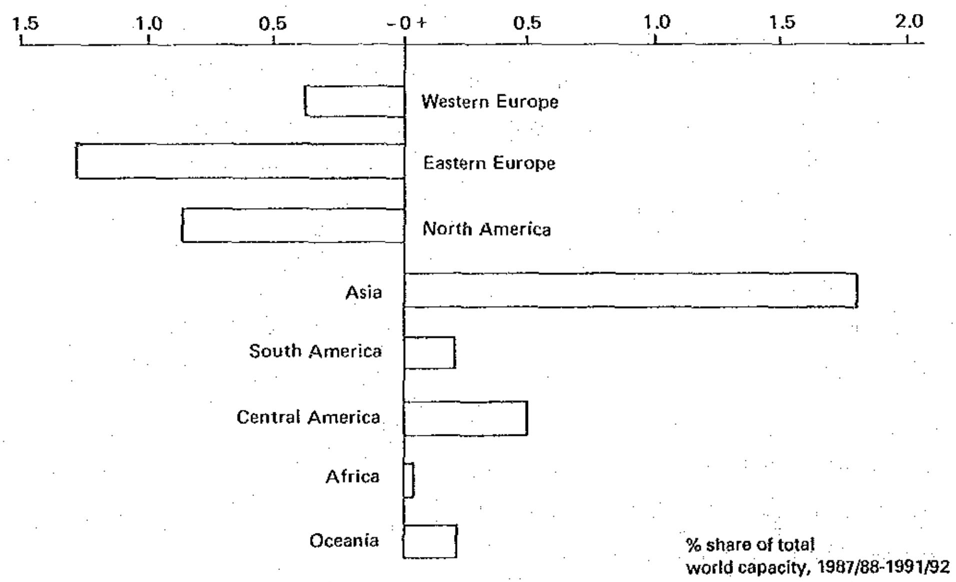


Fig. I-4-7 Expected Change of Ammonia Capacity by Region

4.3.2 Imports and Exports

Ammonia import-export statistics by region in 1987 excluding planned economy region according to International Fertilizer Industry Association data are described in A-Table 4-12. The exports of USSR, a major exporting nation, compiled from totaling values of importing nations according to the above data are described in A-Table 4-13. As a result of totaling statistics from both data, ammonia trade in 1985 was 6.8 MMTN; in 1986, 6.2 MMTN; and in 1987, 7.2 MMTN.

Imports and exports by region are summarized below. Southeast Asia imported 570 KTN, a rapid ten-fold increase compared with 60 KTN in 1980. In the South Asian region, India imported 340 KTN, which also is over a ten-fold increase in ten years, and when the DAP plants presently under construction become operational, it will reach 500~600 KTN/Y. In the Mediterranean region, Turkey imported 570 KTN; and Spain, 420 KTN; they are both consistently high-quantity importing nations. There has been a large increase in the African region from 190 KTN in 1986 to 330 KTN, due to the import increases in Morocco, Senegal, and South Africa.

The United States has dual characteristics of an importing and exporting nation, although in terms of balance, it imports 740 KTN. That is, it imports almost the total amount which Canada exports, in addition with imports from Trinidad and Tobago, amounting to 1,510 KTN, while exporting 770 KTN.

Majority of exports come from the Eastern Europe particularly USSR and Rumania, having their own exporting ports on the Baltic and Black Seas. This region's exportable surplus is approx. 2 MMTN/Y (of which USSR accounts for 1,730 KTN).

Total export of the Middle Eastern region is 870 KTN, and in the 1990s the exportable surplus is expected to reach 1.4 MMTN/Y. In North America, Canada exports 1,110 KTN, most of it going to the United States. In the Caribbean region, Trinidad and Tobago has ammonia plants specifically for export and has exported 870 KTN.

4.3.3 Price Trends

A thesis was presented by Mr. P. L. Louis at the International Fertilizer Industry Association's Raw Materials Committee Meeting which was held in Sevilla, Spain in November, 1987. It is outlined as follows: "At present, the world's ammonia production is 100 MMTN/Y, 7 MMTN/Y of which was traded internationally in 1986. A trade quantity, 7% of total production, can be considered very little and the supply quantity could have been far greater than such a small quantity for demand fulfillment, well the fact was only a fraction of total ammonia production was traded. Also, from a different point of view, 7 MMTN/Y trade is vulnerable to problems that can arise in both production side and demand side." It goes without saying that price fluctuates erratically for a product only a small portion of which constitutes trade. In addition, with a limited number of exporting nations, and almost 40% of supply coming from the Eastern European region, primarily USSR, the product's price was determined by circumstances not conducive to the principles of free trade. This is apparent in the past trends of ammonia prices: in 1974 after the first Oil Shock, the price shot up to US$570 /T FOB, but in the following two years, in which new plants began operation, it crashed to US$100/T FOB. It gradually recovered to US$200/T FOB range toward 1981, but as a result of the agricultural recession in the first half of the 1980s, the international market continued in a slump. In 1987, the price began to rise due to such factors as suspended exports from the Eastern European region including USSR, due to a cold wave.

There are additionally several factors that are very difficult to forecast which influence the fluctuation of ammonia prices. One of them is of course price of crude oil. However, the percentages of variable cost comprising of naphtha, natural gas, etc., which constitute ammonia production cost vary greatly according to the size, performance, site conditions, etc., of production facilities. There is no exact correlation between ammonia production cost and crude oil price in light of the increase of new large-scale plants which utilize low-priced natural gas as raw material. There is also the effect of agricultural product surplus and market condition on farmers' desire to invest in fertilizer use. Low agricultural-product prices discourage farmers to make investments. Drought and other irregularities of climate results in insufficient purchases of fertilizer. Also, the six to eight-year cycle of ammonia price fluctuation is caused by the causal relationship between investments for plants made according to market forecasts and the effect that products from such plants going on market has on the ammonia market price.

As mentioned above, since the factors influencing ammonia market price are intricately interrelated, it is not simple to estimate future prices. There is one reliable attempt, the World Nitrogen Survey, 1986 conducted by the World Bank. In it, some regions in the world that have potential for ammonia plants construction are hypothesized. The total capital cost comprised of plant construction cost and off-site plant cost, etc. based on site conditions, is calculated for each region. Based on the capital cost, raw material cost and others, ammonia production cost is calculated. Next, internal rate of return is taken into account and the realization price is calculated. The future price is estimated from this, with the assumption that price will be determined by the market.

In a price forecast up to 1995 based on the method above for site-designation in three representative regions, US Gulf, Western Europe, and Middle East, the following are some of the conditions assumed.

The balance of nitrogen demand and supply will be restored in 1989/90. Even if numerous new plants start operation, no large surplus would be produced in the following five-year period.

Eastern Europe is not expected to export large quantities of low-priced nitrogenous products as in the early part of the 1980s. In other words, a normal market atmosphere would prevail when there is a balance between demand and supply, so the state of balance reached in late 1980s is expected to continue for several years.

The range of crude oil prices is designated between 17~21 US$/bbl; a 3%/Y consumption growth rate is assumed for nitrogenous fertilizer, and 1,000T/D is assumed as standard ammonia plant size.

The ammonia price forecast for the period 1990-1995 is described in Table I-4-25.

Table I-4-25 Ammonia Price Forecast

Unit: US$/T FOB

	Low forecast	Average price forecast	High forecast
U.S. Gulf	180	210	235
West Europe	185	215	240
Arabian Gulf	183	213	235

Source: Chemical Economics Aug. 1988

4.3.4 Zimbabwe's Internal Situation

(1) Ammonia Import

In Zimbabwe, SABLE produces ammonia by waterelectrolysis. It is currently operating its 76,000 T/Y facilities at full capacity, and the recorded highest annual production is 78,652 tonnes. Although almost all of this ammonia is utilized for production of nitric acid and ammonium nitrate, because the capacity of the ammonia plant is small in comparison with that of the nitric acid/ammonium nitrate plant, the deficit ammonia is continually imported.

The total import amounts and quantities are described in the following tables. The amounts are export-nation FOB prices, and the IMF Average Exchange Rate was applied in converting the import amounts (Z$) totaled by the nation's Central Statistics Office into U.S.$.

Table I-4-26 Average Exchange Rate

Unit: Z$ per US$

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0.629	0.677	0.680	0.643	0.689	0.757	1.011	1.244	1.612	1.665	1.661

Source: IMF, International Financial Statistics.

Table I-4-27 Import of Anhydrous Ammonia

Unit: 1,000

Year	Amount	
	Z$	US$
1978	1,735	2,563
1979	1,369	2,013
1980	4,231	6,580
1981	6,755	9,804
1982	9,327	12,321
1983	6,029	5,963
1984	6,666	5,359
1985	6,089	3,777

Source: Statistical Yearbook of Zimbabwe 1987

Table I-4-28 Ammonia Import

Year	Quantity (T)	Z$1,000	US$1,000	Unit price (US$/T)
1983	506,303	6,130	6,063	–
1984	593,543	6,788	5,457	–
1985	18,711	6,090	3,778	201.9
1986	34,421	9,995	6,003	174.4
1987	19,055	5,553	3,343	175.4

Source: Information from Central Statistical Office

Note: It is assumed that the volume of imported ammonia in 1983 and 1984 has statistical errors.

(2) Domestic Demand

Most of ammonia in the domestic market is consumed as raw material for producing fertilizer, and SABLE exclusively processes ammonia into ammonium nitrate and ships it as final product or as intermediate for producing compound fertilizer. Ammonia is also used in small quantities by WINDMILL and ZFC in the granulation process of producing compound fertilizer (see A-Fig. 4-7). The ammonium nitrate plant capacity of SABLE is 245 KT/Y, and SABLE achieved a production record of 244,200 KT/Y in the past, but normally produces at a rate of 220-240 KT/Y. The quantity of ammonia required by this production is 101-111 KT/Y. SABLE's statistics on ammonia and ammonium nitrate, although somewhat dated, are described in Table I-4-29.

Table I-4-29 Ammonia and Ammonium Nitrate of SABLE

Unit : T

	1981	1982	1983	1984	1985
Produced ammonia	72,000	74,000	72,000	70,000	n.a.
Imported ammonia	31,274	39,696	25,887	24,800	n.a.
Produced ammonium nitrate	225,000	243,000	243,000	198,000	206,000

Ammonia requirement for producing compound fertilizer is 0.9-1.0 KT/Y in the case that the 250-280 KT/Y of compound fertilizer is produced as shown in A-Table 4-14 (1) ~ (4).

The largest ammonia demands for industrial use other than for fertilizer is for 16-17 KT/Y of ammonium nitrate for use in explosives, which is equivalent to 8.5 KT/Y of ammonia. This is supplied by SABLE and can not be clearly differentiated from ammonia demand for producing fertilizer and is included in it. 600-700 T/Y of 23% aqueous solution of ammonia is consumed for producing industrial chemicals, another 1,200 T/Y of the above is for H control in mining industry in the highest estimation, about 200 T/Y of anhydrous ammonia is consumed for refrigeration, and other forms of large consumption are not found. In a word, ammonia demand for industrial use is less than 1,000 T/Y excluding the demand for producing ammonium nitrate for use in explosives which is counted in the demand for producing fertilizer.

As mentioned before with regard to ammonia supply, SABLE exclusively operates a 76,000 T/Y ammonia production plant at maximum capacity. Although by-product ammonia from coke ovens is theoretically possible, the ZIMBABWE IRON & STEEL and WANKIE COLLIERY are presently not recovering ammonia. Even if recovery of ammonia is attempted, it is not economically feasible, since ammonia recovered will not be much and the separation of impurities such as phenol would be necessary. Also, 600 T/Y and 200 T/Y anhydrous ammonia could be produced by ZISCO which is producing 40 KT/M of coke and by WANKIE producing 14 KT/M of coke respectively. But these quantities are not viable as potential sources for ammonia supply. Therefore, although SABLE produces ammonia, approx. 30 KT/Y in short is imported, and this imported ammonia is received by SABLE and then distributed domestically.

(3) Distribution Channel and Cost

At present, imported ammonia from the Gulf Coast is unloaded at Richard's Bay approx. 200 km northeast of Durban, South Africa, transported approx. 2,000 km by rail from South Africa to Kwekwe via Beitbridge at the border of Zimbabwe, and stored at SABLE's ammonia tanks. SABLE transports ammonia at a 3,600 T/M rate using 80 ammonia tank cars each with 25.5 tonnes load capacity. Two storage tanks are installed at Kwekwe, each with capacity to store 1,000 tonnes of ammonia at 12.5 bar pressure.

According to the information from SABLE, the desirable price of anhydrous ammonia for SABLE is at most Z$530 at Kwekwe on-rail. This is the ammonia production cost of SABLE as of August, 1988. However, the present production cost must be recalculated in accordance with the latest electricity tariff revised in October 1988 as mentioned in 4.3.5(3).

The imported ammonia price is calculated as shown below.

South Africa, Richard's Bay CIF	318 (Z$/T)
Rail	102
Surtax	84
Unloading, others	30
Total	534 (Z$/T)

Excluding the freight cost, US$25/T, between the Gulf Coast and South Africa, the Gulf Coast FOB price is US$167/T (exchange rate in 1987: 1.661 Z$/US$). Although this is slightly lower than the 1987 FOB price of US$175.4/T shown in Table I-4-28, it is not clear whether this difference is attributable to a result of the bias, from approximate computation of the ammonia price or to basing computation on the low-end of costs. Moreover, the Z$102 /T rail transport cost in calculation above is approximately equal to the Z$101/T cost between Durban and Kwekwe obtained in the study from NATIONAL RAILWAYS OF ZIMBABWE, but since unloading is at Richard's Bay, an amount approx. Z$10/T should be added on.

(4) Ammonia Production by Water Electrolysis

SABLE has produced hydrogen for ammonia production by water electrolysis using electricity which up to now has been in abundance. The high-pressure water electrolysis plant by LURGI process is well-maintained and is operated very efficiently. However, in order to produce 76,000 T/Y of ammonia, 10,300 to 10,500 kWh/T ammonia of electricity is consumed and this shows that at least 100 MW of electricity is necessary. Also, expansion of the plant by water electrolysis process is difficult. Considering that the electricity receiving facility of ZISCO located in the same region is 33 MW, 100 MW is a large quantity relative to the electricity supply of this area. New power plants will be needed sooner or later in Kwekwe, since the demand of electricity will grow due to the future industrial promotion and household demand caused by the population increase. Saving the quantity of electricity presently consumed largely for producing ammonia by changing ammonia production process from water electrolysis to coal utilization and to use the saved electricity for the future electric demand increase would be highly advantagenous.

Up to now, although it was small-scale, ammonia production was feasible at a production cost competitive with imports due to low electricity tariff. However, electricity cost which is over 60% of ammonia production cost as of August 1988 is expected to further drive it up in view of the electricity tariff revision probable in the future. Therefore the price of domestic nitrogenous fertilizer will exceed international prices, resulting in a situation unfavorable to the national economy.

On the other hand, by the application of coal gasification process, the production cost of ammonia is lowered by the low material cost. The price of domestic nitrogenous fertilizer then will be maintained at a reasonable range. Also, even if there is coal price increase in the future, the raw material cost increase is small compared to the electricity cost increase of water electrolysis, and consequently the increased added value to Zimbabwe by ammonia production would be large.

4.3.5 Forecasts

(1) Past Studies

There have been various reports forecasting Zimbabwe's fertilizer demand. According to the Mini-Fertilizer Plant Projects (Dec. 1983) report by UNIDO, the estimated demands of N and P_2O_5 in 1990 are 130,000 tonnes and 57,000 tonnes, respectively; and in year 2000 is 184,000 tonnes and 115,000 tonnes, respectively. This data was computed by multiplying the 1980/81 consumption quantities of N, 85,000 tonnes; and of P_2O_5, 45,000 tonnes with the respective annual growth rates; N, 4.0%; P_2O_5, 4.8%.

According to MONTAN-CONSULTING GMBH (May, 1983), the nitrogenous fertilizer demand in 1990/91 is 115,000 tonnes; 2000/01: 150,500 tonnes; and in 2010/11: 220,000 tonnes.

The UNDP report estimated consumption for years 1995, 2000, and 2020, by applying a 3% and 4% annual growth rate on the following three base years, respectively: 1980/81 and 1981/82, when there was no drought nor restrictions on fertilizer import, and 1984/85, when fertilizer consumption stagnated due to increased stockpiles of maize, as described in the following table.

Table I-4-30 Forecasts of Planned Nutrient Consumption per Year Summary

Unit: 1,000 T

Base year	Yearly growth rate, percent	Base years			*	1995			*(4)	2000			*(4)	2010			*(4)
		N	P_2O_5	Total	Specif. consum. kg/ha	N	P_2O_5	Total	Specif. consum. kg/ha	N	P_2O_5	Total	Specif. consum. kg/ha	N	P_2O_5	Total	Specif. consum. kg/ha
1980	3	86.21	47.89	159.45	(1) 93.50	139.33	89.61	248.49	92.01	155.73	86.50	255.02	106.67	209.30	116.25	327.10	193.37
1980	4					162.36	86.23	287.13	106.34	194.43	104.21	349.23	129.38	292.00	155.27	517.02	191.49
1981	3	99.70	46.43	174.39	(2) 80.35	150.82	70.23	263.80	97.70	174.85	81.42	305.23	113.27	235.00	109.43	411.03	151.23
1981	4					176.17	80.39	301.95	111.83	215.89	97.80	367.36	136.06	324.23	144.76	543.74	201.39
1984	3	71.45	37.61	133.40	(3) 60.65	99.91	52.66	189.71	68.71	114.67	60.36	214.14	79.31	154.19	81.16	287.94	106.64
1984	4					111.75	57.89	205.38	76.07	136.95	70.43	279.83	92.55	205.67	104.25	369.87	137.60

Notes: * Specif. consum. kg/ha = Specific total nutrient consumption in kg/ha
(1) Planted area : 1,705,427 hectares
(2) Planted area : 2,170,271 hectares
(3) Planted area : 2,200,000 hectares (assumed)
(4) Arable land : 2,700,000 hectares

Source: UNDP report, Dec., 1987

In this case, the value of 2.7 million ha was used for the area to be fertilized calculated on the basis of the arable area of large-scale commercial farmland. In this report, it is assumed that the annual production of anhydrous ammonia is 200 to 300 KT NH_3/Y, i.e., 164 to 246 KT N/Y. The former values are the equivalent of 600 T/D ammonia, which is considered minimum capacity in terms of size of equipment, production costs, and projected nitrogenous fertilizer demand. This projected demand corresponds to the value resulting from applying a 4% annual growth rate on 1980/81 as base year. On the other hand, the latter value corresponds to 900 T/D ammonia, and this case is considered medium scale and economically more advantageous than the case of 600 T/D.

(2) Demand Forecast

1) Background of future fertilizer demand increase

The First Five-Year Plan shows the direction for Zimbabwe's economic development and policies of recommended measures. This plan is highly praiseworthly in that it aims at achieving a balanced agricultural production structure. It states policies to maintain the high productivity of large-scale commercial farming sector while gradually boosting the productivity of communal farm in order to increase the relative importance of communal farming in total agricultural production quantity. It also states to promote resettlement to the communal farm. In this study estimation of the ammonia demand in 1995/96 is made assuming that the above government policies are continued in the same way from 1990 through 1995 and the government measures for communal farming and resettlement lands are successful. Prior to the estimation, the condition of agriculture in Zimbabwe will be reviewed.

Commercial farms implement intensive farming procedures, using large volume of fertilizer and shipping most of production to the market, thereby making a very important and large contribution to agriculture of Zimbabwe. Commercial farming is expected to continue maintaining a major role, but large increase in fertilizer consumption in the future is not probable. However, some increase in fertilizer consumption by commercial farming can be expected in order to increase production and to cultivate more productive crops.

Conversely, the activities of communal farming which supports the livelihood of many farmers is by no means unimportant, but it has not made up to now large contributions in terms of distribution of products on the market.

The government, however, is promoting communal farming as well as a resettlement programme to reduce over-crowding and to settle landless farmers. Although limited, resettlement land is gradually increasing, reaching 170,000 ha in 1987/88. In order to increase production, irrigation systems are expanded and agricultural materials such as fertilizer and pesticides are produced. The government is allotting precious foreign currency for importing agricultural materials.

As a result of realization of these policies, in recent years, the agricultural products sold by communal farming sector to the outside market are increasing. As described in Table I-4-31, the amount of agricultural products sold to AMA by communal farming sector has increased remarkably; in comparison with a 1.2 fold growth (139.6/117.1) in own consumption in the period 1980-1984, the sales to AMA grew 4.4 fold (128.2/28.9). This indicates the productivity of the communal farming has increased. It is attested by the fact that in the period 1980-1984, the gross agricultural output of the commercial farming sector increased 1.74 times while in the same period, that of the communal farming sector increased 1.83 times.

Table I-4-31 Gross Agricultural Output (1980-1985)

Unit: Million Z$

Year	National gross output at current price	Communal land			Commercial areas
		Sales to marketing authorities	Production for own consumption	Total	Gross output at current price
1980	711.5	28.9	117.1	146.0	565.5
1981	1,021.5	79.5	185.1	264.6	756.9
1982	1,080.0	84.6	186.7	271.3	808.7
1983	969.1	68.7	97.8	166.5	802.6
1984	1,250.0	128.2	139.6	267.8	982.2

Source: Central Statistical Office

The production of communal farming is expected to continue growing rapidly supported by government policies and guidance, and the consumption of fertilizer by this sector is expected to rise very rapidly.

2) Premises for demand forecast

Since the plant is expected to be in full operation in 1995/96 in case this project is implemented, the nitrogen requirement in 1995/96 shall be forecasted. Premises for this estimation are shown below.

① Growth rate of agricultural production

A 5%/Y growth rate of agricultural production is planned in the First Five-Year Plan. Therefore, this growth rate is applied in this study.

② Increase of planted area

According to A-Table 4-18 Development of Fertilizer Industry in Zimbabwe, UNDP, 1987, the increase of planted area is projected as follows.

1.71 MM ha (1980) → 2.12 MM ha (1983)
Growth rate: 7.4%/Y

The projection described in A-Table 4-3 based on CSO information (August 1988) is as follows.

1.71 MM ha (1980) → 2.61 MM ha (1988/89)
Growth rate: 5.4%/Y

A 5%/Y growth rate is applied in this study, slightly conservative compared to growth rates above.

③ Planted area estimated in 1995/96

The planted area in 1995/96 is projected as follows.

$$2.61 \times (1.05)^7 = 3.67 \text{ MM ha}$$

A 3.50 MMha planted area in 1995/96 is estimated in this study, applying again a conservative value.

Of the above, 0.60 MMha is estimated for planted area of commercial farming, based upon the following considerations.

The planted area in the period 1980-1983 is 0.483-0.601 MMha, according to A-Table 4-18. The planted area in the period 1985/86-1988/89 is 0.552-0.613 MMha, according to A-Table 4-3. In view of these values and assuming the planted area is to remain constant in the future, the planted area of commercial farming in 1995/96 is estimated 0.60 MMha. Therefore, the planted area of communal farming is estimated 2.90 MMha.

④ The percentage of nitrogen in total nutrients

The nitrogen percentage in total nutrients is 0.54 according to A-Table 4-10 and Table I-4-19.

⑤ Increase of nitrogen dosage

Prior to estimating the increase rate of nitrogen dosage, the current dosages by agricultural sector are analyzed.

The following is discerned from Table I-4-19.

Total sales in nutrient tonnes : 153,844 T

The following is discerned from Table I-4-20.

Fertilizer consumption	Commercial Farming Sector	310 KT/Y
	Communal Farming Sector	120 KT/Y
	Total	430 KT/Y

The planted area is as follows according to A-Table 4-3.

Commercial Farming Sector	478,462 ha
Communal Farming Sector	1,811,996 ha

Consequently, the nutrient dosage per ha is calculated as follows.

Commercial Sector

153.8 KT x 310/430 = 110.9 KT
110.9 KT/478.5 Kha = 0.232 T nutrients/ha

Communal Sector

153.8 KTx 120/430 = 42.9 KT
42.9 KT/1,812 Kha = 0.0237 T nutrients/ha

In other words, the quantity of nutrients applied by the communal farming sector is 1/10 of the commercial farming sector.

Next, the increase rate of application of nitrogen is estimated as follows. A 2%/Y rate of increase is forecast for the commercial farming sector. The application rate of communal farming sector is 1/10 of the commercial farming sector at present, however, it is estimated to expand to 1/5 of the commercial farming sector by 1995/96.

The assumptions above are justified by the description stated below. Refer to the appendix for details.

3) Demand forecast

The nitrogen requirement in 1995/96 is estimated as follows.

① Approach 1

In conducting a demand forecast, the standard application volume of fertilizer is first examined, the future target level is studied, then the target application volume is forecast with respect to this future target level.

Standard application quantity

The large-scale commercial farming sector's fertilizer application rates per ha by crop has been described in Table I-4-16, making a distinction between basal application (by volume of compound fertilizer) and top dressing (by volume of ammonium nitrate). The ratio of fertilizer consumption volumes by crop has been also described in Table I-4-21.

The ammonium nitrate demand is 324.45 kg/ha computed by calculating the weighted average of the top dressing per ha from the above values.

Plant -Crop	Relative fertilizer consumption of the principal crops in %		Top dressing LSCF Sector N as AN kg/ha	Weighted specific consumption AN kg/ha
Maize	61		380	231.8
Wheat	8		450	36.0
Tobacco	(B) 4%	Virginia	75	3.0
	4%	Burley	300	12.0
Cotton	6		150	9.0
Coffee &	(4) 2%	Coffee	300	6.0
Tea	2%	Tea	220	4.4
Sugarcane	4		475	19.0
Potatoes &	(3) 1.5%	Potatoes	150	2.25
Vegetables	1.5%	Vegetables	1,000	15.0
Soybeans	(4) 2%	Soybeans	100	2.0
and others	2%	Assumed	150	3.0
Total				324.45 ANkg/ha

N content in AN (SABLE production) : 34.5% by weight

Specific consumption in kg N/ha : 324.45 x 0.345 = 111.935 kg N/ha.

Source: UNDP report 1987

In other words, most of the nitrogenous fertilizer comsumed as straight fertilizer is top dressing, amounting to 324.5 kg/ha of ammonium nitrate, or 111.9 kg/ha in N equivalent.

The Chemistry and Soil Research Institute of MLARR established the recommended dosage of fertilizer for general crops as 100 kg N/ha during periods of little rain and 120 kg N/ha during periods of abundant rain, or 110 kg N/ha on the average.

On the other hand, according to the Fertilizer Yearbook (1985) of FAO the fertilizer application volume of farmlands of the world are as follows.

Unit : kg/ha

Region	N	P_2O_5	K_2O	Total
World average	47	22	17	87
European average	111	57	60	228
Asian average	60	19	7	85
African average	11	7	3	20
Zimbabwe	34	14	9	57

Source: FAO Fertilizer Yearbook 1985

As described above the nitrogen application of Zimbabwe's large-scale commercial farming sector reaches the application standard. But the national average for the nitrogen application per ha is only 34 kg. Although this value is much higher than the average for Africa, it is only approx. half of the Asian average, and one-third of the European average. The 111.9 kg N/ha of Zimbabwe's large-scale commercial farming sector and 100-120 kg N/ha recommended by the Chemistry and Soil Research Institute are equivalent to Europe's average nitrogen application volume.

In order to increase agricultural production in Zimbabwe to a stable maximum level, it is necessary to apply the standard application volume of nitrogen fertilizer specified by the Chemistry and Soil Research Institute. To apply 110 kg of N per ha it is necessary to apply a total of 385,000 TN/Y of nitrogen to the total planted area of 3.5 MMha.

However, the quantity is approx. three times of present consumption, and is considered the ideal fertilizer application quantity. Consequently it is not possible to reach this level in a short period. Approximately half of this volume, approximately 190,000 TN/Y, is regarded as an suitable target level for the near future.

② Approach 2

According to Table I-4-30, Development of Fertilizer Industry in Zimbabwe, UNIDO 1987, the estimated fertilizer nutrient consumption per ha in 1995 is, in the highest case, 111.8 kg; and in the lowest case, 68.4 kg.

A 100 kg/ha of nutrient is regarded as suitable and this volume is adopted in this study. Consequently, the nitrogen requirement in 1995/96 is:

$$0.100 \text{ T/ha} \times 0.54 \times 3.5 \times 10^6 \text{ ha} = 189{,}000 \text{ TN/Y}$$

③ Approach 3

Based on the assumption mentioned above, when the growth rate of fertilizer application per ha of the commercial farming sector is assumed as 2%/Y, the nutrient dosage per ha in 1995/96 is:

$$0.232 \text{ T/ha} \times (1.02)^9 = 0.277 \text{ T/ha}$$

Assuming one-fifth of the above value, the nutrient dosage per ha in the communal farming sector is calculated as follows.

$$0.277 \text{ T/ha}/5 = 0.056 \text{ T/ha}$$

Consequently, the nitrogen requirement in 1995/96 is:

$$0.277 \text{ T/ha} \times 0.54 \times 0.60 \text{ MMha} = 89{,}748 \text{ TN/Y}$$
$$0.056 \text{ T/ha} \times 0.54 \times 2.90 \text{ MMha} = 87{,}696$$

177,444 TN/Y

4) Conclusion

Among approaches described above, the results of Approach 2 and Approach 3 founded on careful scrutiny are summarized as follows.

	Approach 2	Approach 3	Conclusion	
NT/Y	189,000	177,400	180,000	
NH_3T/Y	229,500	215,400		200,000

In this study, the demand for nitrogen in 1995/96 is estimated 180,000 T/Y, and for ammonia, estimated slightly conservatively at 200,000 T/Y.

(3) Price

As described above, the forecast of ammonia prices is extremely difficult due to the complex interrelation of various factors with their various probabilities.

The 1987 ammonia prices will be reviewed. The freight cost of ammonia tankers is described in Fig. 1-4-8.

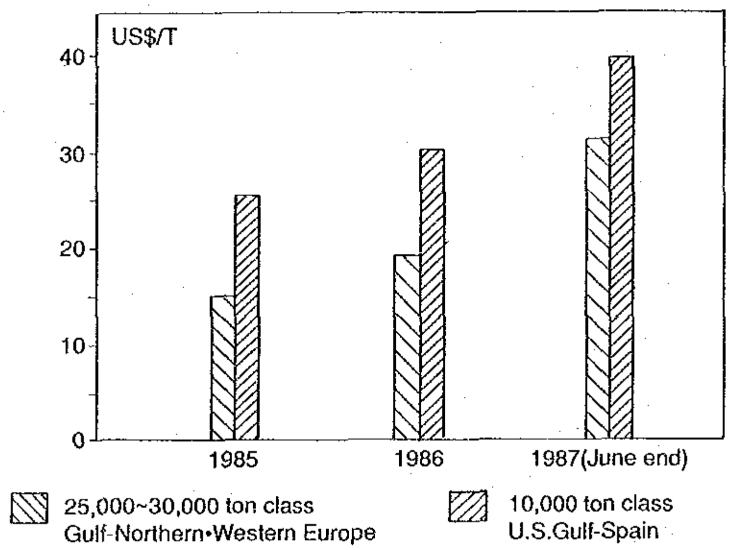


Fig. I-4-8 Trans-Atlantic Freight Cost of Ammonia (Estimate)

As described in A-Fig. 4-1 and A-Fig. 4-2, the 1987 ammonia prices did not recover from the prices crashing to rock-bottom of the previous year. The 1987 FOB prices of ammonia in the area of US Gulf and Caribbean-region are reviewed in the followings. Values should be given as weighted averages, but since supporting transaction data for the respective price ranges is not available, the simple average of monthly prices for the above year was calculated. The result was US$106/T, with a high of US$125/T. The freight cost of 10,000 DWT-class ammonia tankers crossing the Atlantic in the above year was approx. US$40/T. The price fluctuations over a longer period, from 1982-1987, indicates the ammonia supply constantly exceeded demand and due to the surplus of agricultural products the ammonia market was declining. The simple average of monthly US Gulf and Caribbean FOB prices was US$137/T, and the mode price range was US$160-170/T.

The freight, that is the difference between the simple average of monthly northwestern Europe C & F prices during the same period, US$161/T, and US$137/T above calculated, was US$24/T. The ammonia price fluctuated erratically due to market situations during this period, but price increase or decrease caused by structural price variations were not observed.

The issue at hand is the Zimbabwe's domestic ammonia prices. This market study postulates the 1988 ammonia price as follows, based on the results of domestic market with consideration of the world market outlined above. The prices used in the study are the Kwekwe on-rail price and the price at the border with South Africa. The unit is U.S. $ and a Z$1.8 = US$1 exchange rate is applied for domestic costs.

Unit: US$/T

	Kwekwe on rail	Cross Border
Ammonia FOB price	175	175
Freight	30	30
Rail	62.2	44.4
Surtax	53.4	—
Others	16.7	16.7
Total	US$337.3/T	US$266.1/T

The ammonia FOB price is based on the data of the 1985-1987 import statistics shown in Table I-4-28 and freight is based on a slightly low value abstracted from the 1987 rate in Fig. I-4-8. Rail cost is Z$112, the value in the case of unloading at Richard's Bay.

It should be noted that in the case ammonia from coal is produced in Kwekwe, US$337.3/T can be applied as it is as the substituting price of product for import, but in the case ammonia is produced at Hwange, the Z$32.51 (US$18.1) transportation cost between Hwange and Kwekwe must be deducted. Consequently, for ammonia which is to be transported to Kwekwe, the substituting price of product for import is estimated as 337.3 - 18.1 = US$319.2.

Also, the substituting price of ammonia produced by SABLE for import is estimated as follows: the Z$530/T production cost as of August 1988 is added with Z$153/T net increase of variable cost due to increased electricity cost resulting from the recent revision of electricity tariff:

530 + 153 = 683 Z$/T → 379.4 US $/T.

Then, from this revised, up-dated production cost, Z$32.51/T (US$18.1/T) Hwange-Kwekwe transportation cost is deducted:

379.4 - 18.1 = 361.3 US $/T

The increase of variable cost due to electricity cost up is described in A-Fig. 4-17.

Summarily, the ammonia prices at 1988 constant price are as follows.

Coal-based ammonia	Kwekwe consumption portion		Hwange consumption portion
	portion replacing domestic product	portion replacing imports	increase
Plant site	76,000 T/Y or less	76,000 T/Y ~ 99,000 T/Y	over 99,000 T/Y
Kwekwe	US$379.4/T	US$337.3/T	——
Hwange	US$361.3/T	US$319.2/T	US$337.3/T

The 1995 ammonia price is subsequently estimated, applying the US Gulf case from the low forecast stated in World Nitrogen Survey, 1986 of the World Bank; freight cost is based upon the 1987 statistics of trans-Atlantic routes.

US Gulf FOB price	US$80
Freight	US$40

The current condition of ammonia production surplus is expected to change into a situation of a slight supply shortage. Even in the case that consumption does not increase so much, the present surplus situation will disappear and supply-demand will balance. It is assumed that there will be no exports from the Eastern European countries at dumping prices nor the drastic increase of energy prices. The US Gulf FOB price is described in terms of 1986 constant prices; if the USA GDP deflator keeps the present 5%/Y through this period, the 1995 nominal price of US$280/T is probable. The freight cost estimated at US$40/T should be adequate as the 1995 nominal price. The changes in rail cost and other domestic costs are especially difficult to estimate since they are regulated by the state policy. However, if the increases of such costs as rail cost are directly or indirectly related to the GDP deflator, presently 13%/Y, they will probably be absorbed by a relative US $ appreciation, so they will not be revised. A 20% surtax will be applied consistently with respect to ammonia. From the above, 1995 nominal price is as follows.

Ammonia FOB price	280 (US $/T)
Freight	40
Rail cost	62.2
Surtax	76.4
Others	16.7
Total	475.3 (US $/T)

4.3.6 Determination of Production Capacity

In the demand forecast, Zimbabwe's 1995/96 ammonia requirement is estimated at 200,000 tonnes. Therefore, ammonia plant capacity of 600 T/D is recommended with regard to the implementation of this project. In this case, ammonia production amounts to 600 T/D x 330 = 198,000 T/Y.

The report, Development of Fertilizer Industry in Zimbabwe, prepared by UNDP, recommends the construction of a 900 T/D capacity ammonia plant, recognizing that this implies a postponement of implementation.

In this report, it is assumed that the plant construction is completed by 1993, and the recommended ammonia plant capacity is 600 T/D. This proposal has the great advantage of Zimbabwe rapidly supplying itself with sufficient amount of nitrogenous fertilizer.

4.4 Urea

4.4.1 World Supply and Demand of Urea

A-Table 4-19 descirbes the record of world production and consumption of urea for the period of 1984/85 - 1986/87. During this period, the world production of urea increased from 26.2 MMT to 28.9 MMT showing a growth rate of 10.4% and consumption of urea grew from 22.7 MMT to 26.4 MMT showing that of 16.2%. Urea is consumed in the production of industrial products such as melamine, isocyanuric acid, urea resin, etc. in addition to fertilizer use. The urea demand for the production of industrial products is estimated to be about 3 MMT, though accurate statistics is not disclosed. Consequently, it is clear that most of the urea produced is consumed as fertilizer. Fig. I-4-9 and Table I-4-32 show the past trend of world urea production capacity.

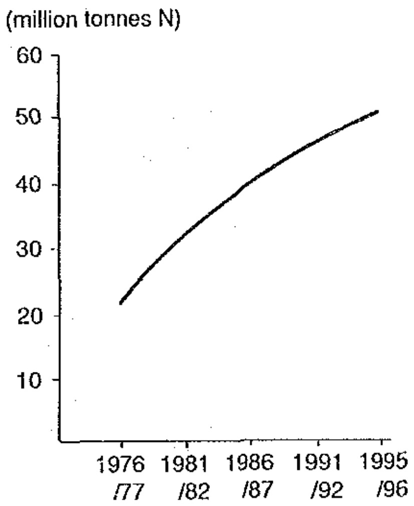


Fig. I-4-9 World Urea Capacity

Table I-4-32 Urea Capacity by Region

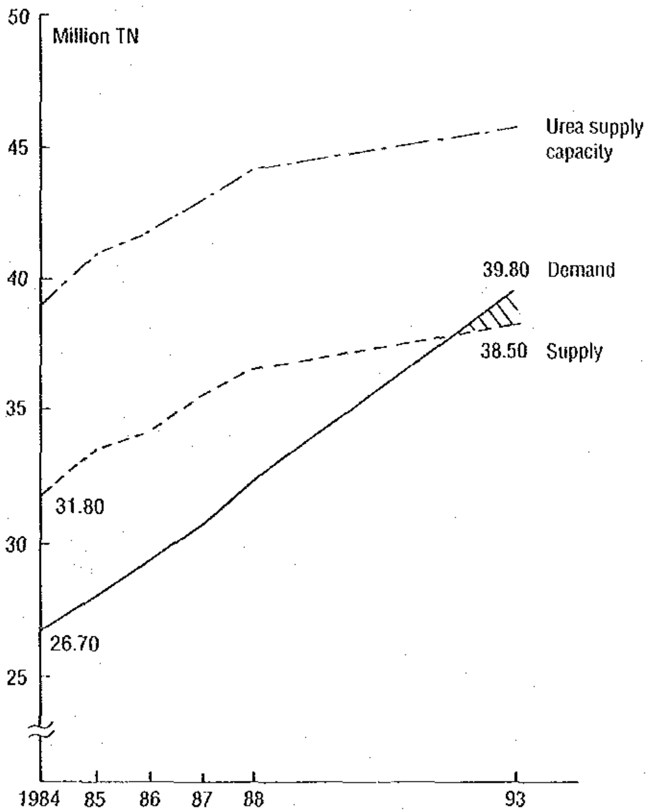
Unit: 1,000 TN

	1986/87	1990/91	1995/96
Western Europe	3,736	3,711	3,803
Eastern Europe	10,029	10,899	11,507
Africa	1,295	1,423	1,423
North America	4,329	4,403	4,403
Central America	1,076	1,759	1,759
South America	1,163	1,425	1,638
Asia	18,642	21,574	25,368
Australia and Oceania	179	376	528
World total	40,476	45,570	50,429

Source: NITROGEN No. 167, May/June 1987

The urea production capacity increased by 19 MMT during the period of 1976/77 to 1986/87. It is forecasted that the capacity will increase by 10 MMT by 1995/96, a growth rate being half that of the last 10 years. This is due to decrease in plans for installation of urea plants except some parts of the world such as Asia that resulted from the price crash of urea that was the consequence of a decrease of agricultural product prices. In Asia, capacity will increase by 6.7 million. Of this estimated increase, installation of new urea plants are decided in India and China with 2 MMT and 1 MMT capacities respectively for meeting each nation's domestic consumption expected to expand. Indonesia plans to install 5 urea plants, increasing urea supply capacity by over 1 MMT. Although this is mainly for meeting domestic demand, Indonesia intends to export urea to make up for the decrease of foreign currency revenues resulting from the fall of crude oil prices. A 1.5 MMT capacity increase is expected in Eastern Europe, most of which are accounted by the modernization/expansion of existing ammonia-urea plants and the construction of several new urea plants. In other regions, such as South America, the capacity increases of 0.5 MMT in Venezuela and 0.2 MMT in Brazil are expected, however in North America and Western Europe, there is almost no increase. In Africa, Nigeria is expected to start production with two plants totaling 0.4 MMT capacity and all of the product will probably be consumed in the domestic market.

On the urea supply and demand balance forecast, Fig. I-4-10 shows the results of a study conducted by the Japanese Ministry of International Trade and Industry (MITI), Chemical Fertilizer Section, in 1987. Increasing at an annual rate of 2.15%, the world urea supply potential in 1984 of 31.8 MMT is expected to reach 38.5 MMT by 1993. The world urea demand in 1984 was 26.7 MMT; however it is expected to reach 39.8 MMT in 1993, growing at a rate of 4.54% greatly exceeding the supply growth rate. As a result, urea supply is expected to be tight in the beginning of the 1990s with a shortage of 1.3 MMT in 1993.



Source: Kagaku Keizai, Jan., 1988

Fig. I-4-10 World Urea Supply/Demand Balance

4.4.2 Urea Trade

Although somewhat dated, the 1984 world urea trade compiled in the study by MITI is described in A-Table 4-20. Fertilizer trade has changed substantially: ammonium sulphate and ammonium nitrate accounted for almost 60% of trade in volume in the middle of 1960 but only for little over 10% at present. On the other hand, urea which amounted to less than 20% in the 1960s currently accounts for approximately 50%. This shows that urea is an important nitrogenous fertilizer in international transactions.

The major exporting regions of urea are Eastern Europe (USSR and Romania), 5 MMT; followed by Middle East (Kuwait, Qatar, and Saudi Arabia), 2.0 MMT; and Netherlands, 1.1 MMT. In North America, the total export quantity of the U.S.A. and Canada is 2.2 MMT, balanced by importation of 2.1 MMT. This means that the U.S.A. is exporting to Asia the equivalent quantity of urea it imports from the USSR and Romania. The major importing region is Asia, specifically China and India; these two nations together account for 7.8 MMT.

As in the case of ammonia, the urea market experienced a price crash in 1986, and prices fell to disposal-level. In 1987 prices gradually rose and trade recovered stability. In the following, some of the features of international transactions in 1987 are discussed. China imported 3.80 MMT according to the government policy for the promotion of increase of cereal grain production. The government supplied 60 kg of fertilizer to farmers for each tonne of grain brought from them and as a consequence, the government reportedly required a large reserve of fertilizer. The supply came mostly from the USSR and Middle East. Conversely, India, a large urea importer, only imported 0.50 MMT in the prescribed year from such nations as the USSR and Romania, in part due to the government policy restricting allotment of foreign currency for urea imports from the previous year. There is question whetehr this restriction on urea imports can remain enforced until operation of India's new ammonia/urea plants. Pakistan was a urea exporter for a time but became an importer again. A quantity of 0.40 MMT of urea was imported from the Middle East and Eastern Europe. This is viewed as a result of the termination of financial assistance toward fertilizer in May 1986, and by the abolishment of restrictions on importation and distribution. It is also noted that Japan imported 0.25 MMT for industrial use, a three-times increase over the previous year, because of the yen appreciation and the reduction of plant capacity of nitrogenous fertilizer industry.

In terms of exports in the same year, USSR remained as the leader with 2 MMT. The nation is less vigorous in urea export than in the previous year. This may be due to, for one thing, the US investigation report on the low import prices of urea from Eastern Europe in 1986. Moreover, the USSR's future domestic urea supply capacity is expected to be 2 MMT/Y at most. Indonesia is expected to significantly decrease exportation compared with 1.5 MMT in 1986. This is in view of the government's policy of prioritizing domestic demand, as exemplified by the ban on exports from November 1986 to March 1987, and the high probability of such measures being adopted in the future.

4.4.3 Price

The international urea market is characterized by the limited number and large requirements of importing nations. Consequently, market conditions are influenced significantly by movements of large, importing nations. Urea prices in 1986-1987 are a prime example. In 1986, due to the largest buyer, India, withdrawing from the market and China restricting purchases, as described in A-Fig. 4-3 and 4, the international price of urea fell to US$65/T bulk FOB and US$80/T bagged FOB. From early 1987 the urea market rapidly recovered by the importation by China. Of course, the price has not recovered sufficiently but it has been gradually improving. It reached US$100/T for bulk and US$115/T for bagged urea and by the middle of 1988 it surpassed US$130/T and US$150/T, respectively.

Urea prices are influenced by not only such factors of the international market but many other factors. As in the case of the price composition of its raw material, ammonia, urea price is influenced by such factors as energy prices, unusual weather conditions, agricultural product market, and size and timing of implementing new plants, which are too variable to predict.

The change of international urea prices in FOB-bulk base since the oil shock is briefly reviewed. After the escalation of oil prices, the urea price shot up to US$350/T in 1974/75, but in 1976/77 following the start-up of new plants world-wide, it fell to below US$100/T. It subsequently fluctuated but rose to a peak of US$240/T in 1980/81. The urea price dropped to the US$120/T level, due to the stagnated fertilizer demand resulting from the few years of recession in the agricultural market, new plants commencing operation mainly in Eastern Euorpe, and exportation at prices probably below variable cost in order to obtain foreign currency. However, in 1983/84, the agricultural market of the U.S.A. improved and also as a result of purchases by China and India in the international market, the price recovered and was US$170/T at one time. That year's urea demand went into inventory stocks being imaginary demand as a result of the surplus in agricultural products, and in 1984/85, the price fell to nearly US$100/T.

Taking the above into account, the World Bank had forecast 1990 - 1995 urea prices in the World Nitrogen Survey, 1986 on premises described in section 4.3.3 above. The estimates are as shown below.

Table I-4-33 Urea Price Forecast (FOB in Bulk)

Unit: US$/T

	Low Forecast	Average Price Forecast	High Forecast
U.S. Gulf	155	185	210
West Europe	160	190	215
Arabian Gulf	158	188	213

The prices of bagged urea are obtained by addition of US$15/T.

4.4.4 Zimbabwe's Domestic Situation

(1) Import of Urea

Zimbabwe imports all of the urea it consumes. The total import value and volume are described in Table I-4-34. The value shows FOB price of exporting nations and the IMF average exchange rate in Table I-4-26 is applied in the conversion of the import ammount totaled by the nation's Central Statistics Office from Z$ into US$.

Table I-4-34 Urea Import

Year	Quantity (T)	Z$1,000	US$1,000	Unit price US$/T
1983	24,000	3,997	3,954	164.8
84	30,265	2,814	2,262	74.7
85	31,182	6,658	4,130	128.3
86	24,106	3,875	2,327	96.5
87	1,031	294	177	171.7

Source: CSO.

In the above table, the 1984 unit price is significantly lower than the international price because of an error in calculations and is estimated to be about US$150/T. The imported quantity in 1987 is extremely low because of problems in allocation of foreign currency.

Imports are in both bulk and bagged form and values above are the sum of the two. The percentages of imports in bulk and bagged form are not clearly disclosed.

(2) Domestic Supply and Demand

Urea adopted for the agriculture use are sold retail by ZFC and WINDMILL either as straight fertilizer or after being processed into compound fertilizer.

Recent sales and imported volumes are shown in Table I-4-35.

Table I-4-35 Urea Sales

Unit: T

	Sale	Import
1984/85	7,118	30,265
85/86	25,493	32,182
86/87	27,155	24,106
87/88	1,629	1,031
Total	61,395	87,584

Note: Sales corresponds that from March through February of next year.

It can be concluded from the table that sales volume in 1987 was small due to the decreased import volume. Excluding this case approx. 30 KT of urea is imported and consumed every year. This sales volume includes the consumption as straight fertilizer and livestock feed, particularly for cattle, the latter being estimated approx. 12 KT/Y.

The difference between the imported volume and sales volume is mostly accounted by the quantity that ZFC and WINDMILL utilize in producing compound fertilizer. The compound fertilizers with high nitrogen nutrient content, for example, J, T and X. brands, include substantial portion of urea.

The following table shows the nutrients of compound fertilizers that are currently registered.

Table I-4-36 Compounds

Compound Tel Code		Nitrogen	Citric Soluble Phosphate	Potash		Minimum Sulphur	Micro Nutrient Content
A	ALPHA	2	17	15	15 sul	10.0%	0.1% boron
B	BRAVO	4	17	15	15 sul	9.0%	0.1% boron
C	CHARLIE	6	17	15	11 sul 4 chlor	7.5%	0.1% boron
D	DELTA	8	14	7	7 chlor	6.5%	
J	JULIET	15	5	20	20 chlor	3.4%	0.1% boron
L	LIMA	5	18	10	10 chlor	8.0%	0.25% boron
M	MIKE	10	10	10	10 chlor	6.5%	
P	POPPA	10	18	0		6.5%	
S	SIERRA	7	21	7	7 sul	9.0%	0.04% boron
*T	TANGO	25	5	5	5 sul	5.0%	
V	VICTOR	4	17	15	11 sul 4 chlor	8.0%	0.1% boron
X	X-RAY	20	10	5	5 chlor	3.0%	
Z	ZULU	8	14	7	7 chlor	6.5%	0.8% zinc

Domestic demand of urea for industrial use is not large, the current consumption being 1.5 –2 KT/Y as raw material for adhesive in manufacturing plywood and furniture. Approximately 500 T/Y is consumed for yeast fermentation and for producing paint.

(3) Domestic Price

The ex-factory prices of not only urea but all fertilizers are posted prices; those posted prices effective since 1985 were revised on September 23, 1988.

Prices before and after revision are as follows.

Table I-4-37 Fertilizer Posted Prices

		Before Revision (Z$)	After Revision (Z$)	After/ Before (%)
Ammonium nitrate	(34.5%N)	406.00	415.40	102.3
Urea	(46%N)	541.40	553.80	102.3
Sodium nitrate	(16%N)	609.80	821.20	134.7
Ammonium sulphate	(21%N)	—	388.60	—

Source: The Herald 23rd Sept., 1988

The price increase of urea is kept to the same percentage as ammonium nitrate, 2.3%, far lower than 23% for superphosphates, 12 - 14% for potash fertilizer, and approximately 20% for compound fertilizers. Regarding the price configuration after revision, compared to urea and ammonium nitrate both being in nitrogen equivalent Z$1,204/TN, ammonium nitrate and sodium nitrate have extremely high estimates at Z$1,851/TN and Z$5,133/TN, respectively. It can be noted that these price configurations indicate the importance of nitrogenous fertilizers in Zimbabwe's agriculture, and the competitiveness and compatibility of urea and ammonium nitrate as major nitrogenous fertilizers.

The distribution cost and margin of ammonium nitrate are analyzed for the purpose of estimating the configuration of urea price. According to information provided by SABLE, the bagged ammonium nitrate ex-factory on rail price before revision is Z$324/T. Adding on Z$8.74/T Kwekwe-Harare rail cost, the Harare on rail price is Z$333/T. Since the retail price of Harare on rail before revision is Z$406/T, the distributor's margin, by the calculation 406/333 = 1.22, is estimated at about 22%.

4.4.5 Charactristics of Urea

(1) World Production

Urea as a fertilizer has a much briefer history than ammonium intrate. Many experiments were conducted in the latter half of the 1930s on the effectiveness of urea as a nitrogenous fertilizer, and urea was shown to be equivalent or in some cases superior to other nitrogenous fertilizers. However, technologies for mass production was developed and large supply began in the latter half of the 1960s. Nevertheless, after the take-off of supply, it eventually surpassed the share held by ammonium nitrate. This trend is still continuing at present as briefly described in Table I-4-38, Fig. I-4-11 and I-4-12 below, cited from an article in Nitrogen No. 163, 1986.

Table I-4-38 Composition of Urea and Ammonium Nitrate in 1984/85

			Urea	AN
Production	As nitrogen	(MMT)	26.1	11.3
	Share	(%)	35	15
	Growth rate	(%)	158.4	22.8
Consumption	As nitrogen	(MMT)	22.8	10.3
	Share [1]	(%)	30 (21)	15 (18)
	Growth rate [2]	(%)	147.8	21.2

Source: Nitrogen No. 163, 1986

Note: 1) The number in ( ) shows the share of 1974/75

2) Growth rate shows the increase rate vs 1974/75

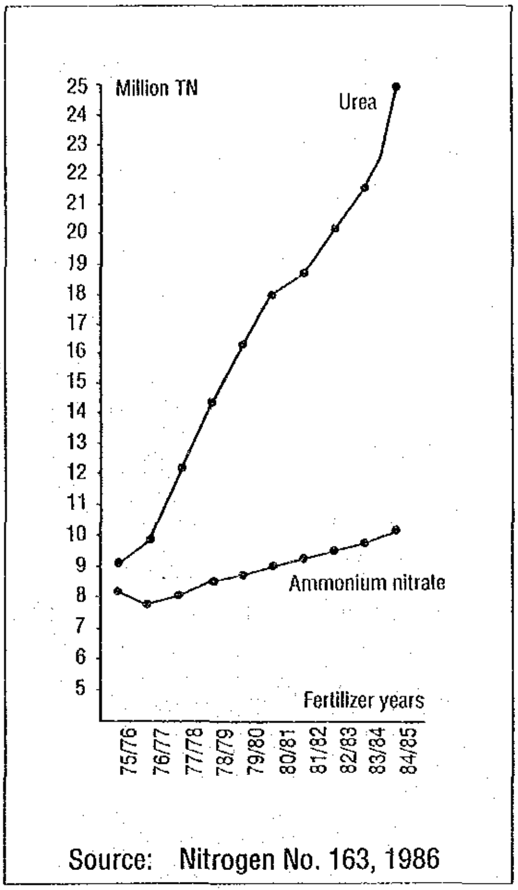


Fig. I-4-11 World Urea and Ammonium Nitrate Production (1975/76-1984/85)

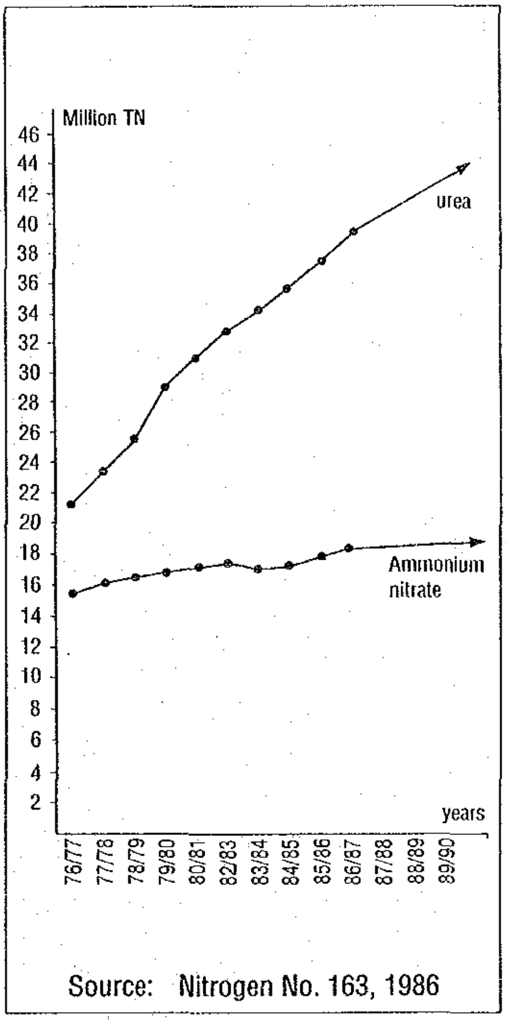


Fig. I-4-12 World Urea and Ammonium Nitrate Fertilizer Plant Capacities (1976/77-1989/90)

This situation is due to the superior characteristic of urea as nitrogenous fertilizer and its economic advantages.

(2) Characteristics of Urea

The characteristics of urea are discussed from the viewpoints of its effectiveness as nitrogenous fertilizer, physical and chemical characteristics, and cost.

1) Characteristics in view of effectiveness

As mentioned above, urea, like ammonium nitrate, shows good fertilizer efficiency. When urea is applied into the soil, it is decomposed by microorganisms into either ammonium carbonate or ammonium bicarbonate, and ammonium ions are adsorbed by soil colloids. Ammonium ion in the soil is absorbed by plants in either this form or in the form of nitric acid ion formed by nitrification.

Also, ammonium carbonate and ammonium bicarbonate derived from urea are weak electrolytes and dissociate a little in water. Consequently they are adsorbed and retained by soil colloids more strongly than other type of nitrogenous fertilizer. Hence they are not leached by irrigation water and well retained in soil showing excellent response.

Tables I-4-39 and I-4-40 describe the results of a comparison of soil adsorption of ammonium ions in various types of fertilizers. These tables show that the soil adsorption of ammonium ion of ammonium carbonate and ammonium bicarbonate is extremely high compared with the ammonium ion of ammonium nitrate, ammonium chloride, and ammonium sulphate.

Table I-4-39 Relative Amount of Ammonia Adsorbed by Different Types of Soil (Ammonium Salt Solution)

Soil Type	Amm. Sulphate	Amm. Chloride	Amm. Nitrate	Urea	
				Amm. Carbonate	Amm. Bicarbonate
Alluvial soil	100	68	74	206	226
Volcanic ash soil	100	59	85	217	225
Tertiary period soil	100	57	61	125	137
Kanto loam	100	68	61	121	129
Mikatagahara soil	100	68	83	132	142

Source: Japan Urea and Ammonium Sulphate Association

Table I-4-40 Relative Amount of Ammonia Adsorbed by Different Types of Soil (Ammonium Salt Solution at pH7)

Soil Type	Amm. Sulphate	Amm. Chloride	Amm. Carbonate	Amm. Phosphate
Volcanic ash soil	100	71	189	239
Alluvial soil (A)	100	89	191	229
Alluvial soil (B)	100	92	133	174
Strongly acidic diluvial soil	*100*	*71*	*169*	*211*
Average	100	81	171	213

Source: Japan Urea and Ammonium Sulphate Association

However, in applying urea, it requires time to decompose into ammonium bicarbonate or ammonium carbonate. This period depends on climatic conditions and characteristics of the soil. Decomposition is slow in places with low temperature such as Northern Europe in autumn and winter but is very fast in other places, and urea works almost simultaneously when applied. Consequently, excluding cases of low temperature, urea shows excellent response.

When urea is applied to land without a covering it with soil in alkaline soil, people concerned in agriculture may be hesitant using it, because of volatization of ammonia.

Excluding these cases, urea shows equal or superior fertilizing effects compared to ammonium nitrate (ammonium nitrate has disadvantages such as the loss of nitrogen through leaching caused by heavy rain and through nitrification in paddy fields).

The application of urea in Zimbabwe is discussed considering the factors mentioned above.

In Zimbabwe, most of area of the high veld and the low veld has a subtropical climate with the annual average temperature between 17.5~22.5°C. The low veld has a tropical climate, with an average exceeding 22.5°C and in some places exceeding 25°C. Also the soil is acidic. Therefore, in case urea is applied, it works immediately, without the volatization of ammonia. Urea will therefore, show excellent fertilizing effects under Zimbabwe's climatic and soil conditions.

2) Physical and chemical characteristics

Hygroscopicity

The hygroscopicity of urea is lower than ammonium nitrate. Hygroscopicity significantly influences the easiness of storing and handling fertilizer. Critical humidity, the criterion for the hygroscopicity of fertilizer, is indicating the limit humidity of moisture absorption, and the lower this value is, the more hygroscopic. Table I-4-41 below describes the critical humidity of urea, ammonium nitrate, and sodium nitrate.

Table I-4-41 Hygroscopicity of Nitrogenous Fertilizers (%)

	10°C	15°C	20°C	25°C	30°C	40°C	50°C
$(NH_2)_2CO$	81.8	79.9	80.0	75.8	72.5	68.0	62.5
NH_4NO_3	75.3	69.8	66.9	62.7	59.4	52.5	48.4
$NaNO_3$	78.0	76.8	77.1	74.4	72.4	70.1	67.3

As described in the above table, the hygroscopicity of ammonium nitrate is the highest. The hydroscopicity increases when the temperature increases. Urea and sodium nitrate are approximately equivalent, and show lower hygroscopicity than ammonium nitrate.

Nitrogen Content

The urea has a guaranteed nitrogen content of 46%, and is the most concentrated nitrogenous fertilizer.

Safety

Unlike ammonium nitrate, urea is not explosive and is a safe fertilizer.

3) Plant cost

With regard to construction cost of urea and ammonium nitrate plants of the same capacity in terms of N, the urea plant cost is approx. 70% of the ammonium nitrate plant. Considering production costs, the investment cost is a large percentage of fixed costs; this is a significant advantage favoring urea.

As mentioned above, because the nitrogen content of urea is an extremely high 46%, the unit cost of transporting nitrogen is the lowest in cost among various nitrogenous fertilizers.

4) Comparison of urea and ammonium nitrate

Urea and ammonium nitrate are compared below in characteristics other than effectiveness mentioned in (2) above.

	Urea	Ammonium Nitrate
Cost	O	X
Supply stability	O	X
N content	O	X
Safety in handling	O	X
Hygroscopicity	O	X
Plant construction cost	O	X

Note: O Good
X Poor

① There is a distinct difference between the import prices of urea and ammonium nitrate, as described in A-Table 4-21. In terms of price per tonne nitrogen, ammonium nitrate is much higher than urea.

② Urea is superior in supply stability; as described in Fig. I-4-11 and I-4-12 its supply capacity is much larger; urea is traded in large volume in the world as mentioned in 4.4.2., while most of ammonium nitrate is produced for captive use at present.

The ranges of price fluctuation described in A-Table 4-21, i.e., 3.1 times for urea compared with 5.3 times for ammonium nitrate, is indicative of the stability of supply.

③ Nitrogen content of urea being 46%, that of ammonium nitrate is 34.5%; therefore urea is 1.33 times ammonium nitrate in N content and this indicates a significant difference of transportation and storage costs.

④ Urea is neither explosive nor inflammable. Ammonium nitrate in contrast is not only explosive but also induces cigar burning in the process of producing compound fertilizer, and for these reasons safety measures are required.

(3) Granulated Urea

Urea has up to the present been supplied as fertilizer in a prilled form. Prilled urea has a size of 3 mm or less, but recently there is a trend throughout the world that for certain uses, urea with larger grain size is preferable. Such large size urea are produced by a fluidized bed process or pan granulation process, which are developed relatively recently. The size is made up to 6 mm, as required.

Urea has various advantages as mentioned above, however, prilled urea is liable to cake in storage and transportation due to its small grain size.

In contrast, granulated urea shows the following characteristics.

1) Less caking property

As compared to prilled urea granulated urea has far less contact area of grains, the main cause of caking. Also because the grain size is large, its compression strength is also high furnishing resistance to breaking.

Less breakage prevents urea from caking, since urea dust resulting from breaking acts as a binder for caking. For these reasons, granulated urea is more favorable.

2) Suitable for bulk blending

The raw materials of bulk-blend fertilizer in many cases are of a 3 to 4 mm grain size. Bulk blending is becoming an accepted practice because it is suited to ready mixing of fertilizers to obtain a compound fertilizer with a proper ratio of nutrients which is appropriate for respective farmland and crop at the user-end. Bulk blending is also suited to produce diverse compound fertilizers in small quantities. In this case, for obtaining a product with nutrients mixed equally, segregation must be prevented. The best means for this is to make the grain size of respective raw materials uniform. Granulated urea is suitable to this end.

3) Low hygroscopicity

Hygroscopicity of urea is low compared to that of ammonium nitrate. Even when exposed to high humidity and high temperature granulated urea which has very small surface area absorbs far less moisture than prilled urea.

The above advantages will justify the use of granulated urea.

(4) Other Advantages

Urea in the form of aqueous solution can be applied to the foliage surface of crops.

This process is called, "foliar application," by which plants are capable of absorbing nutrients rapidly. That is, when crops are sprayed with a urea solution of 0.2-0.5% (occasionally 1%) concentration, the foliage easily absorbs it to produce of protein inside the crop. With fruit trees, the response to nitrogen is seen immediately after foliar spraying, much more rapidly as compared to fertilizer application to the soil. In such a case that crops are injured, by strong wind for instance, foliar application is very effective in recovering crop condition. It also is not limited to fruits but can be broadly applied to vegetable produce in general.

In addition, besides being utilized as fertilizer, urea can be fed directly as animal feed.

(5) Nitrogenous Fertilizers Recommended for Production in Zimbabwe

Ammonium nitrate has been produced in Zimbabwe since 1969, part of which is used for industrial explosives and the balance for fertilizer. It is known that ammonium nitrate is an effective fertilizer. Also, ammonium nitrate is extremely important in Zimbabwe from the standpoint of promotion of mining. Therefore, it was a wise decision that ammonium nitrate production was selected in constructing the first nitrogenous fertilizer plant in 1969.

What is the appropriate product to be made by this second nitrogenous fertilizer plant?

Since industrial explosives in Zimbabwe is sufficiently supplied by the existing ammonium nitrate plant, the newly selected product must be one that would promote Zimbabwe's agriculture. Consequently, urea is the clear choice, and the reasons are in the significant advantages it has, as mentioned above. The most significant reasons are the superior effectiveness and advantages in manufacturing and transporting costs. Numerous urea plants have been constructed or planned in the developing nations of Africa, Asia, and South America, etc. up to the present. This clearly shows how much better urea is than other nitrogenous fertilizers.

Effort should be made in one respect in Zimbabwe in case of urea production. This is guidance of farmers by agricultural specialists. Farmers in Zimbabwe have been using ammonium nitrate for a long time. Although urea is imported each year and is applied as fertilizer, the farmers should be familiarized with the use of urea more and more.

4.4.6 Forecasts

(1) Past Research

As in the case for ammonia, the following information are available.

MONTAN CONSTRUCTING GMBH:
Coal Resources and Utilization Pre-Feasibility Study, 1983

T.A. HOLDINGS LTD:
Coal to Methanol and Ammonia Project, 1982

UNITED NATIONS DEVELOPMENT PROGRAMME:
Development of the Fertilizer Industry in Zimbabwe, 1987.

Among these, the MONTAN report alludes to urea as a candidate of fertilizer produced from ammonia. However, an adequate analysis on urea is not made.

The UNDP report indicates that the nitrogenous fertilizer to be produced should be urea, and is noteworthy for the detailed discussion made in view of technical and economic aspects. However, the studies regarding utilization of urea in Zimbabwe such as agricultural research and market forecast aren't done thoroughly.

The T.A. Holdings report is the most important report. Its major discussion is cited below.

"The farmers of Zimbabwe say they prefer ammonium nitrate to urea, but this is because the disadvantages in urea are overrated. The resistance toward application of urea is probably because a certain quantity is lost through not covering it with soil or not ploughing it in.

This problem should not occur though, because prior to planting crops the cultivated land is prepared, usually by turning the soil over. Application to the soil surface after rain is recommended, but application should be avoided during the dry season especially when weeds and organic trash are spread over the land. It may be washed out of sandy soil immediately after application in the case of heavy rain fall or use of irrigation water, but it generally takes the form of ammonia and is sustained in the soil well."

The above corresponds to views held by the Survey Team. Unfortunately, the background of the study has been changing since the time of the report, and furthermore, the evaluation of urea from an agronomical point of view is not complete.

(2) Demand Forecast

For the industrial utilization of urea a relevant information is provided in Appendix 1-2, including that for the production of urea resin, to be of reference for a more concrete study in this matter.

For making forecast and discussion of required amount of urea, in the agricultured of Zimbabwe the history of urea application is too short and data of urea application is limited. In sections 4.3.5 (2) and 4.4.7, discussions are made from all possible viewpoints. Although the potential of increased urea demand is thought to be extremely high, the actual increase would largely depend on financial and agricultural policies.

Table I-4-42 shows the demand forecast of nitrogenous fertilizer of the member nations of SADCC.

Table I-4-42 Nitrogenous Fertilizer Demand Forecast for SADCC Nation (1980/81-2010/11)

Unit: Nitrogen Equivalent, 1,000 T

	1980/81	1990/91	2000/01	2010/11
Malawi	17	21	27	35
Mozambique	27	34	45	65
Tanzania	20	26	35	50
Zambia	48	62	85	110
Others	6	10	15	30
Total	118	153	207	290

The TRANS AMMONIA CO. in the U.S.A. forecasted the mid 1990s urea demand of Zimbabwe and neighboring nations.

Zimbabwe	100 KT/Y
Zambia	85
Mozambique	13
Malawi	13
Tanzania	30
Kenya	22
Total	263

These demand must be carefully considered whether these potential demands become actual or not in view of self-supply capability, foreign currency reserves and others of each nation. In the case of Tanzania, the financing arrangement for the installation of a large-scale ammonia and urea plant using natural gas is actively conducted.

Finally it should be emphasized again that as the most important point, it is necessary to promote the customary use of urea by farmers. Farmers in any nation are conservative in their management behavior. It is understandable that they rely on tried methods in light of harvests being once in a year and not consistent. Consequently, urea application at present isn't accepted as a common agricultural practice in Zimbabwe. As mentioned above, urea has superior characteristics among nitrogenous fertilizers. However, under the present circumstances that farmers have no knowledge on suitable application nor superior response of urea, steady growth of urea demand cannot be expected. Prior to the urea plant starting supply of the product, the imports of urea should be increased for making farmers accustomed to its usage. Efforts should also be made for popularization of knowledge on urea and for making favorable circumstances for its use.

For example in France, ammonium nitrate had been mainly applied as straight nitrogenous fertilizer, but with the popularization of urea use, urea demand increased, showing a rapid growth of imported urea, from 485 KT in 1986 to 608 KT in 1987, which is a 25% increase.

(3) Price Estimation

First, urea price as of 1988 is discussed. Although the international price of urea is showing recovery after it crashed as ammonia did in 1986, it has not come back up sufficiently yet. As described in A-Fig. 4-4, the change of Middle East FOB price of bagged urea in 1982-88, the average of monthly prices is US$132.8/T, and there were two mode price ranges, US$130-140/T and US$160-170/T. As mentioned in the section on ammonia, this period is the oversupply period of urea resulting from worldwide agricultural product surplus and new plants starting operation. In light of this tendency and taking the bagged-urea FOB price in the middle of 1988 into consideration, applying the actual 1987 FOB price of the nation US$171.7/T as its 1988 projected price seems adequate. According to the study by TRANS AMMONIA, the 1988 C & F price of bagged urea in the Central-Eastern African region is US$203/T. Assuming that urea is unloaded in Beira and transported to Harare by way of Machipanda, a 15% surtax is applied, and that the FOB price of bagged urea is US$172/T, the Harare on rail price and cross-border price are estimated below.

Unit: US$/T

	Harare on rail	Cross-Border
Bagged-urea FOB price	172	172
Freight	20	20
Rail cost	15.7	10.1
Surtax	31.2	–
Others	10	10
Total	248.9	212.1

The Z$1.8=US$1 exchange rate is applied in converting Zimbabwe dollar to US$.

Adding to this Harare on rail price a 22% increase, as distributor's margin as in the case of ammonium nitrate, the result is:

248.9 x 1.22 = US$303.7/T→ Z$546.7/T.

As in the case of ammonia, if a urea plant is installed in conjunction with a coal-based ammonia plant in Kwekwe or Hwange, and assuming the total product is distributed using sales network at Harare, the transportation cost of Kwekwe-Harare Z$8.74/T (US$4.86/T) or Hwange-Harare Z$20.75/T (US$11.53/T) should be deducted from urea price of Harare on rail. That is, the bagged-urea price at each site is estimated as follows.

Plant site	Kwekwe	248.9 - 4.86 = US$244.0/T
	Hwange	248.9 - 11.53 = US$237.4/T.

Next, urea price in 1995 will be estimated. African Southeast coast C & F price in 1986 is calculated as follows. In this calculation, the low forecast price US$160/T is taken from the three price levels for bulk FOB, Western Europe, estimated in World Nitrogen Survey, 1986 by the World Bank using the realization price method.

Pooled price, bulk FOB, Western Europe	US$160/T
Bagging cost	15
Freight	25
African Southeast coast C & F	US$200/T

Export of urea from Eastern Europe was one of the main factors in the price fluctuations of urea in the past ten years. It appears that there have been many cases of urea exported from this region at drastically low prices. As already mentioned in the first half of Chapter 4, considering that toward the mid 1990s the supply and demand are in balance or in short supply, extraordinarily low prices due to dumping are not expected. The freight estimate is compatible with US$40/T of ammonia.

The above FOB price is an estimation at the fixed value of 1986 US$. Assuming the U.S.A. GDP deflator continues at the current 5%/Y rate, the 1995 nominal price is estimated US$248/T. Therefore, the 1995 nominal price of Harare on rail is estimated as follows.

Urea, bulk FOB price	US$248/T
Bagging cost	23
Freight	25
Rail cost	16
Surtax	47
Other	10
Harare on rail	US$369/T

4.4.7 Determination of Production Capacity

It is assumed that the plant capacity for the ammonia will be 600 T/D, that the SABLE's water electrolysis ammonia plant will be shut down and existing SABLE nitric acid and ammonium nitrate plants will continue operation without capacity alteration, that 300 T/D of ammonia will be supplied to SABLE, replacing present production and import, and that all of the remaining 300 T/D will be processed into granulated urea.

By deducting losses in manufacturing and handling, the urea product supplied to the market is calculated to be 78,000 T/Y in terms of nitrogen. Whether this urea production capacity is reasonable or not will be discussed from the aspect of demand.

(1) Domestic Consumption as Fertilizer

1) Premises

The total nitrogen demand in 1995/96 is 180,000 T/Y as mentioned in section 4.3.6. Considering that the application of urea is not commonly accepted, the application of urea shall be promoted most progressively in Mashonaland West, Mashonaland Central, and Mashonaland East, and Manicaland, provinces having intensive agricultural production and favorable agricultural, soil, and climatic conditions. As described in A-Fig. 4-8, this region accounts for 76% of the nation's total fertilizer sales quantity.

The use of urea shall be promoted mainly as straight fertilizer, on the basis of advantages of granulated urea. As described in Table I-4-19 the demand for it as straight fertilizer amounts to 76% of total nitrogen demand.

2) Potential demand of urea as fertilizer

Based on the premises above, the calculation of the potential demand for urea in 1995/96 is

180,000 T/Y N x 0.76 x 0.76 = 104,000 TN/Y.

This is of course the volume in the case all nitrogenous fertilizer used as straight fertilizer in the provinces above is all converted to urea, so it is necessary to deduct from it the portion of ammonium nitrate application.

(2) Other Uses

1) Domestic consumption as animal feed, etc.

Assuming the same usage as mentioned in section 4.4.4 of this report, the domestic consumption of urea in 1995/96 for animal feed and industrial use (as raw material for adhesive, etc.) is estimated 15,000 T/Y. This amount is equivalent to 6,900 TN/Y.

2) Demand in neighboring nations

As mentioned in section 4.4.6 above, the urea demand of neighboring nations in 1995/96 is estimated 163 KT/Y. Zimbabwe may not cover all of urea demand of neighboring nations, although exportation of approx. 1/3 of this volume can be expected. This amounts to 54,000 T/Y of urea, the equivalent of approx. 24,800 TN/Y.

The total of these volumes, i.e., the total of other uses, reaches 31,700 TN/Y.

(3) Conclusion

Consequently, the potential market size for urea in 1995/96 is 104,000 + 31,700 = 135,700 TN/Y, and the volume of nitrogen supplied by the projected urea plant, 78,000 TN/Y, accounts for 57.5%.

It can be concluded from the above that the projected capacity of the urea plant is very small in view of potential demand.

4.5 Balanced Fertilization and Distribution

4.5.1 Balanced Fertilization

The following table shows the consumption ratio between compound and straight fertilizers by N, P_2O_5 and K_2O taking the average of values in 1985/86 - 1987/88 as described in Table I-4-19.

Unit: %

	N	P_2O_5	K_2O
Compound	24	90	84
Straight	76	10	16

Similarly, the average fertilizer sales volume during this three-year period cited from A-Table 4-10 is 460,684 T/Y, of which compound fertilizer accounts for 257,876 T/Y. The $N:P_2O_5:K_2O$ ratio in total fertilizer is roughly 10:5:3, and that in compound fertilizer is roughly 8:15:9.

On the other hand, the 1995/96 nitrogenous fertilizer demand will be 180,000 TN/Y and therefore is approx. double the current consumption volume. Consequently, if the consumption of P_2O_5 and K_2O are the same as the current situation, balanced fertilization would be seriously disrupted.

Thus, in order to obtain adequate quantity and quality of crop production, it is necessary to produce sufficient quantities of P_2O_5 and K_2O in proportion with N, and especially it is desired that the production of compound fertilizer is increased.

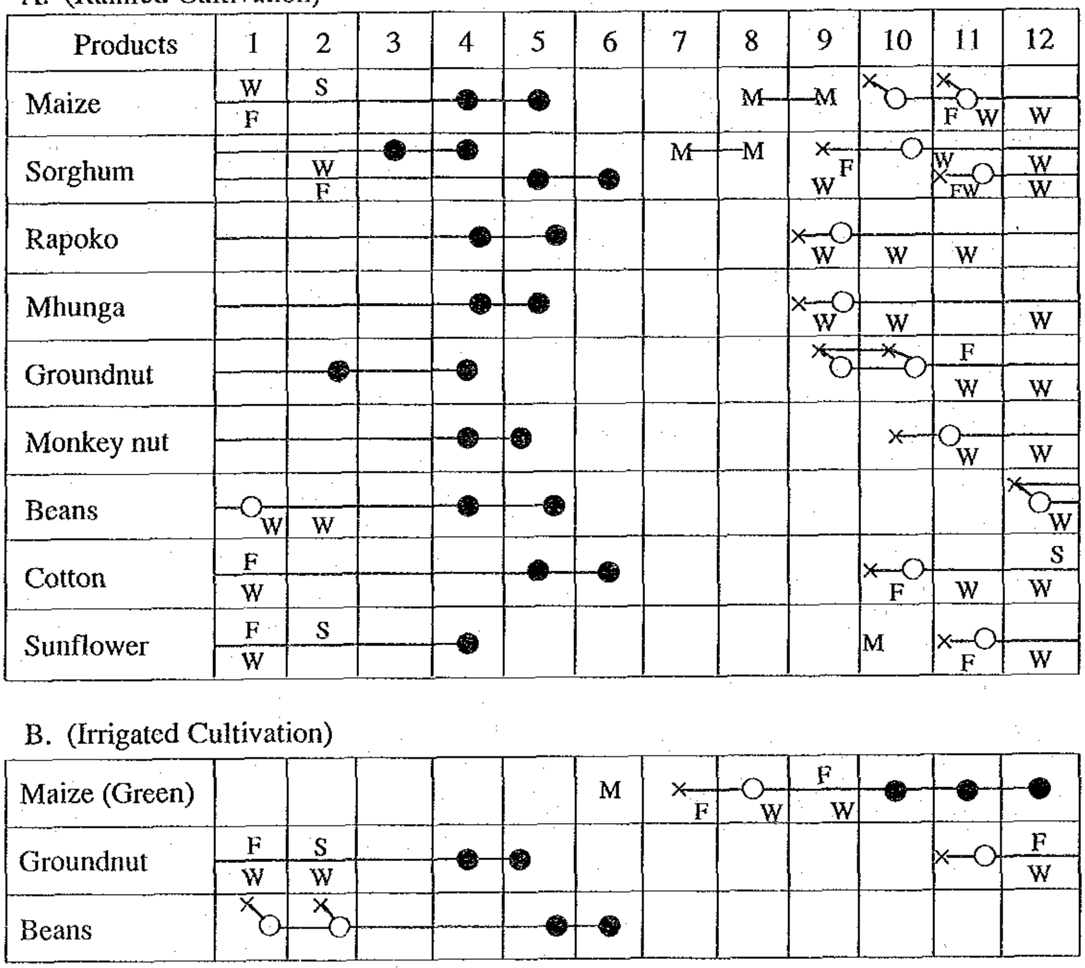
4.5.2 Improvement of Fertilizer Distribution System

A smooth shipment of product is a key factor in distribution when the demand for fertilizer increases.

A summary of the cultivation of major crops in the nation is described in Fig. I-4-13; chemical fertilizers are applied from July through February in the fields of rain-fed cultivation as well as irrigated cultivation while there is no application from March through June.

Conversely, shipments from fertilizer plants (ZFC and WINDMILL) are concentrated in two periods, March through May and September through November.

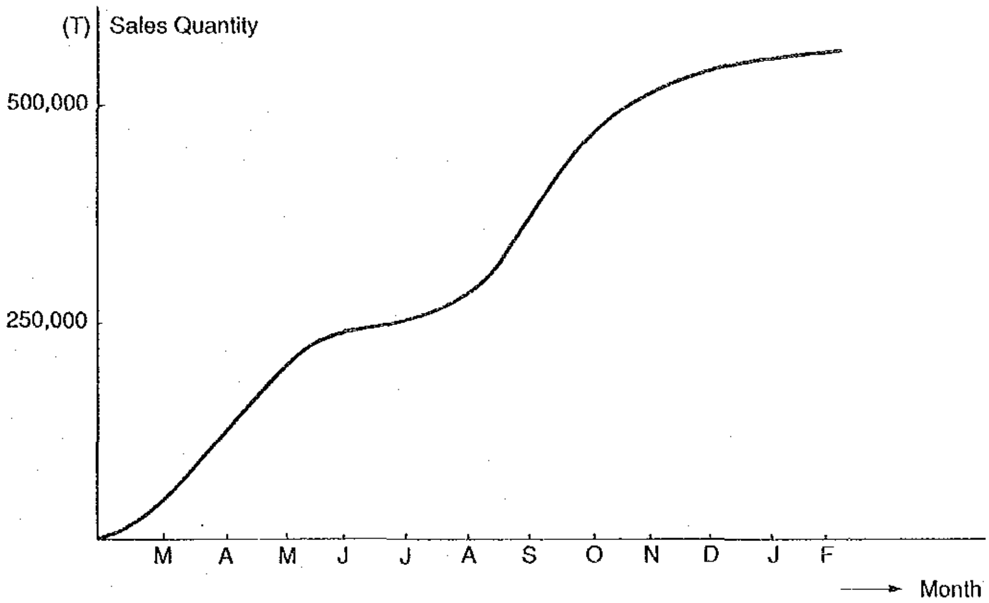
A. (Rainfed Cultivation)



Note: ×-Land Preparation, O-Sowing, ●-Harvesting,
M-Manure, F-Chemical Fertilizer, W-Weeding,
S-Agro-Chemicals

Source: Association for International Cooperation of Agriculture & Forestry 1986

Fig. I-4-13 Cultivation Periods of Crops



Source: ZFC-WINDMILL

Fig. I-4-14 Monthly Fertilizer Sales Quantity (Accumulate)

Well-balanced application of N, P_2O_5 and K_2O is required for keeping crops in good condition and for getting good yields. Consequently, in addition to the increase of nitrogen application, consumption of phosphatic and potash fertilizers in the form of compound fertilizer will surely increase. On the other hand, in communal lands and resettlement areas agricultural production will be promoted and the organization of agricultural cooperatives enlarged, opening the way to the advancement of agriculture and farm management for the entire nation. Therefore, the distribution of fertilizer to remote areas is expected to increase.

Consequently, as the distributed quantity of fertilizer increases and the distribution region expands, the management of shipping periods with a high degree of regularity is desirable for smooth distribution. For this end, it would be necessary to establish storage depots in the main regions throughout the nation.

Appendix

Appendix 1-1 Future Expansion of Nitrogen Application in Zimbabwe

In Volume 1, Part 1, Section 4.3.5, the growth rate of N application in commercial farming sector and consumption of N in communal farming sector are assumed as below.

Commercial Farming Sector	:	2%/Y
Communal Farming Sector	:	1/5 of Commercial Farming Sector (in1995/96)

This appendix evaluates whether the above estimate is justifiable based on the discussions for selected crops as examples.

In the commercial farming sector, wheat is studied solely because of the following reasons.

- Expansion of total area managed by this sector is not expected from a socio-economic perspective.
- Increased production of wheat will be required in the future.

On the other hand, in the communal farming sector, maize and cotton are selected among crops. And then justification of the above estimate is conducted in view of the conditions specified in the policies of the First Five-Year Plan.

Moreover, the above three crops were selected for discussion because they are specified as main crops in the First Five-Year Plan, and the fertilizer consumption on their account is 75% of total fertilizer consumption, as described in A-Table 4-1.

Sensitivity analysis is desirable for the method of evaluation but data is not sufficiently available. Instead, designating as the base the yield resulting from fertilizer applied by the communal farming sector, currently 1/10 that of the commercial farming sector, the increased yield resulting from increased fertilizer application by the commercial sector is viewed macroscopically to determine the effects of fertilizer. Although the effects of nutrients other than nitrogen are merged in this method, this is considered negligible because of the relatively large effect furnished by nitrogen.

The average values of 1980-85 data are applied to analysis by this auxiliary method, and not data of 1985 alone because of the statistical bias it would incur. From the data applied described above, the data of 1983, the year of severe drought, is excluded.

Data described in Table 1-4-16 is utilized for the fertilizer application rate of the commercial sector and values 1/10 of the values in the data above are utilized for that of the communal sector. Calculation of the effects of nitrogen nutrient resulting from increased application by this method is described in A-Table 4-15.

1. The Case of Maize

The estimated yield resulting from increased application of nitrogen is calculated based on the data described in A-Table 4-1 and A-Table 4-15. The 1995/96 estimated yield for communal sector is calculated in the following.

1985 yield	1.394 T/ha
yield increase due to increased N application	0.371
estimated yield for 1995/96	1.765 T/ha

The 1995/96 planted area is extrapolated from the 1988/89 planted area of the communal area (A-Table 4-3) as follows.

$(945 + 130)$ Kha x $(1.05)^7 = 1.513$ Kha

Multiplying this value with the estimated yield above, the 1995/96 communal-sector total yield is estimated as follows.

1,765 T/ha x 1,513 Kha = 2,670 KT

The First Five-Year Plan specifies to increase the 1985 production in communal sector (A-Table 4-1) at a 5 % - annual rate. The 1995/96 target production in accordance with the Plan:

1,558 KT x $(1.05)^{10} = 2{,}538$ KT

is satisfied by the projected rate above.

2. The Case of Cotton

Utilizing the same method as in the case of maize, the estimated yield of the communal sector is

1985 yield	0.846 T/ha
increased yield due to increased N application	0.137
estimated yield for 1995/96	0.983 T/ha

The 1995/96 planted area is

$(138 + 20)$ Kha x $(1.05)^7 = 222.3$ Kha

and the estimated total yield of the communal sector for the same year is as follows.

0.983 T/ha x 222 Kha $\approx$ 218 KT

The 1995/96 target production calculated by the same method as in the case of maize is as follows.

$110 \text{ KT} \times (1.05)^{10} = 179 \text{ KT}$

The above estimated yield is slightly larger than the target production. Therefore the increase of nutrient nitrogen projected above is adequate with regard to the communal sector.

3. The Case of Wheat

At present, most of wheat production is concentrated in the commercial sector, and the percentage of production by the communal sector is very small. This is thought to be due to various conditions. For instance, most of lands suitable for wheat cultivation are owned by commercial farmers, who can invest in irrigation facilities and large fertilizer application which are requisites for wheat cultivation.

In this context, toward 1995/96, the wheat production is assumed to increase in proportion with the increase of wheat-planted area in the commercial sector. Given the basic premise that expansion of the area managed by the commercial sector is not expected, this connotes that production of crops other than wheat will be reduced.

As described in Table I-4-16 the average N application for wheat is as follows.

basal application	compound fertilizer	650 kg/ha
	average N content	8%
top dressing	ammonium nitrate	450 kg/ha
	N content	34.5%

650 kg/ha x 0.08 = 52.0 kg N/ha
450 x 0.345 = 155.3

207.3 kg N/ha

In the First Five-Year Plan, 55 Kha planted area and 5T/ha yield are projected as 1990 targets. The 1995/96 target production is extrapolated from the 1990 wheat production increased at a 5% annual rate as follows.

$5 \text{ T/ha} \times 55 \text{ Kha} \times (1.05)^5 = 351 \text{ KT}$

The planted area required for this quantity at a 5T/ha yield is 70.2 Kha.

The most recent reliable data concerning the planted area for wheat is 16.9Kha in 1984 described in A-Table 4-1. With respect to this value, the increase of nitrogenous fertilizer necessary for achieving the above target production is

0.207 TN/ha x (70.2 - 16.9)Kha = 11.0 KTN

This nitrogen requirement is the equivalent to approximately 1/2 of assumed nitrogenous fertilizer consumption increase in commercial farming sector, 23.5 KT/Y (see A-Table 4-16).

The remaining 1/2 is thought necessary and sufficient for increased application to other main crops of the commercial sector, tobacco, coffee, and tea (according to A-Table 4-18, these three crops account for 12% of total fertilizer consumption), as well as other crops.

A-Table 4-1(1) Crop Area and Production by Sector

Maize

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	910,739 2)	227,733 2)	3,999 2)	600,000	900,000	667	1,510,739	1,127,733	1,340
1981	1,833,395	363,448	5,044	1,000,000	1,000,000	1,000	2,833,395	1,363,448	2,078
1982	1,213,376	316,440	3,835	595,000	1,100,000	595	1,808,376	1,416,440	1,277
1983	624,786	283,880	2,201	285,000	1,050,000	271	909,786	1,333,880	682
1984 3)	678,403	224,586	3,021	454,400	1,136,000	400	1,132,803	1,360,586	833
1985 3)	1,153,000	238,000	4,844	1,558,000	1,018,000	1,394	2,711,000	1,256,000	2,158

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

Sorghum

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	16,299 2)	6,766 2)	2,409 2)	66,000	120,000	550	82,299	126,766	649
1981	25,131	9,290	2,705	100,000	200,000	500	125,131	209,290	598
1982	17,355	8,232	2,108	50,000	200,000	250	67,355	208,232	323
1983	7,536	7,672	982	44,000	280,000	157	51,536	287,672	179
1984 3)	18,071	9,903	1,825	37,440	156,000	240	55,511	165,903	335
1985 3)	54,048	15,049	3,591	76,000	211,000	360	130,048	226,049	575

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

A-Table 4-1(1) Crop Area and Production by Sector (Cont'd)

Wheat (Commercial farms only)

	Production (tons)	Area (hectares)	Yield (kg/ha)
1980 1)	154,993 1)	36,556 1)	4,749 1)
1981	183,516	36,845	4,981
1982	191,880	37,378	5,134
1983	110,990	21,547	5,151
1984 2)	83,807 1)	16,891 1)	4,962 1)

1) Only large scale commercial farms.
2) Provisional data.

Groundnuts

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	10,675 2)	3,841 2)	2,779	67,000	175,000	383	77,675	178,841	434
1981	18,797	12,909	1,456	100,000	300,000	333	118,797	312,909	380
1982	16,377	11,923	1,374	95,000	240,000	396	111,377	251,923	442
1983	9,152	10,709	855	22,500	180,000	125	31,652	190,709	166
1984 3)	6,194	7,014	883	18,720	144,000	130	24,914	151,014	165
1985 3)	6,938	6,938	1,000	61,000	118,000	512	67,938	124,938	544

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

A-Table 4-1(2) Crop Area and Production by Sector

Soybeans

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	89,403 2)	40,783 2)	2,192 2)	8,000	12,000	667	97,403	52,783	1,845
1981	66,131	30,971	2,135	6,750	9,000	750	72,881	39,971	1,823
1982	88,596	48,417	1,830	3,000	7,000	429	91,596	55,417	1,653
1983	78,626	54,909	1,432	2,000	4,000	500	80,626	58,909	1,369
1984 3)	88,763	54,169	1,639	970	2,260	429	89,733	56,429	1,590
1985 3)	85,542	40,986	2,087	1,675	2,000	837	87,217	42,986	2,029

1) Estimates.
2) Refers to large scale commercial farms only.
3) Provisional data.

Cotton

	Commercial			Communal 1)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	145,533	74,921	1,943	12,000	15,000	800	157,533	89,921	1,752
1981	125,594	66,054	1,901	45,000	59,000	763	170,594	125,054	1,364
1982	107,886	58,014	1,860	27,000	51,000	529	134,886	109,014	1,237
1983	114,021	67,976	1,677	32,500	65,000	500	146,521	132,976	1,102
1984 3)	151,746	80,155	1,893	70,000	100,000	700	221,746	180,155	1,231
1985 3)	164,186	79,658	2,061	110,000	130,000	846	274,186	209,658	1,308

1) Estimates.
2) Only large scale commercial farms.
3) Provisional data.

A-Table 4-1(2) Crop Area and Production by Sector (Cont'd)

Coffee 1)

	Productive area 2)			Non productive area 1)
	Production (tons)	Area (hectares)	Yield (kg/ha)	
1980	5,261	4,098	1,284	2,194
1981	5,476	4,608	1,188	3,705
1982	6,073	5,042	1,204	3,990
1983	8,234	7,008	1,177	2,251
1984 3)	9,977	7,296	1,367	1,392

1) Figures relate only to large scale commercial farms.
2) In the table the area planted has been classified into productive and non-productive depending on whether or not it can be harvested. Areas where the coffee has not matured for harvesting is classified as non-productive.
3) Provisional data.

Tobacco

	Commercial 1)			Communal 2)			Total		
	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	119,818 3)	63,703 3)	1,801 3)	231	365	633	120,049	64,068	1,874
1981	69,226	39,393	1,757	195	367	531	69,421	39,760	1,746
1982	88,423	45,552	1,941	774	1,080	717	89,197	46,632	1,913
1983	93,331	46,327	2,015	645	1,400	460	93,976	47,727	1,969
1984 4)	116,157	49,962	2,325	774	1,210	640	116,931	51,172	2,285
1985 4)	106,557	51,999	2,049	1,190	1,700	700	107,747	53,699	2,006

1) Includes flue-cured and burley tobacco.
2) Estimates.
3) Only large scale commercial farms.
4) Provisional data.

A-Table 4-1(3) Crop Area and Production by Sector

Sugarcane

	Productive area			Non productive area
	Production (tons)	Area (hectares)	Yield (kg/ha)	
1980	2,528,000	24,515	103.1	6,038
1981	3,551,000	34,146	103.9	466
1982	3,587,000	31,547	113.7	533
1983	3,438,000	33,033	104.1	1,400
1984 1)	3,459,000	33,048	104.7	109

1) Provisional data.

Tea (Large scale commercial farms)

	Tea (made or black)		
	Production (tons)	Area (hectares)	Yield (kg/ha)
1980	9,661	4,143	2,332
1981	9,916	4,247	2,335
1982	10,602	4,423	2,397
1983	10,551	4,476	2,357
1984 1)	11,807	4,447	2,655

1) Provisional data.

Source: Statistical Yearbook 1987

A-Table 4-2 Large Scale Commercial Farming (1973-85)

Year	Area of farms covered	Permanent farm and forest employees	Area under crops	Area under fruit	Area under irrigation	Production of						Holdings of		
						Flue-cured Tobacco	Other Tobaccos	Grain Maize	Sorghum	Ground nuts (un-shelled	Cotton	Cattle	Sheep	Pigs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	'000 ha	no.	hectares	hectares	hectares	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	'000	'000	'000
1973	14,958	236,472	597,647	6,189	113,833	64,216	5,416	784,365	25,632	6,317	105,708	2,573	246	99
1974	15,112	240,985	606,363	5,983	113,332	70,288	3,389	1,567,175	10,560	9,614	120,859	2,575	230	96
1975	15,193	236,542	585,236	5,359	127,194	82,085	2,421	1,260,393	4,411	8,333	121,345	2,781	218	105
1976	15,148	242,224	561,207	5,228	130,558	106,723	1,734	1,205,340	15,319	9,645	107,742	2,902	208	109
1977	15,303	245,444	570,028	4,752	146,787	82,466	1,488	1,140,067	14,532	6,255	115,238	2,959	195	121
1978	15,317	239,469	559,225	4,275	149,377	81,148	2,168	1,102,289	15,585	5,879	129,037	2,812	172	108
1979	15,064	235,455	538,105	4,064	151,698	105,022	2,262	705,466	18,883	7,537	130,218	2,478	152	86
1980	14,798	203,194	571,169	3,663	154,806	117,370	2,452	887,519	16,299	10,675	145,553	2,208	141	89
1981	14,482	196,337	595,870	4,005	158,328	67,267	1,885	1,712,708	24,315	15,360	117,960	2,189	141	95
1982	13,516	169,250	581,331	3,679	165,405	85,452	2,876	1,120,653	16,910	14,271	104,754	2,197	134	103
1983	12,825	159,829	544,882	3,543	143,845	89,084	4,109	575,950	7,209	8,547	111,093	2,161	145	104
1984	12,473	163,036	527,860	4,062	135,597	111,755	4,052	666,403	17,566	5,394	145,346	2,033	144	78
1985	11,299	147,842	537,635	3,415	149,835	101,059	3,668	1,083,100	53,127	4,439	154,960			

Column: Notes and Explanations

1 Includes farms on which no farming activities were being carried out except for 1985.

1 and 2 ....Refers to 30 September of each year.

3-11 ....Refers to year ending 30 September of each year.

12-14 ....Refers to 30 June for 1972-1976 inclusive, from 1977 refers to 31 March.

2 ....Includes owners, partners, occupiers and lessees actively engaged in farming either as private limited liability companies or on a non-corporate basis. Farmers' wives are also included where they take an active part in the running of the farm. Domestics, Other Employees (Storemen, factory employees etc.) and, Casual and Contract employees are excluded.

3 ....The 1975 figure is not precisely comparable with those for other years as it excludes the area planted to other vegetables (other than onions, peas and tomatoes) garden plants etc. grown commercially. The extent of the change was small, however, as is indicated by the fact that the area planted to other vegetables, garden plants, etc. in 1974 was only 2,449 hectares.

5 ....The 1975 figure is not precisely comparable with those for other as it excludes area irrigated to other vegetables (other than onions, peas and tomatoes), garden plants etc. grown commercially. The extent of the change was small, however, as is indicated by the fact that the area irrigated to other vegetables, garden plants etc. in 1974 was only 2,067 hectares.

12-14 ....Excludes unclassified livestock refers to 31 March of each year.

A-Table 4-3 Crop Area Estimates by Sector

Unit: Ha

Crop	1985/86				1986/87					1987/88					1988/89				
	LSC	SSC	Communal & Resettlement	Total	LSC	SSC	Communal	Resettlement	Total	LSC	SSC	Communal	Resettlement	Total	LSC	SSC	Communal	Resettlement	Total
Flue cured tobacco	61,000			61,000	66,000	51	224		66,275	63,000	60	250		63,310	65,000	60	250		65,310
Burley tobacco	12,000	500	1,200	13,700	900	106	1,605		2,611	1,000	120	1,600		2,720	1,000	120	1,600		2,720
Oriental tobacco				0		19	64		83		20	70		90		20	70		90
Cotton*	74,000	10,000	150,000	234,000	80,000	13,000	138,000	15,000	246,000	80,000	13,000	138,000	17,000	248,000	80,000	13,000	138,000	20,000	251,000
Maize grain	195,000	5,000	1,200,000	1400,000	110,000	37,070	942,600	121,400	1,211,070	120,000	37,000	945,000	125,000	1,227,000	150,000	37,000	945,000	130,000	1,262,000
Maize seed	8,000			8,000	9,000				9,000	9,000				9,000	9,000				9,000
Wheat	42,000			42,000	42,000				42,000	36,000				36000	45,000				45,000
Barley	6,000			6,000	5,700				5,700	5,000				5,000	6,000				6,000
Soybeans	50,000	1,000	3,000	54,000	55,000	257	2,488	980	58,725	60,000	300	2,500	1,000	63,900	65,000	300	2,500	1,000	68,800
Groundnuts	2,500	5,000	140,000	147,500	5,000	10,354	176,645	10,200	202,199	6,000	12,000	180,000	11,000	209,000	7,000	12,000	180,000	12,000	211,000
Sunflower	1,600	2,000	32,000	35,600	6,200	6,310	72,670	1,950	87,130	6,200	6,000	70,000	2,250	84,450	6,200	6,000	70,000	2,500	84,700
Sorghua	20,000	2,000	225,000	247000	5000	2,480	164,322	8,400	180,202	4,000	2,500	165,000	8,500	180,000	4,000	2,500	165,000	8,500	180,000
Coffee	9,500			9,500	9500				9,500	10,000				10,000	10,500				10,500
Rapoko			200,000	200,000	50	3,000	109,211	7,040	119,301		3,000	110,000	7,000	120,000		3,000	110,000	7,000	120,000
Mhungs			300,000	300,000	112	1,031	187,277	2,600	191,020		1,000	180,000	2,500	183,500		1,000	180,000	2,500	183,500
Edible beans	1,000		20,000	21,000	1,500	574	16,890		18,964	1,500	700	17,000	700	19,900	1,500	700	17,000	700	19,900
Sugar cane	33,000			33,000	33,000				33,000	33,000				33,000	33,000				33,000
Tea	5,500			5,500	5,500				5,500	5,500				5,500	5,500				5,500
Fruit (incl. Citrus)	4,500			4,500	4,500				4,500	4,500				4,500	5,000				5,000
Vegetables/Flowers	2,500			2,500	3,500				3,500	4,000				4,000	4,500				4,500
Potatoes	18,000			18,000	2,000				2,000	2,000				2,000	2,000				2,000
Fodder	7,000			7,000	7,500				7,500	8,000				8,000	8,500				8,500
Silage	10,000			10,000	11,000				11,000	11,500				11,500	12,000				12,000
Pasture	15,000			15,000	15,500				15,500	16,000				16,000	16,500				16,500
Total	578,100	25,500	2,271,200	2,874,800	478,462	74,252	1,811,996	167,570	2,532,280	486,200	75,700	1,809,420	174,950	2,546,270	537,200	75,700	1,809,420	184,200	26,06,520
Sector total	603.6		2,271.2		552.8		1,979.6			561.9		1,984.4			612.9		1993.6		

Source: CSO

A-Table 4-4 (1) Large Scale Commercial Farm

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Tobacco:										
Flue-cured:										
Farm count	no.	78	465	249	224	–	–	*	–	1,017
Area planted	hectares	3,324	22,015	11,310	12,382	–	–	23	–	49,054
Crop sold	tonnes	7,361	43,248	26,035	24,374	–	–	41	–	101,059
Yield per hectare	kg	2,215	1,964	2,302	1,969	–	–	1,783	–	2,060
Burley:										
Farm count	no.	28	18	28	41	–	–	–	–	115
Area planted	hectares	578	212	315	847	–	–	–	–	1,952
Crop sold	tonnes	1,055	349	632	1,528	–	–	–	–	3,564
Yield per hectare	kg	1,825	1,646	2,006	1,804	–	–	–	–	1,826
Maize for grain:										
Total maize for grain:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Area planted	hectares	5,794	92,915	39,435	44,366	1,633	1,355	9,153	2,479	197,130
Crop reaped	tonnes	25,236	516,211	208,152	274,270	7,103	5,435	37,190	9,503	1,083,100
Yield per hectare	kg	4,356	5,556	5,278	6,182	4,350	4,011	4,063	3,833	5,494
Farm retentions (included above)	tonnes	5,147	39,475	52,069	20,083	3,178	2,021	8,947	2,923	133,843
For seed:										
Farm count	no.	*	35	39	62	*	*	5	4	149
Area planted	hectares	64	2,454	2,067	2,924	51	22	185	79	7,846
Crop reaped	tonnes	225	7,817	9,239	11,353	202	29	426	70	29,359
Yield per hectare	kg	3,516	3,185	4,470	3,883	3,961	1,318	2,303	886	3,742
Total area planted to maize:	hectares	5,858	95,369	41,502	47,290	1,684	1,377	37,375	2,558	204,976
Industrial crops:										
Sorghum:										
Total:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Area planted	hectares	455	9,166	553	1,711	332	140	1,104	484	13,945
Crop reaped	tonnes	1,659	34,529	2,862	8,166	1,047	315	3,116	1,433	53,127
Yield per hectare	kg	3,646	3,767	5,175	4,773	3,154	2,250	2,822	2,961	3,810
Farm retentions (included above)	tonnes	47	460	71	33	197	221	723	359	2,111

A-Table 4-4 (2) Large Scale Commercial Farm

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Wheat:										
Farm count	no.	38	143	69	107	*	*	18	10	397
Area planted	hectares	6,960	12,211	5,220	8,506	394	562	640	562	35,055
Crop reaped	tonnes	28,072	61,080	29,789	46,129	1,873	1,927	3,290	2,134	174,294
Yield per hectare	kg	4,033	5,002	5,707	5,423	4,754	3,429	5,141	3,797	4,972
Barley:										
Farm count	no.	*	12	24	6	–	*	22	*	69
Area planted	hectares	28	503	1,725	176	–	40	2,143	22	4,641
Crop reaped	tonnes	163	2,088	9,663	990	–	190	12,058	48	25,200
Yield per hectare	kg	5,821	4,151	5,589	5,625	–	4,750	5,627	2,182	5,430
Coffee (productive):										
Farm count	no.	82	41	*	13	*	–	4	4	148
Area planted	hectares	5,113	1,200	60	293	3	–	188	116	6,973
Crop reaped	tonnes	6,661	1,602	83	357	1	–	301	222	9,227
Yield per hectare	kg	1,303	1,335	1,383	1,218	333	–	1,601	1,914	1,323
Coffee (unproductive):										
Farm count	no.	45	7	*	–	–	–	*	*	56
Area established	hectares	1,243	425	11	–	–	–	13	30	1,722
Cotton (unginned):										
Total										
Farm count	no.	...	...	...	...	–	...	...	...	...
Area planted	hectares	7,258	28,157	408	27,464	–	1,315	887	4,800	70,289
Crop reaped	tonnes	21,610	50,563	702	63,352	–	4,033	1,433	13,267	154,960
Yield per hectare	kg	2,977	1,796	1,721	2,307	–	3,067	1,616	2,764	2,205
Groundnuts (unshelled):										
Farm count	no.	10	29	44	17	*	*	23	7	134
Area planted	hectares	47	682	961	126	1	10	68	31	1,926
Crop reaped	tonnes	76	1,286	2,540	353	–	21	136	27	4,439
Yield per hectare	kg	1,617	1,886	2,643	2,802	–	2,100	2,000	871	2,305
Farm retentions (included above)	tonnes	–	14	45	1	–	1	14	8	83

A-Table 4-4 (3) Large Scale Commercial Farms

Area and Production of Crops and Fruit, by Province (1985)

Crop	Unit	Manicaland	Mashonaland west	Mashonaland east	Mashonaland central	Matabeleland north	Matabeleland south	Midlands	Masvingo	Total
Soya beans (threshed):										
Farm count	no.	18	205	103	113	*	*	19	9	474
Area planted	hectares	850	20,818	8,208	8,960	73	4	1,052	442	40,407
Crop reaped	tonnes	1,681	41,543	17,544	21,048	139	16	1,670	775	84,416
Yield per hectare	kg	1,978	1,996	2,137	2,349	1,904	4,000	1,587	1,753	2,089
Farm retentions (included above)	tonnes	29	934	282	286	16	16	114	156	1,833
Sunflowers (threshed):										
Farm count	no.	14	33	16	9	4	*	20	*	102
Area planted	hectares	51	1,809	226	126	9	22	219	8	2,470
Crop reaped	tonnes	20	592	184	70	5	28	140	3	1,041
Field per hectare	kg	392	327	814	556	556	1,273	639	375	421
Total area under crops:	hectares	41,069	210,619	95,969	117,767	5,101	4,218	19,138	43,744	537,635
Fruit grown Commercially:										
Citrus:										
Orange:										
Farm count	no.	14	10	10	16	*	11	16	*	84
Total number of trees	'000	10	18	6	169	1	38	13	5	260
Area established	hectares	42	84	28	697	13	189	40	40	1,133
Value of sales	$'000	22	127	15	2,469	9	2,060	95	86	4,882
Total citrus:										
Farm count	no.	...	...	...	...	...	...	...	...	...
Total number of trees	'000	13	18	9	203	1	45	13	18	321
Area established	hectares	55	85	50	959	19	223	42	91	1,524
Value of sales	$'000	38	127	23	2,628	13	2,348	97	181	5,454
Tropical:										
Farm count	no.	...	...	...	...	–	...	...	...	...
Area established	hectares	251	137	37	52	–	–	–	18	495
Value of sales	$'000	561	715	13	83	–	2	1	6	1,381
Total area under crops and fruit:	hectares	42,246	210,856	96,353	118,895	5,120	4,512	19,195	43,863	541,050

A-Table 4-5 Nitrogen Fertilizer Statistics

Unit: 1,000 TN

	Total Nitrogen	Ammonium Sulphate	Ammonium Nitrates	Urea	Total Other N	Total Compounds
			Production			
Western Europe						
1984/1985	12,088.5	713.5	4,994.7	2,295.6	789.0	3,295.7
1985/1986	11,539.0	774.8	5,160.1	1,816.1	880.7	2,907.2
1986/1987	11,219.2	702.0	5,058.2	1,788.9	926.5	2,743.7
Eastern Europe						
1984/1985	20,417.7	1,050.5	7,828.6	6,544.9	1,776.4	3,217.3
1985/1986	21,240.5	1,086.8	7,403.1	6,929.5	2,083.6	3,737.6
1986/1987	22,289.3	1,134.9	7,820.9	7,389.1	2,277.0	3,667.5
Africa						
1984/1985	1,829.6	71.2	512.9	864.9	42.9	337.7
1985/1986	1,704.1	60.9	588.4	713.8	41.6	299.4
1986/1987	1,726.9	78.6	636.9	601.2	46.4	363.9
North America						
1984/1985	1,4150.3	466.0	914.6	2,844.0	7,584.9	2,340.8
1985/1986	1,2102.4	443.6	924.4	2,475.3	6,431.8	1,827.3
1986/1987	1,2017.4	450.5	874.5	2,736.1	5,741.0	2,215.4
Central America						
1984/1985	1,408.9	318.5	166.2	589.5	248.2	86.5
1985/1986	1,741.7	391.3	164.2	822.5	263.8	99.9
1986/1987	1,633.9	307.0	165.7	816.0	254.4	90.9
South America						
1984/1985	1,148.6	56.8	120.3	678.3	92.1	201.1
1985/1986	1,174.0	78.6	125.2	644.9	90.3	235.0
1986/1987	1,274.5	55.0	111.0	713.4	100.5	294.8
Middle East						
1984/1985	1,504.0	13.9	30.4	1,271.5	32.0	156.2
1985/1986	1,572.9	12.8	28.7	1,344.2	27.5	159.7
1986/1987	1,731.0	13.9	42.4	1,454.6	30.0	190.1
Asian CPE's						
1984/1985	12,927.0	194.0	712.0	4,311.0	7,695.0	15.0
1985/1986	12,195.1	183.0	679.0	4,655.0	6,663.1	15.0
1986/1987	12,248.0	165.0	700.0	4,820.0	6,548.0	15.0
South and East Asia						
1984/1985	9,030.3	662.9	241.8	6,668.2	119.3	1,338.1
1985/1986	9,747.2	752.1	233.5	7,164.4	140.6	1,456.7
1986/1987	11,207.7	736.7	237.7	8,484.6	129.1	1,619.7
Oceania						
1984/1985	246.5	50.0	20.0	135.0	6.0	35.5
1985/1986	279.0	45.0	18.0	164.0	8.0	44.0
1986/1987	255.1	40.7	25.0	143.0	9.7	36.7
World Total						
1984/1985	74,751.4	3,597.3	15,541.5 20.8%	26,202.9 35.1%	18,385.8	11,023.9
1985/1986	73,295.9	3,828.8	15,324.7 20.9%	26,729.7 36.5%	16,631.0	10,781.7
1986/1987	75,603.1	3,684.2	15,672.2 20.7%	28,946.8 38.3%	16,062.6	11,237.5

Source: Statistical Supplement, 1987 British Sulphur

A-Table 4-5 Nitrogen Fertilizer Statistics (Cont'd)

Unit: 1,000 TN

	Total Nitrogen	Ammonium Sulphate	Ammonium Nitrates	Urea	Total Other N	Total Compounds
	Consumption					
Western Europe						
1984/1985	11,016.2	385.5	5,174.9	1,074.9	953.4	3,427.4
1985/1986	11,125.4	378.1	5,094.0	1,335.9	985.1	3,332.3
1986/1987	11,479.7	379.3	5,176.6	1,547.1	1,093.2	3,283.4
Eastern Europe						
1984/1985	15,409.1	738.5	7,062.5	3,139.5	1,538.6	2,930.1
1985/1986	16,202.3	760.9	6,280.3	3,543.6	1,934.1	3,683.3
1986/1987	16,531.0	851.6	6,716.9	3,776.9	1,694.7	3,491.0
Africa						
1984/1985	1,931.1	108.9	611.6 31.7%	736.6 38.1%	42.1	431.9
1985/1986	2,098.1	150.6	688.7 32.8%	762.0 36.3%	42.0	454.8
1986/1987	1,893.3	90.8	678.2 35.8%	617.4 32.6%	42.1	465.3
North America						
1984/1985	11,717.9	168.0	833.0	1,591.1	6,781.0	2,344.8
1985/1986	10,751.4	148.4	655.7	1,912.6	5,859.9	2,174.8
1986/1987	10,538.7	141.1	642.3	1,851.2	5,774.6	2,129.4
Central America						
1984/1985	1,764.0	479.5	153.9	670.3	248.4	211.9
1985/1986	1,912.5	511.7	150.0	788.6	264.1	198.1
1986/1987	1,929.3	497.1	162.1	834.4	254.6	181.1
South America						
1984/1985	1,430.0	183.0	123.0	780.3	44.0	299.7
1985/1986	1,509.7	178.8	125.8	815.1	38.1	351.9
1986/1987	1,798.7	235.1	131.7	971.8	6.8	453.1
Middle East						
1984/1985	929.2	24.1	38.3	561.3	33.5	272.0
1985/1986	964.0	24.9	48.9	592.8	30.3	267.1
1986/1987	1,075.6	24.2	59.6	707.3	24.0	260.7
Asian CPE's						
1984/1985	15,761.7	245.8	706.0	6,556.3	7,697.0	556.6
1985/1986	14,565.0	219.0	673.0	6,652.7	6,631.3	389.0
1986/1987	14,223.4	165.0	665.0	6,746.8	6,335.0	309.6
South & East Asia						
1984/1985	10,276.2	503.3	240.0	7,465.4	55.5	2,012.0
1985/1986	10,846.0	533.1	277.2	7,945.6	61.8	2,028.4
1986/1987	12,162.8	560.8	225.6	9,145.2	58.7	2,172.5
Oceania						
1984/1985	351.6	58.9	22.6	105.8	6.1	158.2
1985/1986	363.8	52.2	20.4	124.0	8.0	159.2
1986/1987	400.0	64.4	26.2	156.1	9.7	143.7
World total						
1984/1985	70,586.9	2,895.4	14,965.9	22,681.5	17,399.6	12,644.5
1985/1986	70,338.1	2,957.7	14,014.0	24,472.9	15,854.7	13,038.8
1986/1987	72,032.3	3,009.6	14,484.2	26,354.2	15,293.9	12,890.1

Source: Statistical Supplement, 1987 British Sulphur

A-Table 4-6 Nitrogen Fertilizer Statistics

Unit: 1,000 TN

	Production			Consumption		
	1984/85	1985/86	1986/87[†]	1984/85	1985/86	1986/87[†]
World Total	74,751.4	73,295.9	75603.1	70586.9	70338.2	72032.3
Western Europe	12,088.5	11,539.0	11,219.2	11,016.2	11,125.4	11,479.7
Austria	300.5	315.0	278.0	161.1	165.1	136.7
Belgium/Lux	715.0	795.0	752.1	195.0	196.0	193.0
Denmark	186.8	164.0	120.8	398.0	382.1	381.3
Finland	307.1	287.0	298.0	196.1	202.1	211.1
France	1,692.5	1,600.0	1,529.4	2,336.7	2,408.1	2,568.3
Germany F.R.	1,271.9	1,219.2	1,119.9	1,451.8	1,516.8	1,587.9
Greece*	429.7	436.4	406.8	428.3	449.7	432.2
Ireland (Rep)	260.0	243.0	226.9	329.7	322.7	371.9
Italy	1,322.8	1,240.0	1,144.9	1,003.2	1,030.0	1,006.9
Netherlands	1,739.2	1,585.0	1,742.4	484.9	497.8	504.0
Norway	510.0	408.3	384.1	111.5	106.0	109.7
Portugal	130.0	165.0	165.3	123.2	137.4	149.9
Spain	994.0	1,014.5	948.6	913.4	900.9	887.9
Sweden	200.6	190.0	164.8	253.4	246.0	223.6
Switzerland	33.5	39.6	32.5	70.7	71.9	71.2
Turkey	628.4	618.0	574.2	954.8	916.0	950.6
United Kingdom	360.0	1,213.0	1,318.0	1,580.0	1,556.0	1,671.0
Eastern Europe	20,417.7	21,240.5	22,289.3	15,409.1	16,202.3	16,531.0
Bulgaria*	836.1	837.8	817.9	479.0	499.9	440.0
Czech	687.5*	647.6*	613.4*	691.7	670.8	640.0
Germany D.R*	960.1	1,078.2	1,252.0	697.0	770.0	709.0
Hungary*	667.7	682.5	672.2	625.9	558.5	593.4
Poland	1,369.3*	1,253.5*	1,444.9*	1,238.5	1,336.6	1,376.6
Romania*	2,212.0	2,197.0	1,900.0	857.0	817.0	716.0
USSR*	13,143.0	14,000.0	14,996.0	10,279.0	10,950.0	11,475.0
Yugoslavia*	470.0	471.9	517.9	469.0	527.5	506.0
Africa*	1,829.6	1,704.1	1,726.9	1,931.1	2,098.1	1,893.3
Algeria	65.0	101.5	113.8	83.0	96.7	114.4
Egypt	689.5	615.0	601.9	744.0	700.0	655.5
Libya	331.4	278.3	239.9	56.4	20.9	22.5
Morocco	34.6	59.5	72.6	104.3	128.3	140.1
Senegal	10.0	12.5	11.9	15.0	7.5	7.5
South Africa	481.9	420.0	428.5	406.6	379.7	364.5
Tunisia	118.0	120.1	153.5	41.5	43.8	47.1
Zimbabwe	68.6	68.9	76.4	71.6	93.0	81.7
North America	14,150.3	12,102.4	12,017.4	11,717.9	10,751.4	10,538.7
Canada	2,456.3	2,418.9	2,466.5	1,296.8	1,278.6	1,150.0
U.S.A.	11,694.0	9,683.5	9,550.9	10,421.1	9,472.8	9,388.7
Central America*	1408.9	1,741.7	1,633.9	1,764.0	1,912.5	1,929.3
Costa Rica	28.1	27.0	21.8	40.3	44.0	51.0
Cuba	161.1	166.6	164.6	294.4	293.6	321.0
Guatemala	9.0	9.0	9.0	55.5	57.1	73.1
Mexico	1,135.7	1,382.3	1,249.5	1,194.2	1,320.2	1,298.7
Trinidad	75.0	156.8	189.0	4.9	4.3	3.5

A-Table 4-6 Nitrogen Fertilizer Statistics (Cont'd)

Unit: 1,000 TN

	Production			Consumption		
	1984/85	1985/86	1986/87†	1984/85	1985/86	1986/87†
South America	1,148.6	1,174.0	1,274.5	1,430.0	1,509.7	1,798.7
Argentina	34.0	29.3	32.5	97.7	101.7	96.0
Brazil	669.0	723.6	712.4	802.0	852.0	988.1
Chile	113.3	113.0	108.4	86.3	106.1	92.0
Colombia	58.9	65.1	75.0	180.9	184.9	197.2
Peru	18.7	47.2	33.0	53.4	49.7	78.9
Venezuela	254.7	195.8	311.7	123.1	146.5	244.7
Middle East	1,504.0	1,572.9	1,731.0	929.2	964.0	1,075.6
Iran	13.8	7.0	72.5	486.6	465.3	529.1
Iraq*	25.7	38.8	64.0	73.0	120.0	131.0
Israel	81.1	77.5	80.0	81.0	53.8	48.6
Jordan*	102.4	91.9	99.2	7.0	9.8	10.8
Kuwait*	280.8	316.0	316.0	0.5	0.7	0.2
Qatar*	341.0	342.2	343.6	0.6	0.5	0.7
Saudi Arabia	397.0*	421.3*	440.0*	138.6	155.0	181.7
Syria*	104.3	115.5	104.1	107.7	131.5	143.6
U.A.Emirates*	157.9	162.7	211.6	3.0	3.1	1.0
Asian CPE's	12,927.0	12,195.1	12,248.0	15,761.7	14,565.0	14,223.4
China P.R.*	12,212.0	11,440.1	11,588.0	14,800.0	13,581.3	13,283.0
Korea North*	700.0	735.0	640.0	639.0	694.0	605.5
Vietnam*	15.0	20.0	20.0	310.2	272.0	320.1
South and East Asia	9,030.3	9,747.2	11,207.7	10,276.2	10,846.0	12,162.8
Bangladesh	343.1	375.7	391.2	386.3	367.7	423.7
Burma	86.5	115.0	168.0	127.4	134.0	142.0
India	3,917.3	4,322.9	5,411.7	5,333.3	5,701.8	6,531.8
Indonesia*	1,402.4	1,749.1	1,849.0	1,296.2	1,305.2	1,375.0
Japan	1,210.2	1,064.5	989.6	698.0	694.0	687.0
Korea South*	659.9	675.0	630.7	401.8	426.1	418.0
Malaysia	47.0	49.0	180.0	249.0	238.0	237.2
Pakistan	1,027.2	1,036.5	1,117.6	936.2	1,128.1	1,335.4
Philippines*	15.7	88.2	124.2	178.0	204.8	293.2
Taiwan*	208.2	210.6	289.1	265.0	240.0	256.1
Oceania	246.5	279.0	255.1	351.6	363.8	400.0
Australia*	191.5	209.0	202.1	301.0	320.0	360.0
New Zealand	55.0	70.0	53.0	29.2	30.3	27.0

†Preliminary
*Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-7 World Nitrogenous Fertilizer Supply/Demand Forcast

Unit: 1,000 T N, %

	1985/86			1990/91			1991/92			% Change	
	Supply *	Demand	Balance	Supply *	Demand	Balance	Supply *	Demand	Balance	Supply	Demand
Developed Area	22,919	22,900	19	22,851	23,020	–169	22,931	23,240	–309	0.01	0.25
N. America	11,119	10,690	429	11,076	10,500	576	11,048	10,650	398	–0.11	–0.06
W. Europe	10,439	10,720	–281	10,662	10,950	–288	10,670	11,000	–330	0.37	0.43
Oceania	335	360	–25	387	400	–13	506	410	96	7.12	2.19
Others	1,026	1,130	–104	726	1,170	–444	707	1,180	–473	–6.02	0.72
Developing Area	15,140	16,790	–1,650	19,566	21,910	–2,344	20,488	22,960	–2,472	5.17	5.35
Africa	208	860	–652	582	1,030	–448	581	1,070	–489	18.67	3.71
Latin America	4,046	3,410	636	4,525	4,590	–65	4,885	4,890	–5	3.19	6.19
Near East	2,926	2,720	206	4,001	3,290	711	4,137	3,400	737	5.94	3.79
Far East	7,960	9,800	–1,840	10,458	13,000	–2,542	10,884	13,600	–2,716	5.35	5.61
Central Planned Area	35,227	30,290	4,937	37,758	35,180	2,578	37,901	36,100	1,801	1.23	2.97
E. Europe	22,432	15,710	6,722	23,580	18,020	5,560	23,701	18,500	5,201	0.92	2.76
Asia	12,795	14,580	–1,785	14,178	17,160	–2,982	14,201	17,600	–3,399	1.75	3.18
World Total	73,286	69,980	3,306	80,175	80,110	65	81,320	82,300	–980	1.75	2.74

*: Available Supply

Source: FAO/UNIDO/World Bank Fertilizer Working Group, June 1987.

A-Table 4-8 Nitrogen Trade Statistics

Unit: 1,000 TN

	Imports			Exports		
	1984/85	1985/86	1986/87†	1984/85	1985/86	1986/87†
World Total	15,688.1	14,622.3	16,967.8	15,901.4	14,732.3	16,990.2
Western Europe	4,055.3	4,242.7	5,021.2	4,879.4	4,324.6	4,577.8
Austria	61.8	75.0	82.6	201.6	205.0	145.6
Belgium/Lux	189.1	245.1	379.6	811.8	785.7	1,006.0
Denmark	245.3	267.0	123.8	52.1	53.1	11.0
Finland	13.5	28.7	15.2	105.0	57.5	53.4
France	960.5	1,027.3	1,261.5	339.9	242.8	238.9
Germany F.R.	882.6	839.4	889.2	647.7	574.8	610.2
Greece	58.3	94.1	97.8	14.3	18.7	33.5
Ireland (Rep)	200.5	195.5	234.9	103.2	82.1	64.0
Italy	202.6	223.0	257.6	413.7	383.3	464.4
Netherlands	210.1	238.7	266.3	1,470.3	1,255.2	1,478.6
Norway	6.2	9.9	14.8	370.4	292.8	200.7
Portugal	17.0	16.9	28.1	25.7	43.3	40.7
Spain	35.5	87.7	240.6	96.4	105.2	71.9
Sweden	195.7	167.9	174.2	89.9	105.7	29.2
Switzerland	52.5	51.5	49.9	–	–	–
Turkey	331.0	305.6	376.2	9.5	16.9	32.3
U.K.	374.9	349.0	517.9	127.9	102.5	97.4
Eastern Europe*	592.5	696.8	532.6	4,342.1	4,596.4	5,351.9
Bulgaria	5.8	7.4	5.5	300.0	302.8	966.3
Czechoslovakia	190.4	185.4	90.8	139.5	145.5	134.2
Germany D.R.	32.0	11.8	5.9	284.3	385.1	379.9
Hungary	203.7	284.9	287.1	285.7	320.3	287.3
Poland	10.6	19.5	2.9	103.7	72.5	77.7
Romania	0.4	0.4	3.8	1,231.3	1,187.9	1,016.8
USSR	24.9	36.6	33.6	1,883.9	2,043.2	2,278.4
Yugoslavia	124.7	150.8	103.0	113.7	139.1	179.7
Africa*	636.4	919.0	598.2	531.9	467.7	412.3
Egypt	32.5	147.1	61.0	53.6	–	9.2
Kenya	34.2	51.0	58.2	–	–	–
Libya	31.9	16.6	26.2	309.6	276.0	242.5
Morocco	91.5	83.1	102.1	7.1	18.7	15.3
South Africa	9.3	41.6	19.8	75.4	67.7	36.1
Tunisia	6.4	3.0	8.1	77.1	78.4	99.5
Zambia	56.6	36.5	30.4	–	–	–
Zimbabwe	10.0	33.5	22.9	–	–	–
North America	2,148.0	2,426.4	3,064.9	3,628.2	2,676.3	3,379.6
Canada	175.7	159.2	211.2	1,499.5	1,367.9	1,651.6
U.S.A.	1,972.3	2,267.2	2,853.7	2,128.7	1,308.4	1,728.0

† Preliminary

* Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-8 Nitrogen Trade Statistics (Cont'd)

Unit: 1,000 TN

	Imports			Exports		
	1984/85	1985/86	1986/87[†]	1984/85	1985/86	1986/87[†]
Central America*	522.4	581.8	521.1	134.6	197.2	291.2
Costa Rica	16.7	30.5	17.9	–	–	–
Cuba	191.4	203.8	178.5	–	–	–
Guatemala	36.2	82.7	56.7	8.8	9.2	10.3
Mexico	70.8	71.7	92.6	57.7	18.1	37.5
Nicaragua	28.2	42.9	49.9	–	–	–
Trinidad	1.8	2.4	1.1	56.0	160.9	227.0
South America*	557.7	588.7	829.5	201.7	145.5	148.9
Argentina	54.2	71.7	46.3	–	–	–
Brazil	152.4	160.0	307.1	12.0	6.7	0.3
Chile	52.7	56.4	97.0	51.1	66.4	33.2
Colombia	145.1	129.8	162.2	–	–	–
Ecuador	49.5	56.2	63.9	–	–	–
Peru	26.6	21.0	65.8	–	–	–
Venezuela	29.0	55.7	57.3	137.8	65.3	115.4
Middle East	577.2	608.3	756.2	1,193.5	1,181.5	1,470.2
Iran	432.5	358.6	556.9	–	–	–
Iraq*	66.9	89.3	48.3	3.5	9.3	23.0
Jordan*	8.0	10.1	11.1	94.9	90.6	100.0
Kuwait*	0.1	0.1	0.2	270.7	265.3	377.2
Qatar*	0.1	–	0.1	326.0	323.4	367.6
Saudi Arabia*	29.2	65.6	67.5	325.6	314.5	373.8
U.A.Emirates*	3.1	1.8	1.5	144.0	157.8	224.6
Asian CPE'S	3,058.9	1,845.0	2,220.3	61.8	16.1	7.2
China P.R.	2,755.9	1,565.8	1,780.6	–	–	5.1
Korea North*	10.0	7.9	11.5	61.8	16.1	2.1
Vietnam	280.7	253.6	414.9	–	–	–
South and East Asia	3,348.9	2,579.9	3,163.7	893.0	1,067.2	1,299.5
Burma*	60.2	5.9	2.6	–	11.5	29.5
India	2,102.6	1,433.8	1,893.7	–	–	–
Indonesia*	112.1	5.9	7.1	93.5	347.7	695.8
Japan	71.5	84.3	133.0	325.5	222.2	84.0
Korea South*	8.3	4.0	1.6	240.7	227.7	188.3
Malaysia	241.7	181.7	117.4	–	16.6	88.1
Pakistan	88.2	85.6	144.0	210.2	171.7	80.5
Philippines*	146.6	201.9	306.3	–	40.4	108.0
Taiwan*	86.3	84.8	70.9	–	6.4	1.6
Thailand	269.4	237.3	344.1	–	–	–
Oceania	181.3	133.7	155.0	35.2	59.8	51.6
Australia*	146.5	103.7	130.0	1.4	1.1	1.1
New Zealand	16.4	17.0	14.4	33.8	58.7	50.5

[†] *Preliminary*

* Denotes calendar year data (1986/87 includes 1986 data, etc.) Regional totals include countries not specified separately.

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-9 Fertilizer Specifications

1) Compouds

Compound	Nitrogen	Citric soluble phosphate	Potash	Minimum sulphur	Micro nutrient content	Use
A	2	17	15 (sul)	10.0%	0.1% boron	tobacco
B	4	17	13 (sul)	9.0%	0.1% boron	tobacco
C	6	17	15 (11 sul, 4 chlor)	7.5% 6.5%	0.1% boron	tobacco
D	8	14	7 (chlor)	6.5%	–	maize/general
J	15	5	20 (chlor)	3.4%	0.1% boron	fruit trees
L	5	18	10 (chlor)	8.0%	0.25% boron	cotton
M	10	10	10 (chlor)	6.5%	–	maize/general
P	10	18	0	6.5%	–	sunflowers
S	7	21	7 (sul)	9.0%	0.04% boron	maize/general
T*	25	5	5 (sul)	5.0%	–	tea
V	4	17	15 (11 sul, 4 chlor)	8.0%	0.1% boron	tobacco
X	20	10	5 (chlor)	3.0%	–	gardening
Z	8	14	7 (chlor)	6.5%	0.8% zinc.	maize/general

* Manufactured only against firm order
Sul = manufactured with potassium sulphate.
Chlor = manufactured with potassium chloride.

2) Straights

Nitrogen

Ammonium Nitrate	34.5% N
Urea	46% N
Sodium Nitrate	16% N

Phosphate

Double Superphosphate (Granular)	37% P_2O_5 (Citric Sol) 5% Sulphur Min.
Single Superphosphate (Powder)	18.5% P_2O_5 (Citric Sol) 12% Sulphur Min.

Potosh

Potassium Chloride (Muriate of Potash)	60% K_2O
Potassium Sulphate (Sulphate of Potash)	50% K_2O 16% Sulphur Min.

Gypsum

Calcium Sulphate (Gypsum) 17.5% S

A-Table 4-10 Zimbabwe – Fertilizer Sales by Product

Unit: T

Year (1/3-28/2)	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
Product								
A	4,655	5,211	3,899	3,170	3,003	2,784	3,804	3,631
B	4,142	3,858	3,593	5,267	4,035	4,654	9,183	10,872
C	18,066	25,070	26,529	36,729	28,558	39,143	40431	30,730
V	8,769	8,595	7,936	8,088	6,430	7,801	7,717	5,742
D	85,559	109,425	100,082	102,835	95,049	113,849	95,980	81,833
J	6,395	5,731	5,068	7,535	5,593	8,625	10,350	9,632
L	39,731	28,421	28,081	38,209	33,898	42,512	37,394	39,870
M	17,831	31,789	28,540	20,792	16,305	18,010	13,337	13,376
P	31,835	10,972	7,334	3,718	5,363	3,295	2,851	2,876
S	25,000	22,876	14,916	18,003	11,076	11,830	13,662	13,037
T	1,174	800	1,676	4,138	1,628	3,784	5,804	5,524
X	6,865	4,378	3,227	1,931	2,405	3,738	2,826	2,972
Z	20,542	23,467	16,992	15,810	13,646	22,362	15,458	12,350
Subtotal	270,564	280,593	247,900	266,225	226,989	282,387	258,797	232,445
AS	229	432	306	371	315	580	749	876
AN	129,044	119,667	168,476	145,415	147,951	171,002	141,919	157,141
Sod. N.	1,031	1,279	1,052	1,489	1,642	1,720	2,199	2,289
Urea	43,408	78,588	22,690	22,850	7,118	25,493	27,155	1,629
SSP	20,395	13,517	10,313	12,594	7,404	12,825	10,913	12,492
D. Super	5,999	5,995	5,852	6,191	5,532	4,693	6,165	5,751
KCl	5,228	5,463	5,858	6,746	4,460	6,790	6,632	6,033
K_2SO_4	514	482	526	720	918	907	1,522	948
Total	476,412	506,016	462,973	462,601	402,329	506,397	456,051	419,604

Source: 1980/81~84/85 FROM: WORLD BANK REPORT NO.6349-ZIM;
1985/86~87/88 FROM: ZFC & WINDMILL AN INDUSTRIAL SECTUR MEMORANDUM (1987)

A-Table 4-11 Ammonia Production and Deliveries in Major Producing Countries

January - December 1987

Unit: 1,000 T N

	Production				Home Deliveries				Exports			
	1985	1986	1987	% change 87/86	1985	1986	1987	% change 87/86	1985	1986	1987	% change 87/86
West Europe												
– France	2,011.5	2,022.0	2,029.0	0.3	1,898.5	1,863.3	1,827.6	–1.9	113.0	158.6	201.4	27.0
– Germany Fed. Rep.	1,907.5	1,570.3	1,931.0	23.0	1,648.0	1,412.6	1,579.6	11.8	259.5	157.7	351.4	122.8
– Italy	1,460.2 E	1,509.7	1,432.1	–5.1	1,316.6	1,320.5	1,368.2	3.6	126.5	158.2	64.4	–59.3
– Netherlands	2,776.3	2,695.4	2,827.9	4.9	2,018.9	1,962.7	2,114.8	7.7	842.4	689.6	782.6	13.5
– Norway	457.7	299.8	347.4	15.9	425.2	298.3	347.4	16.5	32.5	1.6	–	–
– Spain	602.3	464.4	449.3	–3.3	1,124.4	1,076.7	957.0	–11.1	–	–	–	–
– United Kingdom	1,767.0	1,388.0	1,415.0	1.9	1,476.0	1,338.5	1,389.0	3.8	302.0	59.5	26.0	–56.3
North America												
– Canada	2,962.5	2,891.0	2,741.1	–5.2	2,035.3	1,808.4	1,675.5	–7.4	791.6	833.5	1,106.6	32.8
– USA	12,010.0	10,431.3	11,720.5	12.4	11,924.0	10,074.0	11,166.7	10.8	917.0	484.8	769.1	58.6
Latin America												
– Brazil	944.8	882.0	951.5	7.9	926.6	953.2	971.6	1.9	27.6	–	–	–
– Trinidad & Tobago	1,085.2	1,141.0	1,127.1	–1.2	171.0	243.4	237.4	–2.5	915.2	925.3	873.2	–5.6
– Venezuela	410.2	481.1	523.1	8.7	282.8	333.9	413.4	23.8	144.6	135.6	91.4	–32.6
Middle East												
– Abu Dhabi U.E.A	282.3	290.8	302.4	4.0	175.2	215.6	226.0	4.8	95.8	75.1	59.1	–21.4
– Bahrain	110.1	288.6	275.7	–4.5	–	–	–	–	77.9	294.1	282.1	–4.1
– Kuwait	322.7	450.6	577.5	28.2	286.9	359.5	432.9	20.4	54.2	78.6	156.9	99.6
– Lybia	411.0	352.2	NA	NA	298.4	259.9	NA	NA	112.6	91.0	36.2	–60.2
– Qatar	526.1 E	544.1	560.8	3.1	363.2	360.5 E	323.8	–10.2	162.9	185.7	237.1	27.7
– Saudi Arabia	436.2	466.7	636.9	36.5	439.4	464.1	508.9	9.7	–	–	132.9	–
Asia												
– India	4,270.2	4,933.2	5,299.4 P	7.4	4,300.2	5,132.1	5,467.9 P	6.5	–	–	–	–
– Indonesia	2,057.3	2,298.5	2,363.9	2.8	1,674.3	1,819.0	2,137.3	17.5	188.1	212.9	202.2	–5.0
– Japan	1,645.5	1,507.9	1,555.6	3.2	1,644.7	1,539.7 E	1,576.6	2.4	–	–	–	–
– Korea, Rep. of	435.0	419.7	477.1	13.7	480.1	403.3	476.3	18.1	–	–	–	–
– Malaysia	NA	NA	321.3	–	NA	NA	299.3	–	–	–	18.7	–
Oceania												
– Australia	404.5	340.0	413.4	21.6	336.0	287.0	366.8	27.8	68.5	52.9	46.5	–12.1

E : Estimate
P : Preliminary

Source: IFA

A-Table 4-12 (1) Ammonia Exports

January - December 1987

Unit: 1,000 T N

	France	West Germany	Italy	Nether.	United Kingdom	Canada	USA	Trinidad	Venezuela	Libya	Abu Dhabi	Bahrain	Kuwait	Qatar	Saudi Arabia	Indon.	Various	1987 Partial Total	1986 Partial Total
West Europe																			
– Austria	–	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	0.4
– Belgium	9.4	11.7	–	433.8	–	–	104.1	83.7	–	–	–	1.7	8.3	–	19.4	–	–	672.1	419.1
– Denmark	–	168.4	–	12.9	–	–	6.9	96.9	–	–	–	–	–	–	–	–	–	285.1	203.7
– Finland	–	25.3	–	22.2	–	–	70.9	4.5	8.6	–	–	–	–	–	–	–	–	131.5	64.0
– France	–	25.6	–	18.1	–	–	–	55.9	–	–	–	24.3	–	16.3	–	–	–	140.2	107.0
– W. Germany	79.1	–	–	88.0	–	–	–	–	–	–	–	–	–	–	–	–	–	167.1	234.6
– Greece	–	–	29.9	–	9.0	–	–	25.0	–	–	–	8.6	–	17.3	–	–	–	89.9	72.6
– Iceland	3.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.3	1.6
– Ireland	–	–	–	1.8	–	–	–	–	–	–	–	–	–	–	–	–	–	1.8	0.0
– Italy	–	–	–	–	–	–	–	25.1	–	–	–	1.2	–	22.7	–	–	–	49.0	12.1
– Netherlands	0.8	0.8	–	–	–	–	–	21.1	–	–	–	–	–	–	–	–	–	22.7	48.0
– Norway	–	6.6	–	8.2	–	–	62.1	–	–	–	–	–	–	–	–	–	–	76.9	75.3
– Portugal	1.7	13.2	–	20.6	3.0	–	–	7.4	–	–	–	3.4	–	–	–	–	–	49.3	37.3
– Spain	47.5	11.3	–	31.1	9.0	–	71.4	53.3	12.2	14.4	–	6.4	–	4.3	–	12.3	–	273.2	281.7
– Sweden	8.5	14.2	–	2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	25.2	22.2
– Switzerland	4.7	5.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.1	28.3
– United Kingdom	40.9	54.4	–	107.8	–	–	–	26.9	–	–	–	–	–	6.6	–	–	–	236.5	220.7
– Sub Total	195.9	337.5	29.9	746.9	21.0	0.0	315.4	399.8	20.8	14.4	0.0	45.6	8.3	67.3	19.4	12.3	0.0	2,234.5	1,828.6
East Europe																			
– East Germany	–	10.1	–	4.9	–	–	–	–	–	–	–	–	–	–	–	–	–	15.0	0.0
– Sub Total	0.0	10.1	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0
North America																			
– Canada	–	–	–	–	–	–	7.2	–	–	–	–	–	–	–	–	–	–	7.2	15.3
– Trinidad	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	14.4
– USA	–	–	–	–	–	1,077.5	–	419.1	13.0	–	–	–	–	–	–	–	–	1,509.6	1,297.5
– Sub Total	0.0	0.0	0.0	0.0	0.0	1,077.5	7.2	419.1	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,516.8	1,327.2
Latin America																			
– Brazil	–	–	–	–	–	–	–	29.1	–	–	–	–	–	–	–	–	–	29.1	16.7
– Chile	–	–	–	–	–	–	–	–	19.5	–	–	–	–	–	–	–	–	19.5	11.8
– Colombia	–	–	–	–	–	–	–	–	15.2	–	–	–	–	–	–	–	–	15.2	10.4
– Costa Rica	–	–	–	–	–	8.2	–	–	–	–	–	–	–	–	–	–	–	8.2	27.1
– Cuba	–	–	–	–	–	–	–	–	22.9	–	–	–	–	–	–	–	–	22.9	19.3
– El Salvador	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.5
– Mexico	–	–	–	–	–	–	108.4	–	–	–	–	–	–	–	–	–	–	108.4	10.6
– Sub Total	0.0	0.0	0.0	0.0	0.0	8.2	108.4	29.1	57.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	203.3	85.8

Source: IFA

A-Table 4-12 (2) Ammonia Exports

January - December 1987

Unit: 1,000 T N

	France	West Germany	Italy	Nether.	United Kingdom	Canada	USA	Trinidad	Venezuela	Libya	Abu Dhabi	Bahrain	Kuwait	Qatar	Saudi Arabia	Indon.	Various	1987 Partial Total	1986 Partial Total
Africa																			
– Algeria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0
– Ivory Coast	0.9	–	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	1.7	0.0
– Liberia	–	–	–	–	–	–	1.4	–	–	–	–	–	–	–	–	–	–	1.4	1.2
– Mauritius	–	–	–	–	–	–	–	–	–	–	2.6	–	–	–	–	–	–	2.6	0.0
– Morocco	3.1	3.8	–	–	5.0	–	15.1	8.0	–	6.6	–	–	–	–	–	–	–	41.5	9.9
– Mozambique	–	–	–	–	–	–	–	–	–	–	7.8	–	–	10.7	–	–	–	18.5	4.1
– Nigeria	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.5	0.0
– Senegal	–	–	–	–	–	–	11.5	6.9	–	–	–	–	–	–	–	–	–	18.4	0.0
– South Africa	–	–	–	–	–	10.2	85.9	–	–	–	–	–	–	–	–	–	–	96.1	20.7
– Tanzania	–	–	–	–	–	–	3.3	–	–	–	–	–	–	–	–	–	–	3.3	3.3
– Tunisia	–	–	–	–	–	–	28.0	10.4	–	–	–	49.0	45.1	–	–	–	–	132.5	128.9
– Others	–	–	–	–	–	–	4.9	–	–	–	–	–	–	7.8	–	–	–	12.7	19.8
– Sub Total	5.5	3.8	0.0	0.8	5.0	10.2	150.1	25.3	0.0	6.6	10.4	49.0	45.1	18.5	0.0	0.0	0.0	330.2	187.9
Middle East																			
– Israel	–	–	–	2.5	–	–	–	–	–	–	–	–	–	–	–	–	–	2.5	0.0
– Jordan	–	–	–	–	–	–	–	–	–	15.3	–	51.8	24.4	5.2	12.3	–	–	109.0	54.3
– Turkey	–	–	3.3	–	–	–	–	–	–	–	–	11.2	–	26.0	57.0	–	–	97.4	70.3
– Sub Total	0.0	0.0	3.3	2.5	0.0	0.0	0.0	0.0	0.0	15.3	0.0	62.9	24.4	31.2	69.3	0.0	0.0	208.9	124.6
Asia																			
– India	–	–	–	–	–	–	–	–	–	–	44.2	102.0	58.2	73.1	9.4	19.3	31.7 (2)	337.9	336.4
– Korea, Rep. of	–	–	–	–	–	–	157.6	–	–	–	4.5	22.4	–	24.6	14.3	34.5	–	257.9	320.6
– Malaysia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.1
– Philippines	–	–	–	–	–	9.9	2.9	–	–	–	–	–	12.3	14.9	–	87.4	23.8 (3)	151.2	87.2
– Singapore	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.3	0.3 (1)	2.6	1.6
– Taiwan, China	–	–	–	–	–	–	27.1	–	–	–	–	–	7.4	7.6	12.3	44.8	3.9 (1)	103.1	114.2
– Thailand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.3	5.4 (1)	6.7	0.6
– Sub Total	0.0	0.0	0.0	0.0	0.0	9.9	187.5	0.0	0.0	0.0	48.7	124.5	77.9	120.2	36.0	189.6	65.2	859.5	860.7
Oceania																			
– Australia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	8.2
– New Zealand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0	0.0
– Sub Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2
Others	–	–	31.2	27.5	–	0.8	0.6	–	–	–	–	–	1.0	–	8.2	0.3	13.0 (5)	82.6	75.3
World total	201.4	351.4	64.4	782.6	26.0	1106.6	769.1	873.2	91.3	36.2	59.1	282.0	156.8	237.1	132.9	202.2	78.2	5,450.7	4,498.3
Total 1986	158.6	157.7	158.2	689.6	59.5	833.5	484.7	925.3	136.0	91.0	75.1	294.1	78.6	185.7	–	213.0	54.5 (4)		
% Change 87/86	27.0	122.8	–59.3	13.5	–56.3	32.8	58.7	–5.6	–32.8	–60.2	–21.4	–4.1	99.4	27.7	–	–5.1	43.6		
Total 1985	113.0	259.5	108.0	842.4	302.0	791.6	917.0	915.2	144.6	112.6	95.9	77.9	54.2	162.9	–	188.1	128.7 (6)		

(1) Malaysia
(2) Australia
(3) Australia 14.8, Malaysia 9.0
(4) Australia 53.9, Norway 1.6
(5) Mexico (January - June figures)
(6) Norway 32.5, Brazil 27.6, Australia 68.6

A-Table 4-13 Main Soviet Ammonia Imports

January - December

Unit: 1,000 TN

	1985	1986	1987
Denmark	42.9	22.2	12.4
Finland	169.2	157.5	176.4
India	–	–	55.0
Italy	72.0	72.3	41.1
Korea Rep. of	–	–	29.7
Morocco	48.1	54.3	32.5
Norsk Hydro Group	92.5	125.4	55.9
Portugal	–	32.2	–
Spain	39.6	216.6	148.9
Tunisia	13.1	25.5	13.8
Turkey	344.3	304.6	474.7
United Kingdom	41.0	10.0	10.0
United States	751.1	557.7	675.5
Total	1,613.7	1,578.2	1,726.0

Source: IFA

A-Table 4-14 (1) Fertilizer Sales (Mar. 1984 - Feb. 1985)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,658	1,345	3,003
B	2,400	1,635	4,035
C	16,821	11,737	28,558
V	3,696	2,734	6,430
D	54,425	40,624	95,049
J	4,666	927	5,593
L	18,838	15,060	33,898
M	11,222	5,083	16,305
P	4,952	411	5,363
S	6,824	4,252	11,076
T	1,628	0	1,628
X	1,606	799	2,405
Z	6,918	6,728	13,646
Total Compounds	135,654	91,335	226,989
Ammonuim Nitrate	90,403	57,548	147,951
Sulphate of Ammonia	264	51	315
Sodium Nitrate	935	707	1,642
Urea	5,542	1576	7,118
Total Nitrogen	97,144	59,882	157,026
Single Supers	5,021	2,383	7,404
Double Supers	2,900	2,632	5,532
Total Phosphates	7,921	5,015	12,936
Potassium Chloride	3,078	1,382	4,460
Potassium Sulphate	326	592	918
Total Potash	3,404	1,974	5,378
Grand Total	244,123	158,206	402,329

A-Table 4-14 (2) Fertilizer Sales (Mar. 1985 - Feb. 1986)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,442	1,342	2,784
B	2,776	1,878	4,654
C	22,608	16,535	39,143
V	4,205	3,596	7,801
D	64,926	48,923	113,849
J	7,263	1,362	8,625
L	22,871	19,641	42,512
M	12,665	5,345	18,010
P	2,680	615	3,295
S	5,994	5,836	11,830
T	3,764	0	3,784
X	2,766	972	3,738
Z	12,014	10,348	22,362
Total Compounds	165,994	116,393	282,387
Ammonuim Nitrate	102,137	68,865	171,002
Sulphate of Ammonia	515	65	580
Sodium Nitrate	1,023	697	1,720
Urea	12,069	13,424	25,493
Total Nitrogen	115,744	83,051	198,795
Single Supers	8,172	4,653	12,825
Double Supers	3,273	1,420	4,693
Total Phosphates	11,445	6,073	17,518
Potassium Chloride	4,579	2,211	6,790
Potassium Sulphate	492	415	907
Total Potash	5,071	2,626	7,697
Grand Total	298,254	208,143	506,397

A-Table 4-14 (3) Fertilizer Sales (Mar. 1986 - Feb. 1987)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	2,409	1,395	3,804
B	5,587	3,596	9,183
C	24,202	16,229	40,431
V	4,468	3,249	7,717
D	55,997	39,983	95,980
J	8,282	2,068	10,350
L	21,561	15,833	37,394
M	8,487	4,850	13,337
P	2,662	189	2,851
S	7,745	5,917	13,662
T	5,804	0	5,804
X	1,724	1,102	2,826
Z	8,260	7,198	15,458
Total Compounds	157,188	101,609	258,797
Ammonuim Nitrate	81,312	60,607	141,919
Sulphate of Ammonia	284	465	749
Sodium Nitrate	1,287	912	2,199
Urea	16,179	10,976	27,155
Total Nitrogen	99,062	72,960	172,022
Single Supers	5,793	5,120	10,913
Double Supers	3,630	2,535	6,165
Total Phosphates	9,423	7,655	17,078
Potassium Chloride	3,743	2,889	6,632
Potassium Sulphate	733	789	1,522
Total Potash	4,476	3,678	8,154
Grand Total	270,149	185,902	45,6051

A-Table 4-14 (4) Fertilizer Sales (Mar. 1987 - Feb. 1988)

Unit: T

Product	ZFC	WINDMILL	Total Tonnes
Compound			
A	1,807	1,824	3,631
B	6,098	4,774	10,872
C	19,589	11,141	30,730
V	3,533	2,209	5,742
D	46,848	34,985	81,833
J	7,705	1,927	9,632
L	21,681	18,189	39,870
M	7,358	6,018	13,376
P	2,237	639	2,876
S	7,566	5,471	13,037
T	5,445	79	5,524
X	1,968	1,004	2,972
Z	5,883	6,467	12,350
Total Compounds	137,718	94,727	232,445
Ammonuim Nitrate	89,224	67,917	157,141
Sulphate of Ammonia	682	194	876
Sodium Nitrate	1,354	935	2,289
Urea	1,314	315	1,629
Total Nitrogen	92,574	69,361	161,935
Single Supers	7,218	5,274	12,492
Double Supers	3,283	2,468	5,751
Total Phosphates	10,501	7,742	18,243
Potassium Chloride	3,429	2,604	6,033
Potassium Sulphate	572	376	948
Total Potash	4,001	2,980	6,981
Grand Total	244,794	174,810	419,604

A-Table 4-15 Effect of Increased Nitrogen Nutrient Dosage

1. Maize

Basal Application	Compound Fertilizer	360 kg/ha
	Average N Content	8.0%
Top Dressing	Ammonium Nitrate	380 kg/ha
	N Content	34.5%

360 kg/ha x 0.08 = 28.8 kgN/ha

380 kg/ha x 0.345 = 131.1 kgN/ha

Total N Applied 159.9 ≒ 160 kgN/ha

Next, the sensitivity is calculated for the following

	dosage	yield
Commercial	160 kgN/ha	4,148 kg/ha
Communal	16 kgN/ha	811 kg/ha

Over the range of 16 kgN/ha:

$$\frac{(4.15 - 0.81) \times 10^3 \text{kg/ha}}{(160 - 16) \text{ kgN/ha}} = 23.2 \text{ kg/kgN.}$$

Therefore, by increasing the N dosage from 1/10 to 1/5 of commercial farming, that is, adding 16 kgN/ha to the dosage in this case the estimated yield increase is 23.2 kg/kgN x 16 kgN/ha = 371 kg/ha.

A-Table 4-15 Effect of Increased Nitrogen Nutrient Dosage (Cont'd)

2. Cotton

Basal Application	Compound Fertilizer	325 kg/ha
	Average N Content	8.0%
Top Dressing	Ammonium Nitrate	150 kg/ha
	N Content	34.5%

325 kg/ha x 0.08 = 26.0 kgN/ha

150 kg/ha x 0.345 = 51.8 kgN/ha

Total N Applied 77.8 ≒ 78 kgN/ha

Sensitivity is calculated for the following

	dosage	yield
Commercial	78 kgN/ha	1,932 kg/ha
Communal	8 kgN/ha	728 kg/ha

Over the range of 8 kgN/ha:

$$\frac{(1.93 - 0.73) \times 10^3 \text{ kg/ha}}{(78 - 8) \text{ kgN/ha}} = 17.1 \text{ kg/kgN.}$$

Therefore, by increasing the N dosage from 1/10 to 1/5 of commercial farming, that is, adding 8 kgN/ha to the dosage in this case the estimated yield increase is 17.1 kg/kgN x 8 kgN/ha = 137 kg/ha.

A-Table 4-16 Nitrogenous Fertilizer Increase by Commercial Farming

From Table 4-19: 1985/86 Nitrogen Sales

92,044 T

From Table 4-20: Current Distribution Ratio of Fertilizer

310/430=0.72

The 1985/86 nitrogen consumption of commercial farming is:

92.0 KT x 0.72 = 66.2 KT

The 1995/96 assumed nitrogen consumption of commercial farming according to paragraph 4-3-5(2)-3)- ③ is:

89.7 KT

Therefore the nitrogenouse fertilizer consumption increase by commercial farming is:

89.7 – 66.2 = 23.5 KT

A-Table 4-17 Effect of Electricity Tariff Rivision on NH_3 Production

Increase in electricity cost for SABLE's ammonia production by water electrolysis as a result of electricity tariff on October 1988.

1. Common Premises

ammonia production volume	76,000	T/Y
unit consumption of electricity for ammonia	10,300	kWh/T
capacity	100	MW

2. SABLE's electricity purchasing contract condition (before revision)

Fixed cost

peak	11,750Z$/MW.month
off peak	3,500Z$/MW.month

Variable cost

peak	6:00 ~ 20:00	1.15Z¢/kWh
off peak	20:00 ~ 6:00	1.05Z¢/kWh

3. SABLE's electricity purchasing contract condition (after revision)

Fixed cost 20.26Z$/kW.month

Variable cost

peak	6:00 ~ 21:00	1.91Z¢/kWh
off peak	21:00 ~ 6:00	1.69Z¢/kWh

4. Calculation based on conditions before revision

Fixed Cost

$$\frac{(11{,}750 + 3{,}500)\text{Z\$/MW.month} \times 100\text{MW} \times 12\text{month/Y}}{10{,}300\text{kWh/T} \times 76{,}000\text{T/Y}} = 0.023376\text{Z\$/kWh}$$

Variable Cost

$$\frac{(1.15\text{Z¢/kWh} \times 14\text{h} + 1.05\text{Z¢/kWh} \times 10\text{h})}{24\text{h}} = 1.1083\text{Z¢/kWh}$$

Total : 2.3376 + 1.1083 = 3.446 Z¢/kWh

Power Cost:

3.446Z¢/kWh x 10,300kWh/T x 1/100 = 354.9Z$/T

A-Table 4-17 Effect of Electricity Tariff Rivision on NH_3 Production (Cont'd)

5. Calculation based on conditions after revision

Fixed Cost

$$\frac{20.26Z\$/kW.month \times 100{,}000kW \times 12month/Y}{10{,}300kWh/T \times 76{,}000T/Y} = 0.031058Z\$/kWh$$

Variable Cost

$$\frac{(1.91Z¢/kWh \times 15h + 1.69Z¢/kWh \times 9h)}{24h} = 1.8275Z¢/kWh$$

Total : 3.1058 + 1.8275 = 4.933 Z¢/kWh

Power Cost:

4.933Z¢/kWh x 10,300kWh/T x 1/100 = 508.1Z$/T

6. Electricity Cost Difference

508.1 – 354.9 = 153.2 Z$/T

A-Table 4-18 Area Planted - Commercial/Communal/Total in Hectares and Specific Total Nutrients (N + P_2O_5 + K_2O) Consumption in Kg/Ha

Crop Plant \ Planted Area (Ha)	1976			1980			1981			1982			1983		
	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total	Comme	Commu	Total
Maize	257,301	760,000	1,017,301	227,733	900,000	1,127,733	363,448	1,000,000	1,363,448	316,440	1,100,000	1,416,440	283,880	1,050,000	1,333,880
Tobacco	66,219	530	66,749	63,703	365	64,068	39,393	367	39,760	45,552	1,080	46,632	46,327	1,439	47,766
Cotton	64,003	35,000	99,003	74,924	15,000	89,924	66,054	59,000	125,054	58,015	51,000	109,014	69,976	65,000	132,976
Wheat	33,325	–	33,325	32,556	–	32,556	36,845	–	36,845	37,378	–	37,378	21,547	–	21,547
Soybeans	24,776	1,577	26,353	40,783	12,000	52,783	30,971	9,000	39,971	48,417	7,000	55,414	54,909	4,000	58,909
Groundnuts	17,755	325,000	342,755	3,841	175,000	178,841	12,909	300,000	312,909	11,923	240,000	251,923	10,703	180,000	190,703
Sorghum	7,131	235,000	242,131	6,766	120,000	126,766	9,290	200,000	209,290	8,232	200,000	208,232	7,672	280,000	287,672
Tea	4,021	–	4,021	4,143	–	4,143	4,247	–	4,247	4,423	–	4,423	4,476	–	4,476
Coffee	3,506	–	3,506	4,098	–	4,098	4,608	–	4,608	5,042	–	5,042	6,986	–	6,986
Sugar	25,328	–	25,328	24,515	–	24,515	34,146	–	34,146	31,547	–	31,547	33,833	–	33,833
Total Planted Area (Ha)	503,365	1,357,107	1,860,472	483,062	1,222,365	1,705,427	601,911	1,568,367	2,170,278	566,969	1,599,080	2,166,049	540,312	1,580,439	2,120,751
Total Fertilizer Consumption (TPY)	345,928	20,000	365,928	386,412	90,000	476,412	–	–	506,016	362,973	** 100,000	462,973	–	–	462,601
Total Nutrient Consumption (TPY) (N+P_2O_5+K_2O)	115,540	6,680	* 122,220	129,328	30,122	159,450	–	–	174,389	121,233	33,400	* 154,633	–	–	154,909
Specific Total Nutrient Cons. Kg (N+P_2O_5+K_2O) / Ha	229.54	4.92	65.69	267.73	24.64	93.50	–	–	80.35	213.83	20.89	71.39	–	–	72.86

NOTES: Comme – Commercial farming sector
Commu – Communal farming sector
* Assumed average content of total nutrients (N+P_2O_5+K_2O) in total fertilizers: 33.4% by mass
** Assumed consumption in communal farming sector
SOURCE:SOCIO – ECONOMIC REVIEW 1980 – 1985, ZIMBABWE (1986)

A-Table 4-19 World Urea Statistics

Unit: 1,000 TN

	Production	Consumption
Western Europe		
1984/1985	2,295.6	1,074.9
1985/1986	1,816.1	1,335.9
1986/1987	1,788.9	1,547.1
Eastern Europe		
1984/1985	6,544.9	3,139.5
1985/1986	6,929.5	3,543.6
1986/1987	7,389.1	3,776.9
Africa		
1984/1985	864.9	736.6
1985/1986	713.8	762.0
1986/1987	601.2	617.4
North America		
1984/1985	2,844.0	1,591.1
1985/1986	2,475.3	1,912.6
1986/1987	2,736.1	1,851.2
Central America		
1984/1985	589.5	670.3
1985/1986	822.5	788.6
1986/1987	816.0	834.4
South America		
1984/1985	678.3	780.3
1985/1986	644.9	815.1
1986/1987	713.4	971.8
Middle East		
1984/1985	1,271.5	561.3
1985/1986	1,344.2	592.8
1986/1987	1,454.6	707.3
Asian CPE's		
1984/1985	4,311.0	6,556.3
1985/1986	4,655.0	6,652.7
1986/1987	4,820.0	6,746.8
South &East Asia		
1984/1985	6,668.2	7,465.4
1985/1986	7,164.4	7,945.6
1986/1987	8,484.6	9,145.2
Oceania		
1984/1985	135.0	105.8
1985/1986	164.0	124.0
1986/1987	143.0	156.1
World Total		
1984/1985	26,202.9	22,681.5
1985/1986	26,729.7	24,472.9
1986/1987	28,946.8	26,354.2

Source: Statistical Supplement, 1987, British Sulphur

A-Table 4-20 World Urea Trade (1984)

Unit: 1,000 T

Import \ Export	W. Germany	Italy	Holland	Burgaria	E.Germany	Hungary	Rumania	USSR	Libya	Indonesia	Kuwait	Quatar	Saudi Arabia	Canada	USA	Venezuela	Others	Total
W. Europe	170	34	233	31	95	45	94	52	100	0	0	0	0	0	6	0	472	1,332
France	84	9	120	5	0	0	0	0	0	0	0	0	0	0	0	0	92	310
Turkey	0	6	0	5	0	0	69	17	100	0	0	0	0	0	0	0	9	206
UK	9	0	31	0	32	5	0	15	0	0	0	0	0	0	0	0	99	191
E. Europe	0	0	0	3	0	41	26	650	0	0	0	0	0	0	0	0	79	799
Hungary	0	0	0	0	0	0	0	397	0	0	0	0	0	0	0	0	0	397
Africa	28	0	47	7	22	0	176	31	0	0	4	0	43	6	19	0	129	512
Nigeria	0	0	0	0	0	0	101	0	0	0	0	0	0	3	0	0	4	108
Asia	158	236	569	438	235	247	815	1,916	559	199	585	673	666	257	807	0	2,199	10,559
China	89	58	41	101	200	247	455	913	332	0	204	196	164	128	296	0	965	4,389
India	52	177	481	183	35	0	188	331	212	0	238	296	178	129	188	0	692	3,380
Iran	0	0	0	103	0	0	90	142	0	0	53	57	43	0	0	0	151	639
Malaysia	0	0	0	0	0	0	10	51	0	113	0	71	0	0	0	0	23	268
Philippine	0	0	15	0	0	0	39	15	0	50	0	0	0	0	126	0	74	319
Vietnam	0	0	0	18	0	0	33	414	0	0	0	47	30	0	0	0	0	542
Oceania	1	0	0	0	0	0	0	32	0	0	0	42	0	0	9	0	14	98
N. America	24	55	175	0	103	0	356	383	14	0	0	0	0	698	121	67	142	2,138
Canada	0	0	64	0	0	0	0	0	0	0	0	0	0	0	121	0	36	221
USA	24	55	111	0	103	0	356	383	14	0	0	0	0	698	0	67	107	1,918
S. America	7	10	93	55	38	22	107	222	0	0	0	0	0	63	190	233	146	1,186
Colombia	0	0	0	0	10	6	27	10	0	0	0	0	0	47	7	142	31	280
Cuba	0	0	0	32	0	0	0	180	0	0	0	0	0	0	0	3	58	273
World Total	389	335	1,118	534	493	355	1,574	3,286	673	199	588	715	709	1,024	1,151	300	3,181	16,624

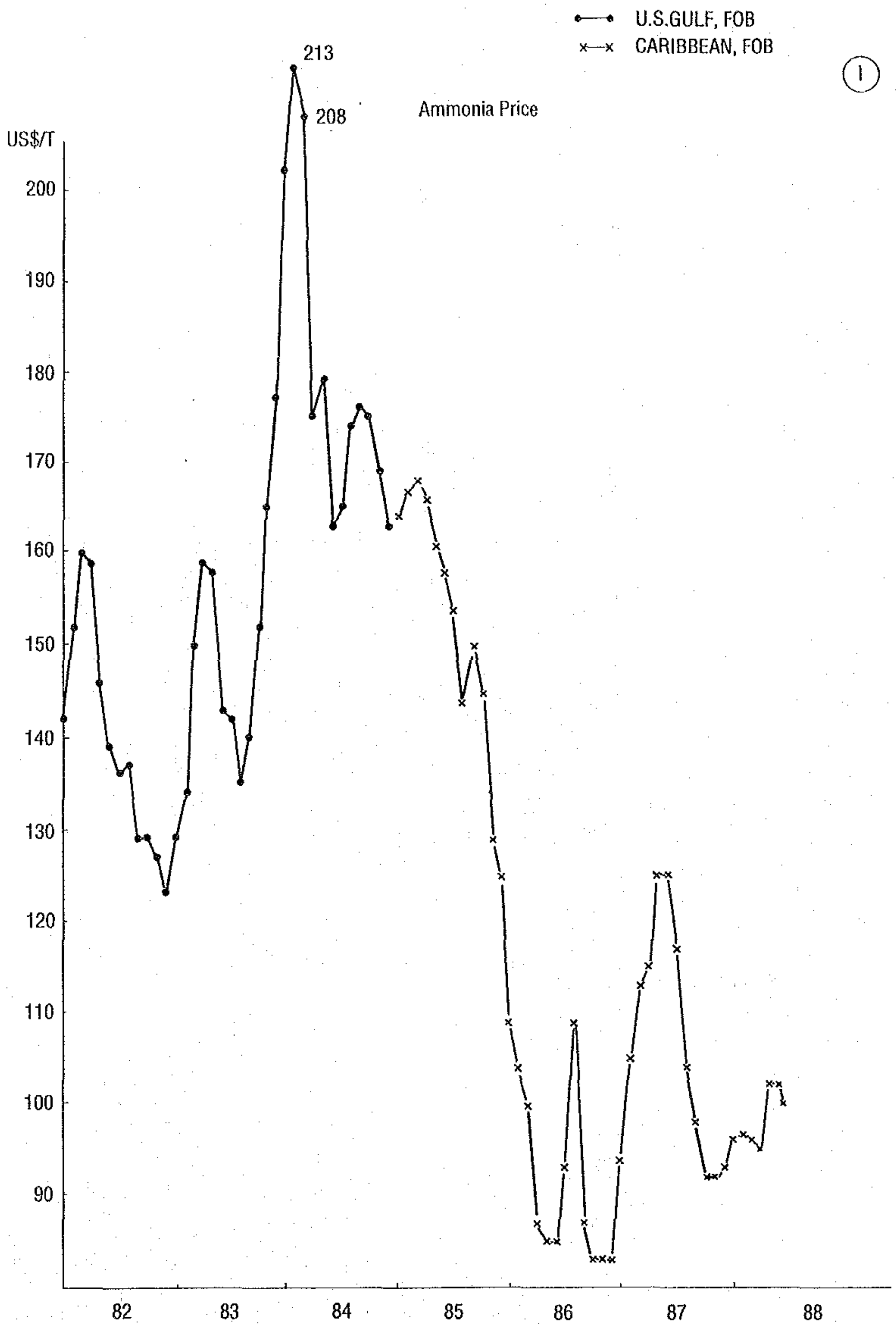
Source: Kagaku Keizai, January, 1988

A-Table 4-21 AN-Urea Price

	1983	1984	1985	1986	1987
AN. (34.5% N)					
Imported quantity (ton)	1,760	2,387	1,875	2,250	2,553
Z$ x 1,000	1,532	1,663	550	753	979
Unit price (Z$/T)	130.3	696.7	293.3	334.7	383.5
(Z$/TN)	377.7	2,019.4	850.1	970.1	1,111.6
(US$/TN)	373.6	1,623.3	527.4	582.6	669.2
Urea (46% N)					
Imported quantity (ton)	24,000	30,265	32,182	24,106	1,031
Z$ x 1,000	3,997	2,814	6,658	3,875	294
Unit price (Z$/T)	166.5	93.0	206.9	160.7	285.2
(Z$/TN)	361.9	202.2	449.8	349.3	620.0
(US$/TN)	358.0	162.5	279.0	209.8	373.3
AN price/Urea price as N	1.04	9.99	1.89	2.78	1.79

Conversion rates of Zimbabwe dollar into U.S. dollar are in accordance with those given in Table I-4-26.

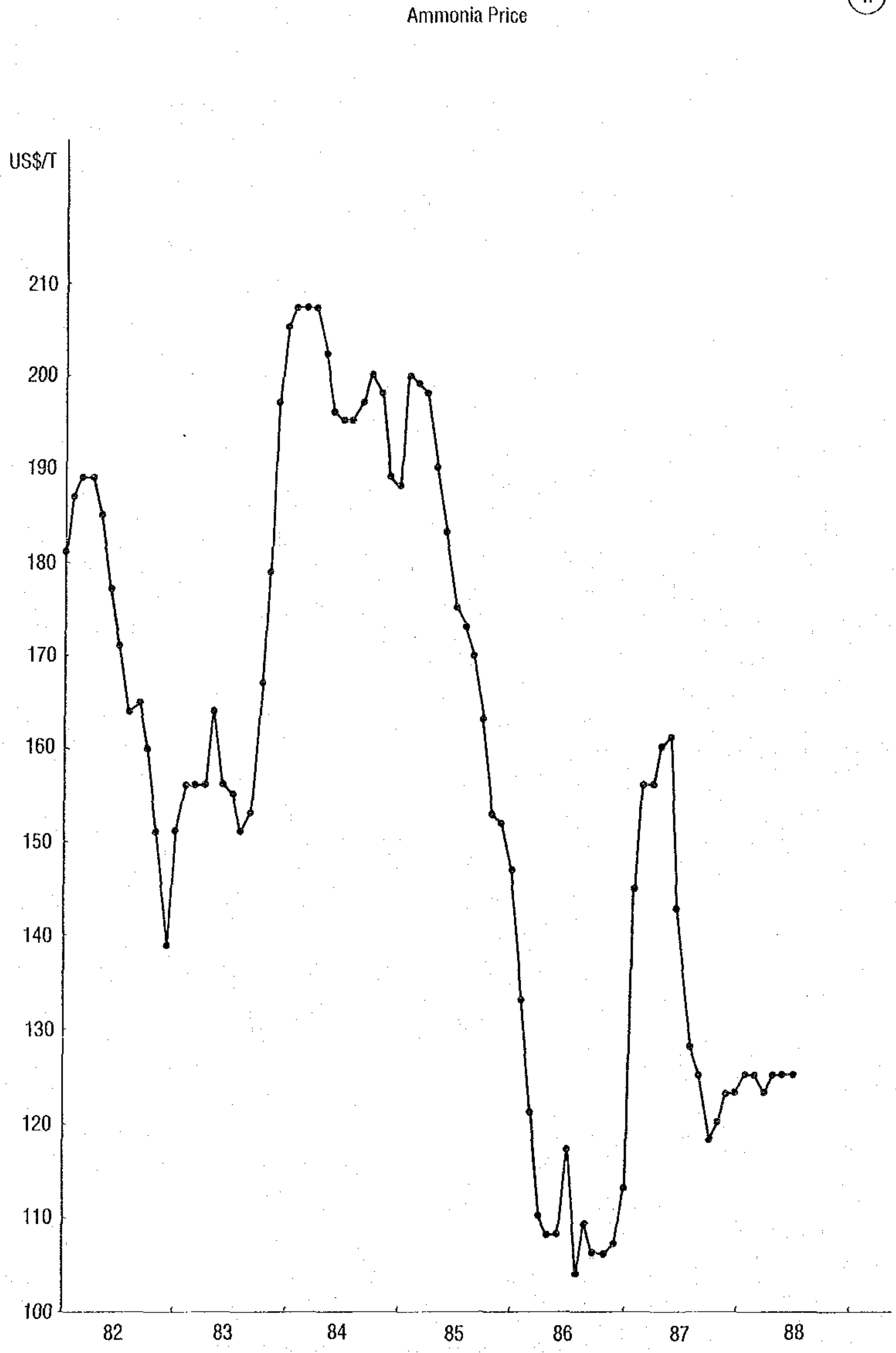
Source: CSO.



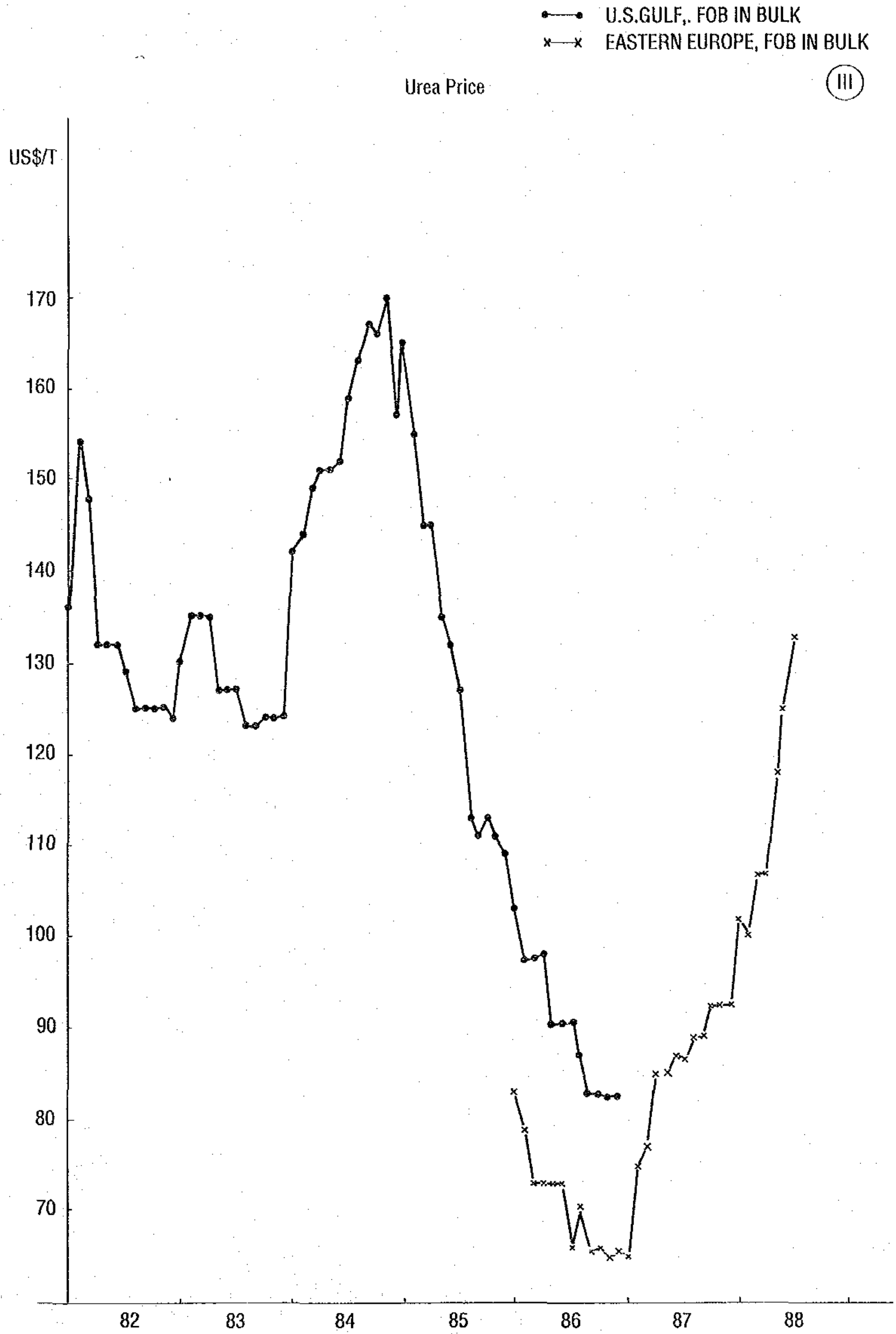
A-Fig. 4-1 Price Fluctuation of Ammonia Price

North West Europe, C & F

(II)



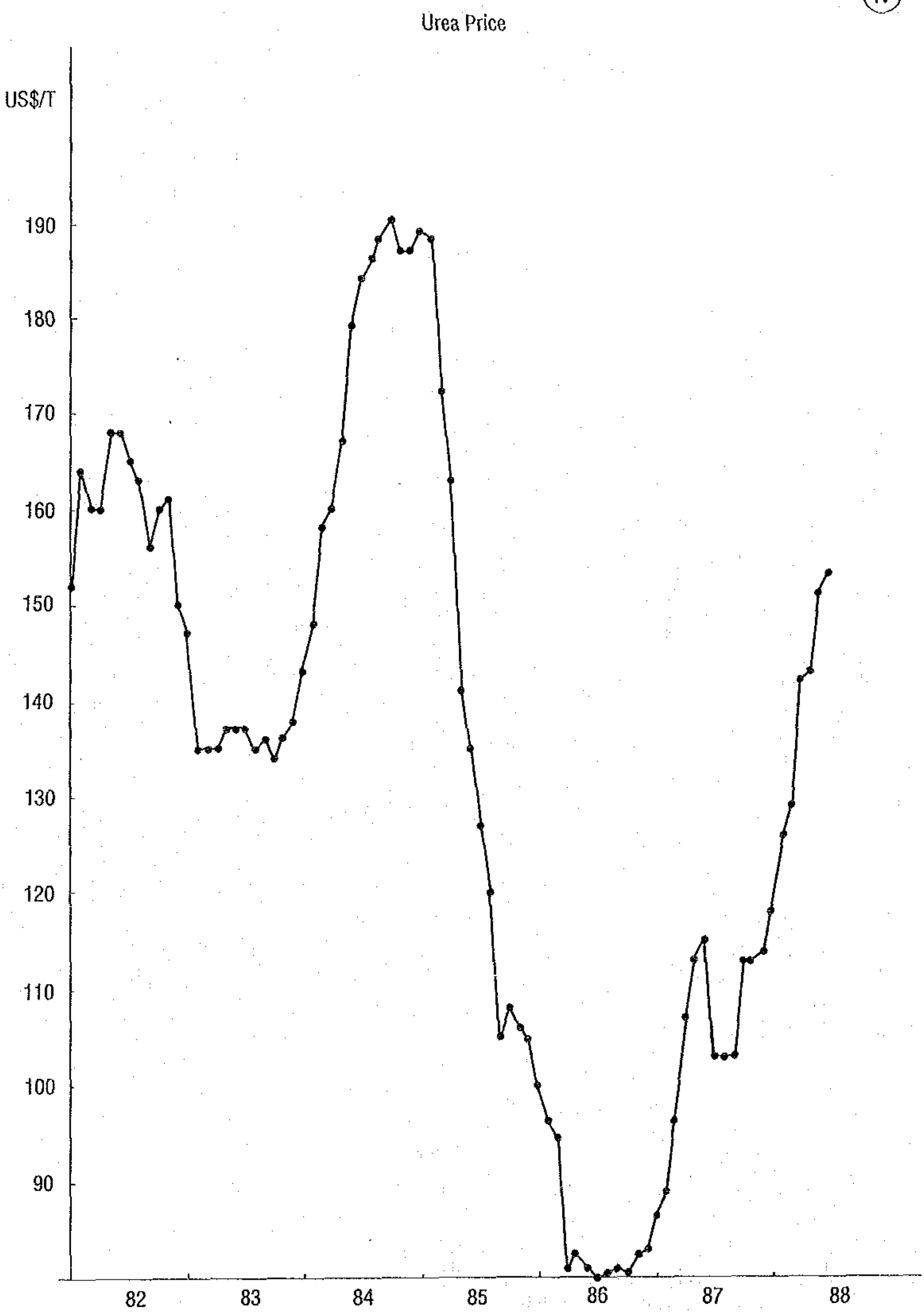
A-Fig. 4-2 Price Fluctuation of Ammonia Price



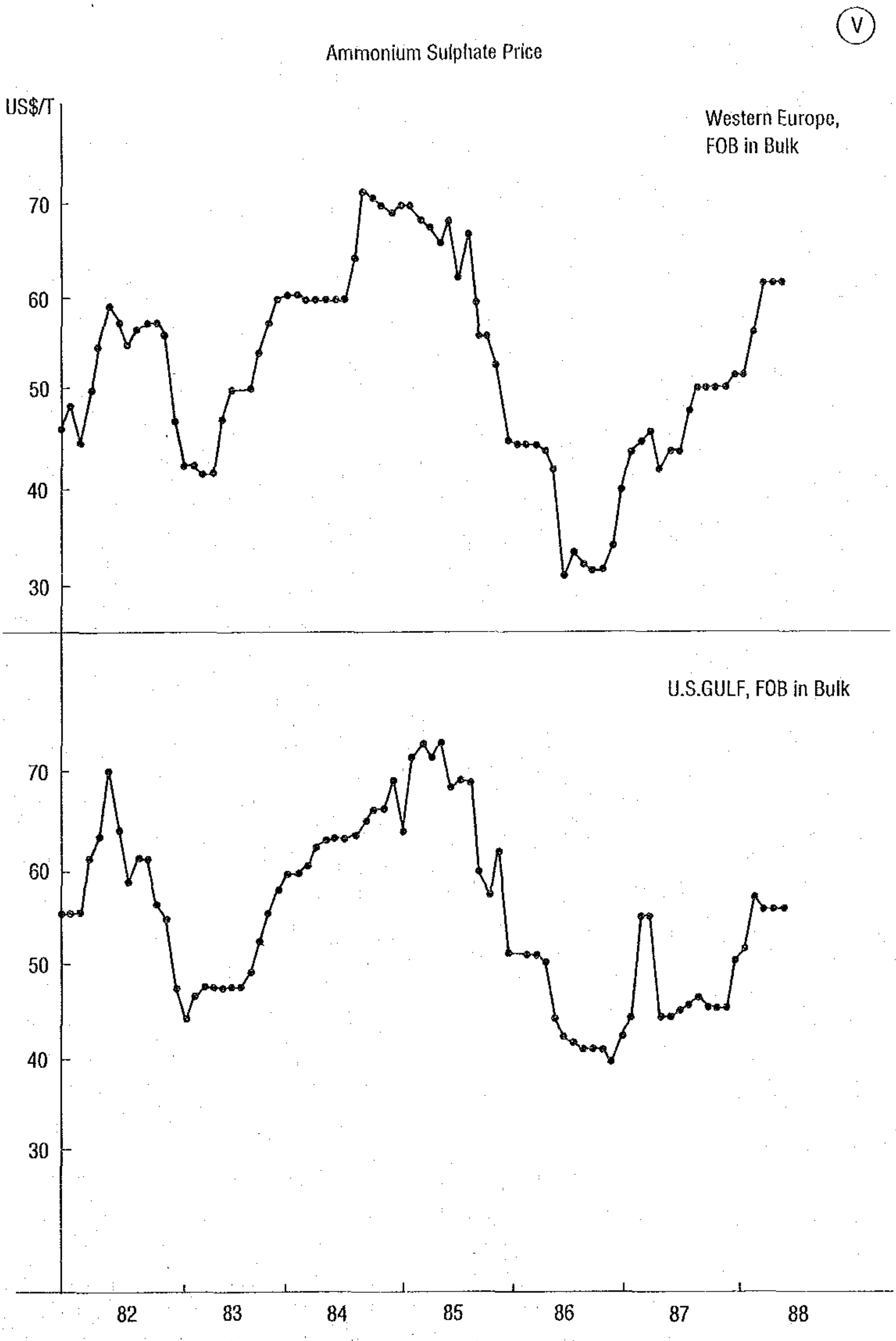
A-Fig. 4-3 Price Fluctuation of Urea Price

Middle East, FOB Bagged

(IV)



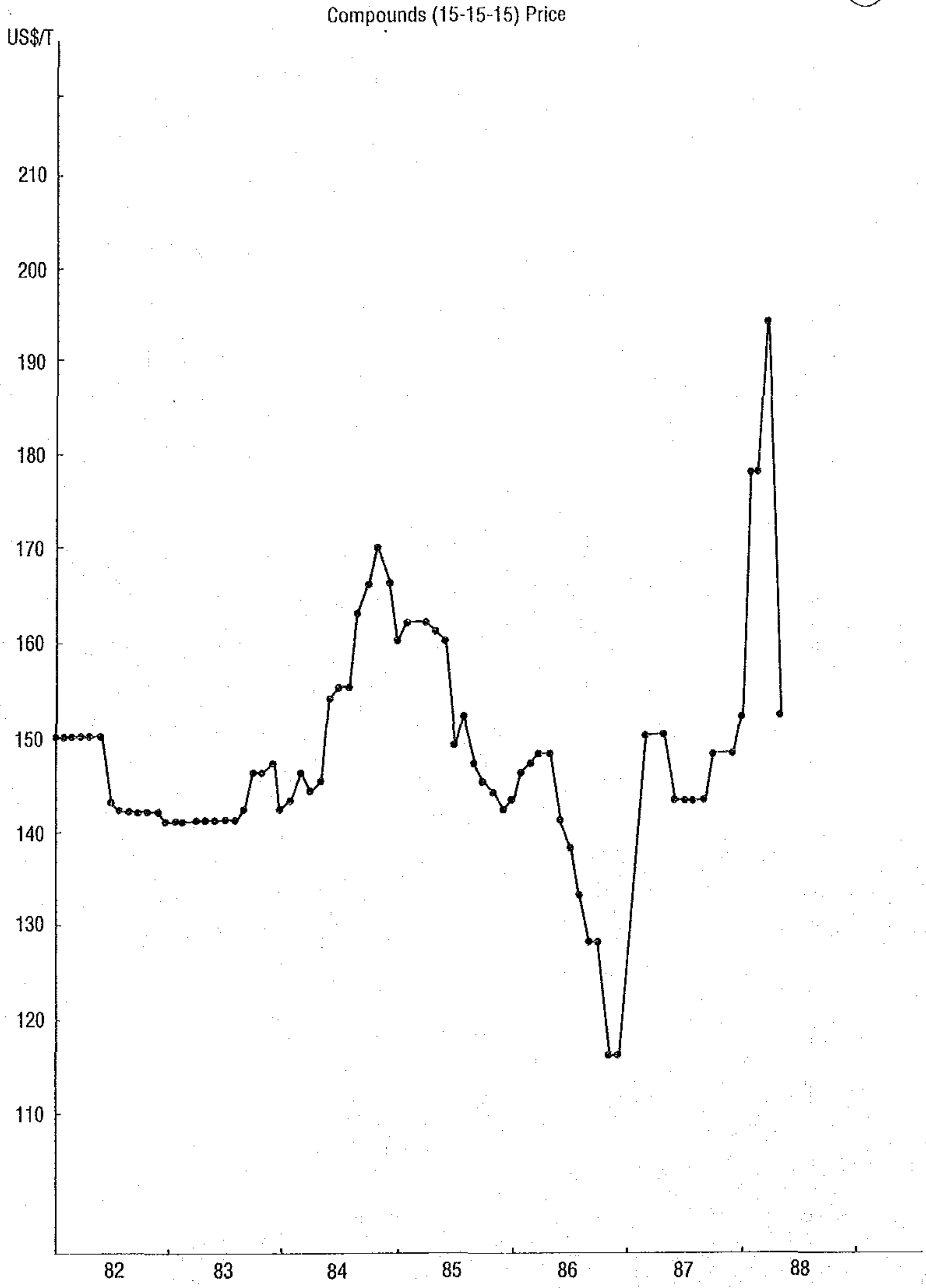
A-Fig. 4-4 Price Fluctuation of Urea Price



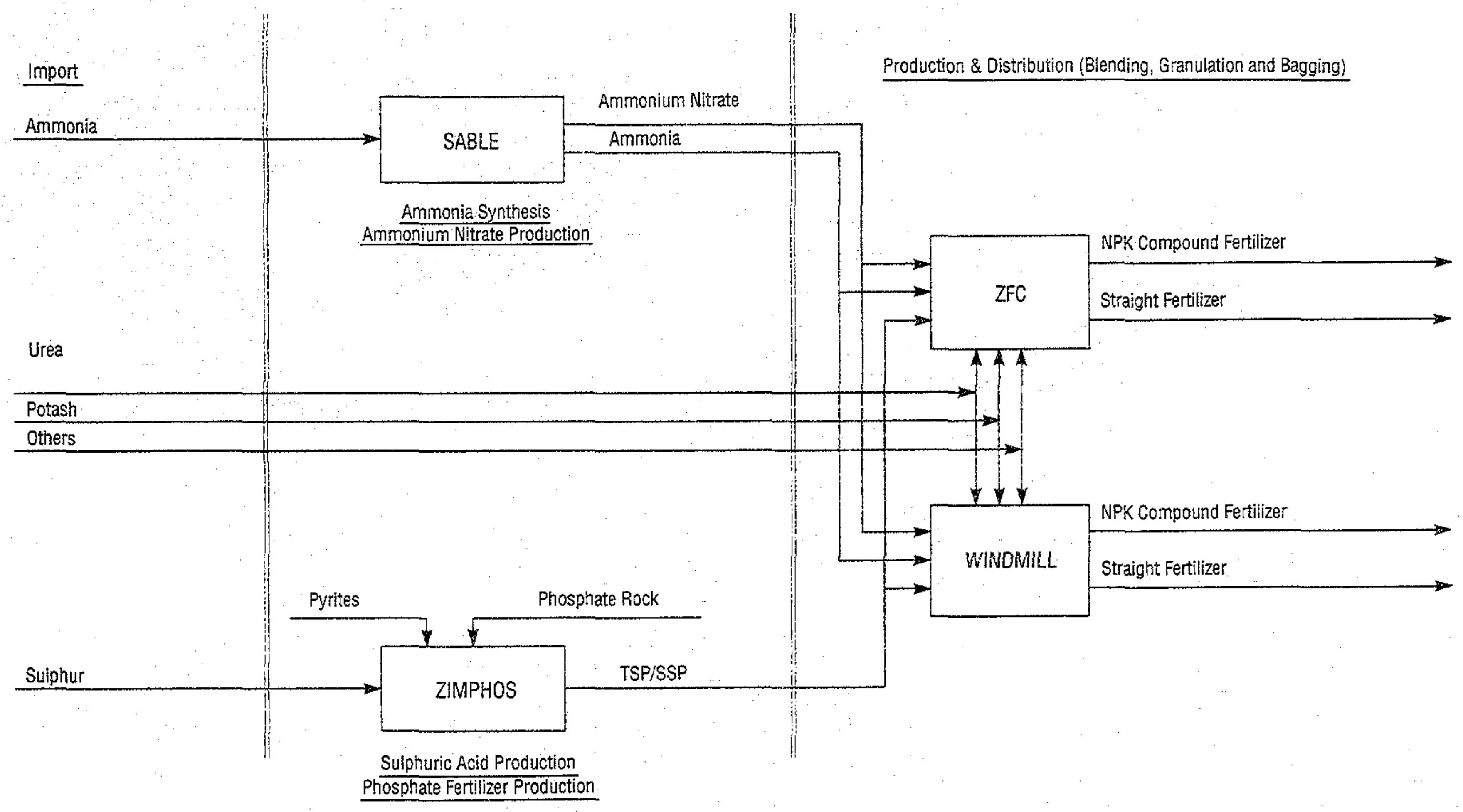
A-Fig. 4-5 Price Fluctuation of Ammonia Sulphate Price

Western Europe, FOB Bagged

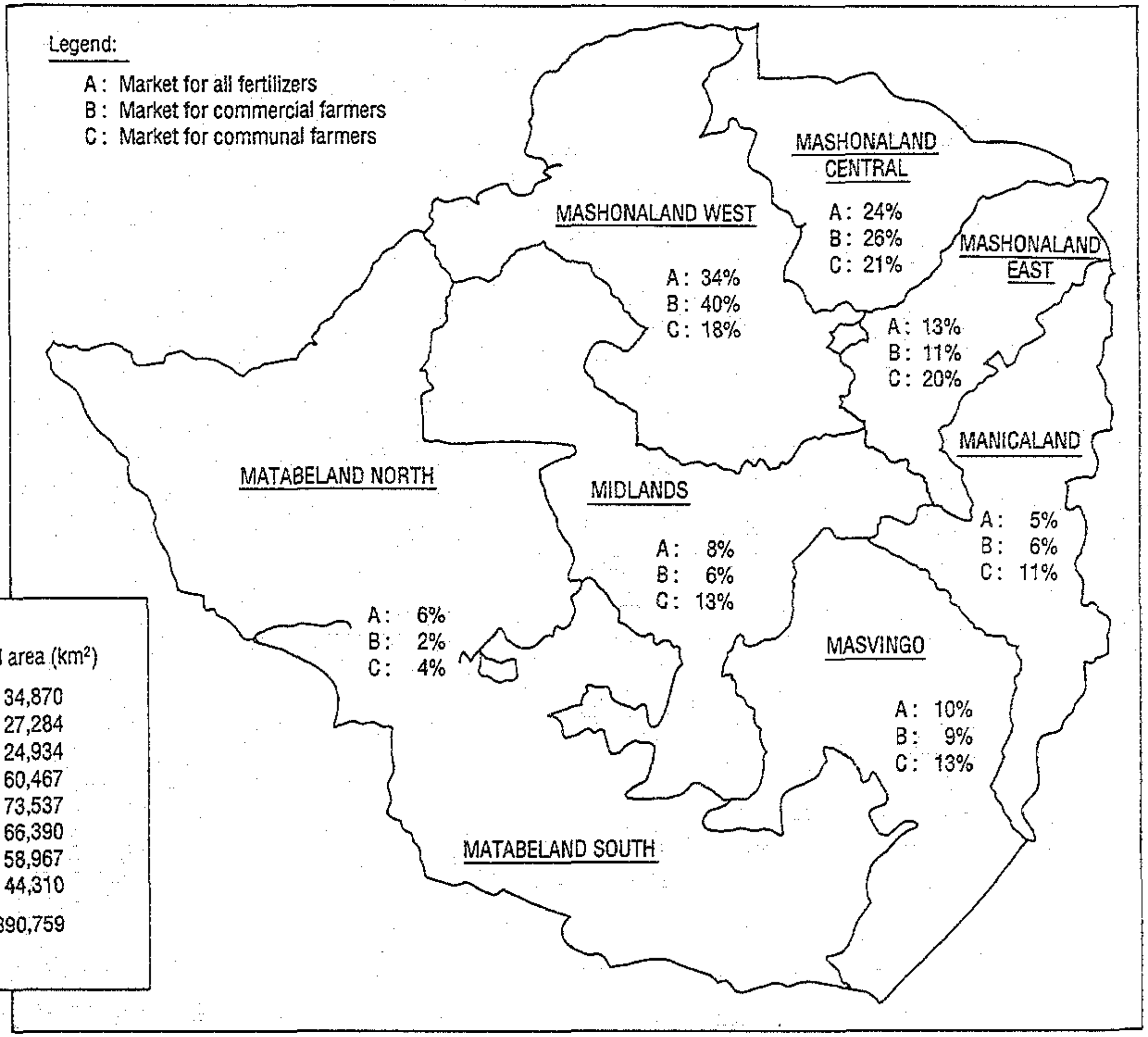
(VI)



A-Fig. 4-6 Price Fluctuation of Compound Fertilizer



A-Fig. 4-7 Schematic Flow of Fertilizer Production and Distribution in Zimbabwe



Land area by provinces	Land area (km²)
Manicaland	34,870
Mashonaland Central	27,284
Mashonaland East	24,934
Mashonaland West	60,467
Matebeleland North	73,537
Matebeleland South	66,390
Midlands	58,967
Masvingo	44,310
Total	390,759

A-Fig. 4-8 Fertilizer Shipment by Province

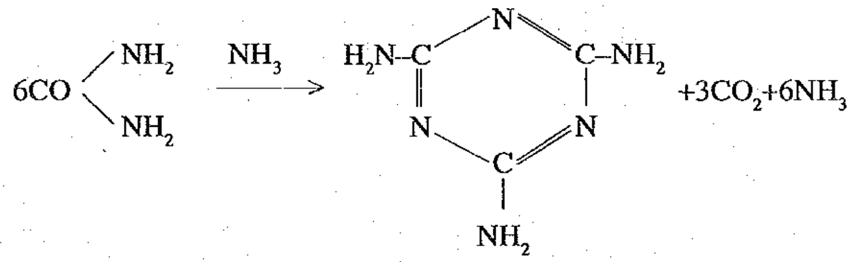
Appendix 1-2 Industrial Utilization of Urea

The major use of urea is for the agriculture, however it is also utilized commonly in the industries. In the chemical industry it is used as a raw material for several derivatives as below.

1. Chemicals

1.1 Melamine

Melamine is derived from urea in the presence of ammonia under high pressure and high temperature or under the presence of certain catalyst in the following reaction formula.

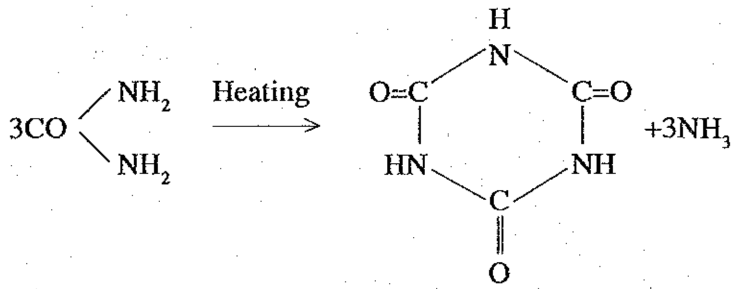


Melamine is mainly converted into a melamine resin combined with formaldehyde. Melamine resin is thermo-setting and used for glues, laminates, coatings and moldings. The investment cost for melamine plant is remarkably heavy. One ton of melamine requires more than three tonnes of urea.

Currently in the world 1.2~1.3 million tonnes of urea would have been consumed for the production of melamine.

1.2 Isocyanuric Acid

Urea is heated up to 300°C or higher, then a condensation reaction takes place releasing *ammonia and isocyanuric acid is formed in the following formula.*



Isocyanuric acid thus produced is purified, and then chlorinated to obtain di-chloride or tri-chloride. The chlorinated products are used mainly as a disinfectant for swimming pools. Some isocyanuric acid is used for the production of paints.

One ton of isocyamic acid requires 1.6~2.0 tonnes of urea. In the world 100 to 150 thousand tonnes of urea would have been consumed for the production of isocyanuric acid.

1.3 Sulfamic Acid

Sulfamic acid is manufactured by the reaction of urea and oleum (fuming sulfamic acid) in the following two steps reaction.

$$CO\begin{cases}NH_2\\NH_2\end{cases} + SO_3 \longrightarrow HSO_3NHCONH_2$$

$$HSO_3NHCONH_2 + H_2SO_4 \rightarrow 2HSO_3NH_2 + CO_2$$

Sulfamic acid is a dry acid and highly stable. It is particularly well suited for scale removal and chemical cleaning of vessels with its less corrosive character.

A big problem of producing sulfamic acid is the disposal of waste sulphuric acid.

The more accessible utilization of urea is in the manufacture of urea resin which is extensively used in the manufacture of plywood, furniture, molded appliance, textile, paper, paint etc. Urea resin is the typical and the most common amino resin and is supplied to the market in a competitive price.

2. Urea Resins

2.1 Chemistry of Urea Resin

Urea resin is chemically a polymer of a condensate product of urea and formaldehyde. Urea itself comprises two amino radicals. And each amino radical reacts with one molecule of formaldehyde giving an addition product, dimethylolurea, as follows.

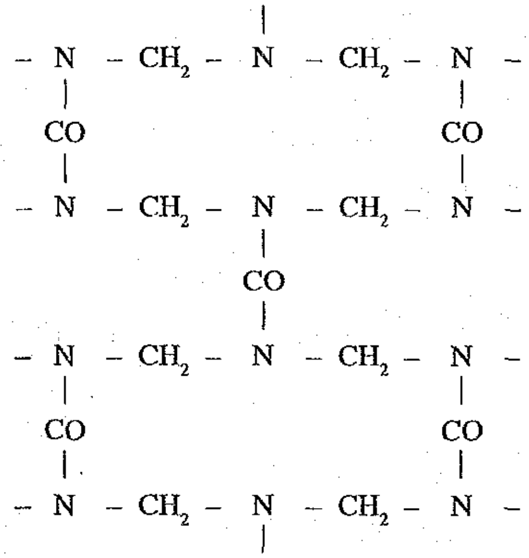
$$CO\begin{cases}NH_2\\NH_2\end{cases} + 2CH_2O \longrightarrow CO\begin{cases}NH-CH_2OH\\NH-CH_2OH\end{cases}$$

Then, under the controled conditions, condensation reaction takes place as follows for an example.

$$CO\begin{cases}NH-CH_2OH\\NH-CH_2OH\end{cases} + CO\begin{cases}NH_2\\NH_2\end{cases}$$

$$\rightarrow HOCH_2\text{-}NH\text{-}CO\text{-}NH\text{-}CH_2\text{-}NH\text{-}CO\text{-}NH_2 + H_2O$$

Finally a three dimensional net work complex is formed as a stable polymer as shown below.



In these reactions the control of mol ratio of urea and formaldehyde, pH, temperature, reaction time, type of catalysts, is most important to achieve the property of the resin suitable for the specific end use.

2.2 Uses

2.2.1 Adhesives

This is the largest use of urea resin.

The finished product resin is in a spray-dried powder form or in a liquid form containing 40% (concentrated) to 60% (unconcentrated) water depending to the uses. The majority is used for the manufacture of plywood and the rest is for the manufacture of particle board, chip board and furniture.

The adhesives must remain in the glue line on the surface between the layers. So the adhesives are made of high viscosity so that they remain in the glue line. In this purpose thickners such as finely ground pecan shells, wheat flour etc. are often used. An example prescription, 100 portion of finished product resin, 40 portion of barley or wheat flour, 1.5 portion of harder forms a glue, of which standard application is $120g/m^2$ of inner surface.

A brochure of plywood making plant is attached to the end of this Appendix for a general reference.

2.2.2 Molding Compounds

This use is quite comparable to adhesives.

The mole ratio of formaldehyde to urea is normally in the range of 1.2~1.5 for preparation of this resin. After reaction in the presence of ammonia or alkaline catalyst for a couple of hours under 40-60°C, the reactant in a form of syrup is filtered and a chopped alpha cellulose filler is added to the syrup about 20 to 25% by weight.

The mixture is steam dried, then pigment, mold release agent and curing catalyst are added to it before milling. The urea resin mold has a good electrical properties. The molding compound is used for manufacture of bottle caps, tablewares, buttons, electric and mechanical parts, stationery etc.

2.2.3 Coatings

The urea resins are the cheapest and fastest curing. They are used in clear coatings for wood furniture setting under room temperature, baked enamels for appliances, and primer coats on automobiles.

The formulations of coatings are sophisticated. In many case the urea resins are assorted with methanol, n-butanol, iso-butanol or other alcohols for effecting alkylation which improves the nature of this resin curing too hard and brittle to be used alone. Usually the urea resin is upto 50% of the total resin solids in the formulation.

2.2.4 Textile Finishes

Mostly methylolated urea, the primary addition product of the urea resin reaction and monomeric, is used for furnishing textile fabrics.

The urea resins react with cellulosic fibres and change their physical properties. They do not react with synthetic fibres, such as nylon, polyester or acrylics, but may self-condense on the surface. This results in a change in the stiffness or resiliency of the fibre.

Processing of cotton fabric with the urea resin gives the garments made of it special features so called as "wash and wear" and "permanent press" according to the processing.

Since the methylolurea monomers have limited warer solubility of about 30%, they are usually marketed in dispersed form as soft pastes containing 55-65% active ingredient to save container and shipping cost.

2.2.5 Paper Industry

The urea resins are used by the paper industry in large volume for a variety of applications. The resins are divided into two classes according to the mode of application. The resins added to the fibre slurry before the sheet is formed are called wet end additive and are used to improve wet and dry strength and stiffness. The resins applied to the surface of formed paper or board, almost invariably together with other additives, are used to improve the water resistance of coatings, the sag resistance in ceiling boards, and the scuff resistance in cartons and labels.

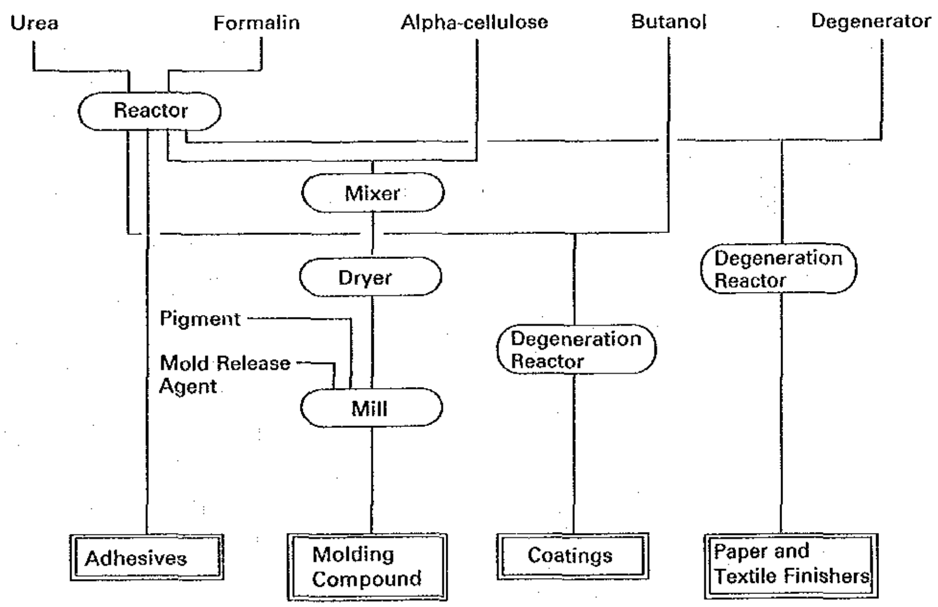
In the purpose of improving the water solubility of the urea-aldehyde polymer and of achieving better adhesion between fibres, application of the anionic polymer made by the reaction of urea resin with sodium bisulfite and application of the cationic polymer made by the reaction of urea resin with polyethylenepolyamines are most widely practiced.

The dosage of the resin is somewhat 0.3 to 2% of the fibre and the use of alum as a mordant is essential.

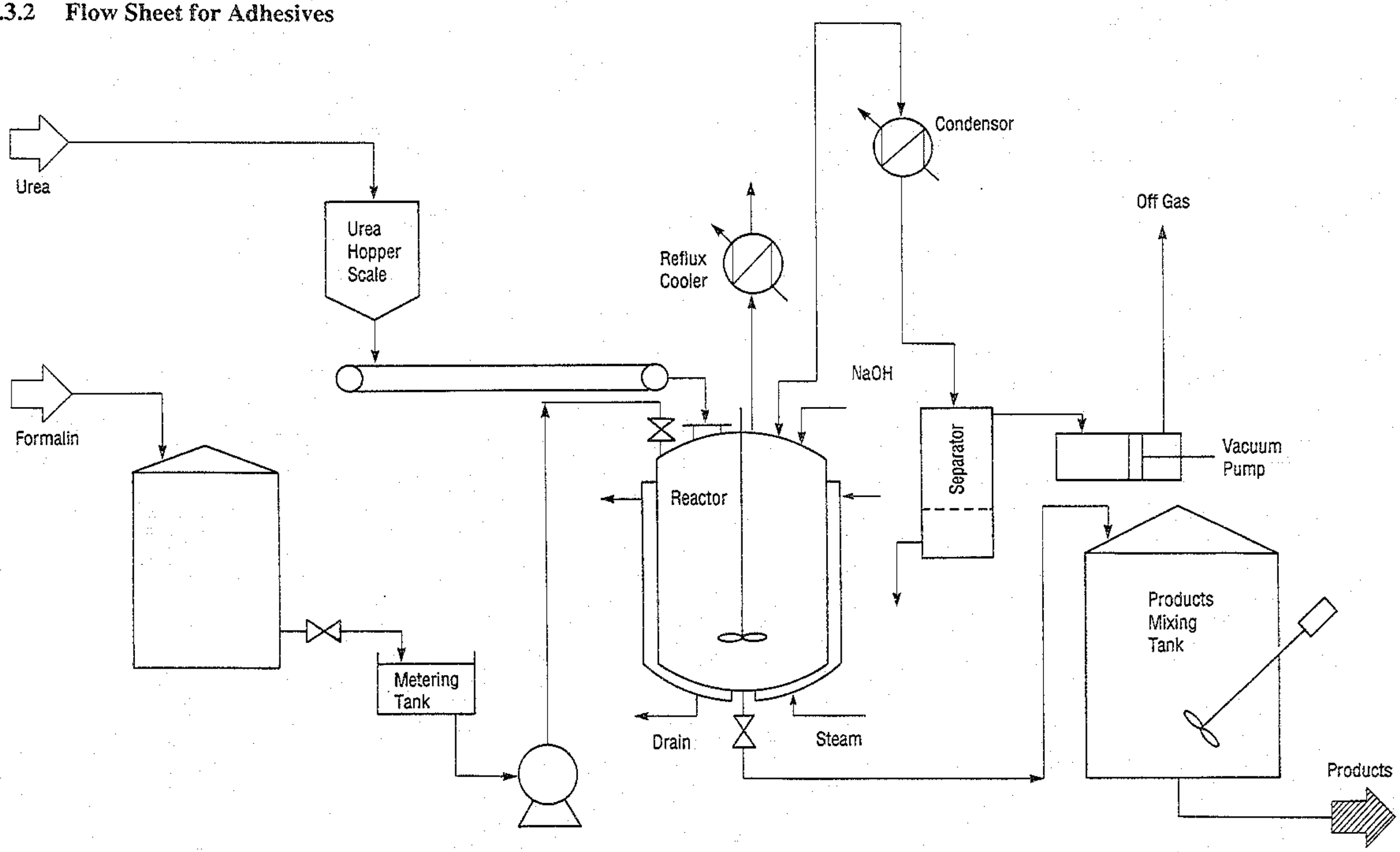
Melamine resins and phenolics are the competing thermo-setting resins with the urea resins.

2.3 Process Flow

2.3.1 Generalized Flow Sheet of Urea Resins



2.3.2 Flow Sheet for Adhesives



2.4 Outline of Process

Outline of the urea resin process is given below taking a case of manufacturing the adhesives as a typical example.

The plant is designed on a batch reaction basis. The main equipment comprise a reflux cooler provided with a condenser of 3~10m^3, a reactor of 10~20m^3 with a jacket/coil for steam heating and water cooling and an agitator and a vacuum condenser connected to the reactor. All the equipment are made of stainless steel. This is to prevent the contamination of products by iron ion and to protect equipment from corrosion by formalin. It is indispensable to provide a continuous measurement system of pH and temperature of reactant since those parameters dictates the product quality definitely. When powder adhesives are to be manufactured, provision of a spray dryer is necessary.

Formalin is metered and charged into the reactor and a catalyst of alkaline substance such as ammonia, caustic soda, sodium carbonate, sodium phosphate is added and pH of the liquid is adjusted to 7.5~8.0.

Then urea is charged under agitation and heating to the range of 80 to 90°C and the reaction liquid is kept for a couple of hours as required to effect the addition reaction. In the next step a weak organic acid such as acetic, oxalic, formic acid or an acidic inorganic salt such as zinc chloride, sodium hydrogen phosphate is added as an acidic catalyst to bring pH of the reactant to 5.0~6.0. The heating under agitation is continued for an appropriate time to achieve the condensation reaction. Again the alkaline catalyst is added to the condensate to adjust its pH to neutral and the excess water is removed under vacuum to the required concentration.

2.5 Plant Cost

A plant, for production of urea resin adhesive, 10,000 T/Y and within the scope of battery limit, would cost above Japanese Yen 200 million in 1988 in Japan.

2.6 Unit Consumption

The consumption of two main raw materials, urea and formalin, varies widely according to the product.

	Adhesive	Molding
Urea	300kg	800kg
37% formalin	700	1300
Mol ratio (formalin/urea)	1.73	1.20

The adhesive quoted here is an unconcentrated product containing less than 60% water. The molding resin here represents a dry product but alpha cellulose is not included.

An example of unit consumption is given below for the case of adhesive resin containing minimum 60% nonvolatile matter.

Urea	340-275kg
37% formalin	680-755kg
10% caustic soda	2.5-3.0kg
10% acetic acid	0.5-3.0kg
Water	5-15m^3
Power	10-50 kWh
Fuel	10-30 l

2.7 Product Specification

For a reference two copies of Japanese Industrial standard are attached to the end of this Appendix 1-2.

JIS K 6801 (1987)	Urea Resin Adhesives for Wood
JIS K 6916 (1975)	Urea Formaldehyde Molding Compounds

2.8 Price in Japan

In 1986 the delivered price of the urea resin molding compounds in Japan ranged Japanese Yen 440-480 per kg.

2.9 Production in Japan

In 1985 in Japan the production of the thermosetting resins comprising urea resin, melamine resin and phenolics, was 911,000 tonnes, in which urea resin amounted to 470,000 tonnes.

When the urea resins are manufactured, a supply of formalin is indispensable. Formalin is a water solution of formaldehyde and its concentration is normally 37% only. Formaldehyde in water is not stable beyond this concentration resulting polymerization. Methanol is added by 5 to 8% in formalin to stabilize the solution. Therefore a transportation of formalin in large quantity is often uneconomical. And the manufacture of formalin might be contemplated concurrently with the manufacture of urea resins. In this view a brief information on the formalin manufacture is given below.

3. Formalin

3.1 Process Flow

An example of flow producing formalin from methanol is given to the next page.

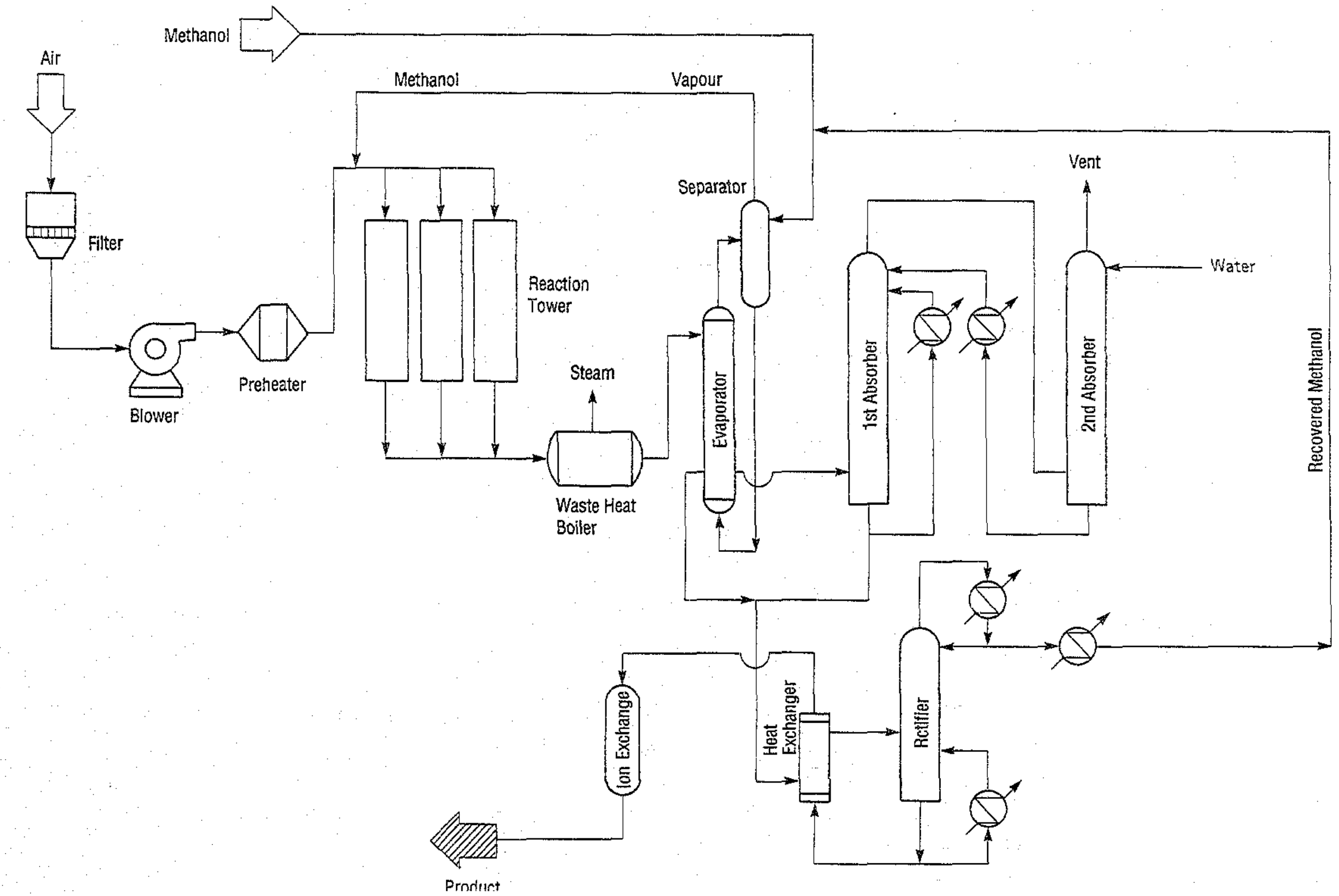
3.2 Plant Cost

Battery limit plant cost of 37% formalin of 18,000 T/y would be about Japanese Yen 1,000 million in 1988 in Japan.

3.3 Unit Consumption

An example of unit consumption for 37% formalin is as follows.

3.1 Example Flow of Formalin



Methanol	430kg
Steam	0.5T
Cooling Water	31m³
Power	44 kWh
Catalyst	Nominal amount

3.4 Product Specification

Formaldehyde (wt%)	37.0±0.5
Formic acid (g/100 ml)	0.03 or under
Ash (g/100 ml)	0.01 or under

Above is in accordance with Japanese Industrial Standards, JIS K-1502.

3.5 Price in Japan

In 1986 37% formalin price in Japan was;

for the resin use	Japanese yen 45-50/kg
for general use	Japanese yen 55-65/kg

3.6 Production in Japan

In 1985 total production of 37% formalin in Japan was 1,200 thousand tonnes.

Plywood Making Plant

Plywood is a product in which several even numbers of boards are plied with glue to dissipate or compensate respective particular defects and to offer a wide size. Plywood thus produced has the particular features of being a wood with the least defects, wide size, long length and high strength mechanically (physically). Plywood is widely used in our daily life and contributes much to the development of culture and welfare. Its demand is ever on the increase.

Insofar as Japan is concerned, Nara (Quercus serrata T.), Shina (Tilia japonica S.), Tamo (Fraxinus var. japonica M.), Sen (Kalopanax Pictus N.), Kaba (Betula: Birch) and Buna (Fagus crenate: Beech) among native woods and Lauan, Mayapis, Kapor, Tanguil and Bagtikan of imported types can be used as peeler log.

In Southeast Asia, wood having the same quality as the exotic timber which Japan imports are used for plywood production and besides those mentioned above Apitong and Teak are included.

In North America, Douglas fir, Hemlock, and Spruce are used for this purpose and in Europe, Birch, Spruce, Poplar and in Africa, Okume is used. Thus, the typical woods of the world are almost entirely used as plywood material.

Outline of the Plant

This plant aims to use logs produced in tropical and semi-tropical regions and it is planned to utilize most effectively logs of large diameter class, straight and 0.45–0.55 of absolute dry specific gravity.

Type and quality of products are as follows, with a daily output capacity of 4,000 sheets (8 hrs.).

Size: 122 cm x 244 cm x 4 mm (4' x 8' x 4 mm)
Quality: Type II AA (1st class), AB (2nd class) and BB (3rd class)

The product is used for general construction purposes such as interior material for housing, ships, vehicles, and furniture, and secondary processing is done on the face and used for similar purposes.

During the course of production of plywood, edge of logs, peeled core, and other waste from plywood and veneer are produced, and these wastes are chipped and used as materials for paper, fibreboard, and particle board. At this plant, they are also used as fuel for the boiler. Some of the edge wood and peeled core are collected and together with unqualified veneer logs, they are sawed into lumber and sold.

Process Description

Preparation of Logs

1. Cutting of logs

Logs stored in a pond are conveyed to the factory yard and are cut by the chain saw to the desired length for feeding to the veneer lathe or to the length of the veneer sheets to be produced.

2. Cooking or steaming

High-density logs require pre-treatment by cooking vats or steam chambers because they are hard and frequently too resinous to permit fresh cutting.

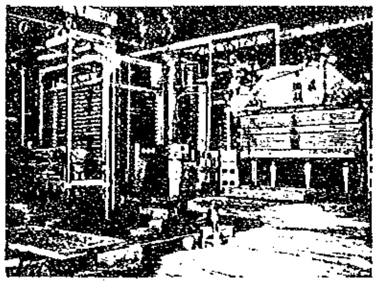
Veneer Manufacturing

1. Veneer cutting
1) Rotary cutting

In automated mills, log chargers with log centering devices are usually installed for speedly, automatic feeding of logs to the veneer lathe. As the log is centered by the centering device before feeding, it can immediately be fixed on the spindles of the veneer lathe and peeled in an endless sheet by utilizing veneer reeling and unreeling machines. The speed of the cutting and reeling is fully synchronized. Full reels are so stored on the deck of the system.

2) Slicing

The "edge-grain" veneer required for the production of decorative plywood is cut by the veneer slicer, which slice across the grain of the log.



Hot press

Fig. 2: Process Flow Sheet for Plywood Manufacturing Plant

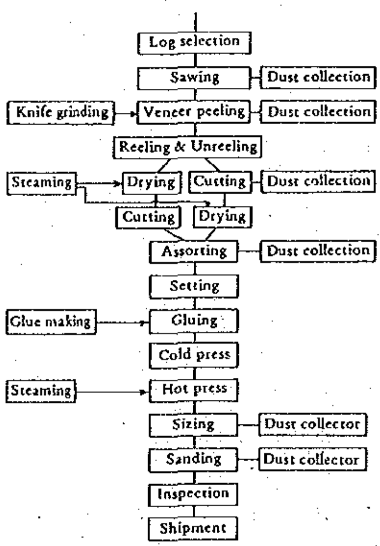
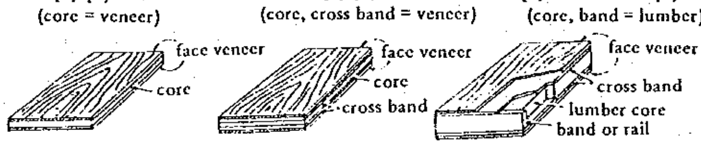


Fig. 1: Construction of Plywood

3 ply plywood (core = veneer) | 5 ply plywood (core, cross band = veneer) | 5 ply lumber core plywood (core, band = lumber)



2. Green veneer clipping

The sheet of green veneer peeled by the veneer lathe is cut by the automatic or manual veneer clipper into the desired dimensions. Full rolls of the reeling machine are transferred to the unreeling unit, and the veneer is unrolled and cut by the veneer clipper.

Where the tray deck system is used the veneer can be sent directly front the tray deck to the veneer clipper of dryer.

3. Veneer drying

In order to ensure the maximum bonding effect of adhesive, veneer sheets must be dried adequately before gluing them together. The moisture content of veneer sheets is the most important factor in gluing. There are two types of veneer dryers, – namely roller and continuous veneer dryers.

4. Veneer Preparation

Narrow strips of veneer are joined together into full size by the following methods.

1) Veneer jointing

For the practical use of narrow on irregular pieces of veneer, the edges must be cut straight for precise jointing. The Arisun clipper or the veneer guillotine jointer are used for this purpose.

2) Veneer taping

After the veneer is processed by the veneer jointer, the veneer taping machine is used to join the veneer edge to edge to prescribed dimensions. This machine is usually used for the jointing of the back veneer sheet.

3) Veneer edge gluing

The veneer edge gluer is used for continuous glue-coating and splicing of the edges of veneer pieces which are carried with the grain at right angle to the direction of the feeding, automatically cutting the veneer to the desired length. Thermo-setting or thermo-plastic glue can be used with this machine. The veneer splicer is used to join the edges of veneer with glue instead of tape and is suitable for both back and core veneer sheets.

Manufacture of Plywood

1. Glue mixing

The glue mixer is used to mix the liquid or powder with the proper amount of water, hardener, filler and other ingredients.

2. Glue spreading

The glue spreader spreads the glue uniformly on the core veneer sheets in the first process to produce plywood from veneer sheets.

3. Pre-pressing

Veneer sheets glued together are stacked and pre-pressed by the cold press. Pre-pressing minimizes overlapping or gapping of the center core veneer which may occur during the carrying of the glued veneer sheets to the hot-pressing process.

4. Hot pressing

After pre-pressing, the plywood is fed to the hot press, where it is put under pressure of 10 – 15 kg/cm^2 in a temperature of 110 – 120°C.

Finishing

1. Sizing

After being hot pressed, the plywood is cut to prescribed specifications by the double sizer, which consists of rip-saw and cross-cut machine.

2. Sanding

The wide belt sander is generally used to finish plywood panels. It utilizes an abrasive belt which runs on serrated rubber contact rollers or platens. The number of heads, the combination of contact rollers and platens and the hardness of the rubber are determined by the kind and grade of finish desired.

3. Grading and inspection

After sanding, the plywood panels are carried by an automatic conveyor for grading and inspection. The panels are inspected and selected for delivery while they are on the conveyor.

Required Plant Site Area

The required building site is 32,000 m^2 (400 x 80 m) plus 10,000 m^2 for future expansion.

The detailed description of machinery and equipment required for 4,000 sheets/day plant are omitted here. However, the FOB price of machinery and equipment which should be imported is ¥1,180,000,000 while the machinery and equipment locally procurable would cost ¥350,000,000.

Locational Condition

1. Site where collection of logs is easy and storing is available.
   (1) Site facing unfrozen rivers, lakes and sea.
   (2) If there is no available water surface, site must be convenient for log collection.
2. Convenient site for sale and transportation of products.
3. Site where labour force is available.
4. Site where procurement of utilities is convenient.

Table 1: Requirement of Raw, Sub Materials & Utilities

Item	Spec.	Quantity
Logs	Suitable for plywood	106 m^3/day
Gum tape	For veneer lathe	23,000 m/day
	For patching	7,000 m/day
Urea resin		3,220 kg/day
Wheat flour		705 kg/day
Ammonium chloride		0.65 kg/day
Electricity		980 kWh
Steam		10 tons/hr.
Water		20 m^3/hr.
Nitrogen gas		150 ℓ/50 hr.
Lubricating oil	JIS No. 1 turbine oil	5,000 ℓ/300 days

Table 2: Required Manpower

Item	No.
Engineer	13
Skilled worker	54
Ordinary worker	96
Odd job man	9
Senior clerical worker	1
Junior clerical worker	7
Total	180

How To Start Smaller Industries

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JAPANESE INDUSTRIAL STANDARD — J I S

Urea Resin Adhesives for Wood — K 6801-1987

1. Scope

This Japanese Industrial Standard specifies the liquid urea resin adhesives ([1]), hereinafter referred to as the "adhesives", used for plywood, glue laminated wood, laminated veneer lumber, particle board, middle class fiber board, general wood working, etc.

Note ([1]) Urea resin adhesives for wood, as they are called here, are limited to the liquid synthetic resin adhesives prepared by using urea and formaldehyde as the main components. They include the copolymers prepared by replacing a portion of urea by melamine, phenols, and others.

Remark: The units and numerical values given in { } in this Standard are based on the traditional unit system and are currently the criteria in force.

2. Classification

Adhesives shall be classified according to the fields of use as given in Table 1.

Table 1. Type of Adhesives

Type	Use
Class 1 (For use at normal temperature)	Mainly for general wood working and glue laminated wood
Class 2 (For use by thermal treatment)	Mainly for plywood and particle board

Remark: Class 2 shall be subdivided into A and B according to the content of free aldehyde (refer to Table 2).

3. Quality

The adhesives, when being tested in accordance with the description in 6., shall conform to the requirements given in Table 2.

Table 2. Quality of Adhesives

Test item			Quality			Test condition	Applicable test clause
			Class 1 (for normal temperature)	Class 2 (for thermal treatment)			
				A	B		
Appearance			No alien matter considered to be harmful			–	6.1
Nonvolatile matter		%	60 min.	43 min.		E-3 h/105 (2) ± 1.5°C	6.2
Preservativeness		h	10 min.			70 ± 2°C	6.3
Miscibility with water		times	2 min.			25 ± 1°C	6.4
pH		–	6.5 to 10.5	6.5 to 11.5		25 ± 1°C	6.5
Free formaldehyde		%	3 max.	Under 1	2 max.	–	6.6
Compressive shearing adhesive strength	Normal state	N/mm^2 {kgf/cm^2}	9.81 {100} min.	–		–	6.7.1
	Warm-water resistance	N/mm^2 {kgf/cm^2}	5.88 {60} min.	–		D-3 h/60 (2) ± 3°C	6.7.1
Wood tensile shear adhesive strength	Normal state	N/mm^2 {kgf/cm^2}	–	1.18 {12} min.		–	6.7.2
	Warm-water resistance	N/mm^2 {kgf/cm^2}	–	0.98 {10} min.		D-3 h/60 (2) ± 3°C	6.7.2

Table 2 (Continued)

Test item			Quality			Test condition	Applicable test clause
			Class 1 (for normal temperature)	Class 2 (for thermal treatment)			
				A	B		
Reference test	Viscosity	Pa·s {P}	0.3 to 15 {3.0 to 150}	0.01 to 15 {0.1 to 150}		25 ± 0.5°C	Reference Test 1.
	Gelation time	min	5 to 150	10 min.		25 ± 0.5°C (3)	Reference Test 2.
	Miscibility with vinyl acetate		Good miscibility	–		23 ± 2°C	Reference Test 3.

Notes (2) Letter "D" means treatment in warm water, and "E" in an air thermostat.

(3) For the Class 2 with the gelation time of not less than 100 min, measurement may be taken at 40 ± 1°C or 50 ± 1°C.

4. Method of Sampling

Sampling of products shall be carried out for each lot in accordance with the sampling method prescribed below:

4.1 Lot The definition of a lot shall be in accordance with 4.1 in JIS K 6833.

4.2 Number of Samples In accordance with 4.2 in JIS K 6833.

4.3 Sampling In accordance with 4.3 in JIS K 6833.

4.4 Sample for the Test Mix the samples taken from the product so that they represent the mean properties and use the admixture for the test, hereinafter referred to as the "sample". Its amount shall be about twice that required for the test.

5. Standard Condition of Laboratory

The condition of a laboratory shall be principally the standard temperature condition Grade 2 and standard humidity condition Grade 2 (23 ± 2°C in temperature and 50 ± 5 % in relative humidity) specified in JIS K 7100.

If there is a special circumstance, however, the standard temperature condition Grade 5 (20 ± 5°C) and standard humidity condition Grade 20 (65 ± 20 %) may be adopted instead. In this case, the temperature and humidity in the laboratory adopted for testing shall be recorded in the test report.

6. Test Method

6.1 Appearance Spread the sample uniformly in a thin film on a clean glass plate with a glass rod and immediately examine with the naked eye for the presence of foreign matters harmful to adhesion such as coarse particles, sand, dust and rust.

6.2 Nonvolatile Matter (Evaporation Residue) Shall be in accordance with 6.4 in JIS K 6833.

6.3 Preservativeness

6.3.1 Apparatus Apparatuses shall be as follows:

(1) Thermostatic Bath Use one capable of keeping the temperature of the bath liquid at 70 ± 2°C.

(2) Test Tube Use a 18 by 165 mm test tube prescribed in JIS R 3503.

(3) Balance Use one with a reciprocal sensibility of 100 mg or coarser.

(4) Thermometer Use a 100-degree thermometer prescribed in JIS B 7411.

6.3.2 Procedure Weigh out 10 g of the sample with the balance into a test tube, stopper lightly with a cork or a rubber stopper, then dip the tube in the bath liquid kept at 70 ± 2°C so that the surface of the sample is approximately 2 cm below the surface of the bath liquid, and read the start time. After about 10 minutes, stopper firmly and measure the time required until the sample is gelatinized and stops flowing by slanting the test tube at every 1 hour's lapse from the start time.

6.4 Miscibility with Water

6.4.1 Apparatus Apparatuses shall be as follows:

(1) Balance Use one with a reciprocal sensibility of 100 mg or coarser.

(2) Erlenmeyer Flask Use a 200 ml Erlenmeyer flask prescribed in JIS R 3503.

(3) Burette Use a burette or a measuring cylinder prescribed in JIS R 3505.

(4) Thermometer Use a 50-degree thermometer prescribed in JIS B 7411.

(5) Thermostatic Bath Use one which can maintain temperature at 25 ± 1°C.

6.4.2 Procedure Weigh out approximately 5 g of the sample in the Erlenmeyer flask, put the thermometer in it and immerse it in the bath liquid kept at 25 ± 1°C to make the temperature of the sample 25 ± 1°C. Gradually add the water previously kept at 25 ± 1°C from the burette and stir to mix the water with the resin well. After stirring thoroughly, again add the water while stirring, and read in the unit of ml the amount of water which has been added till the resin becomes immiscible and sticks to the inside walls of the flask as an insoluble matter. Then calculate the miscibility with the water from the following formula in integral multiples. This measurement shall be performed until water is added 20 times and the frequency exceeding it shall be denoted as 20 times or more.

$$L=\frac{W}{S} \quad \cdots\cdots (1)$$

where L : multiples denoting the miscibility with water

W : amount of water added (ml)

S : weight of the sample (g)

6.5 pH In accordance with 6.2 in JIS K 6833.

6.6 Free Formaldehyde

6.6.1 Apparatus Apparatuses shall be as follows:

(1) Balance Use one with a reciprocal sensibility of 10 mg or coarser.

(2) Ground-Stoppered Erlenmeyer Flask Use a 200 to 300 ml Erlenmeyer flask prescribed in JIS R 3503.

(3) Burette Use a 25 ml burette prescribed in JIS R 3505.

6.6.2 Reagents Reagents shall be as follows:

(1) Methyl Red-Methylene Blue Use the solution prepared according to 4.3 in JIS K 8001.

(2) 0.1 mol/l {0.1 N} and 1 mol/l {1 N} Hydrochloric Acid Use the hydrochloric acid prepared by the dilution of the acid prescribed in JIS K 8180 and standardized in accordance with JIS K 8001.

(3) 0.1 mol/l {0.1 N} and 1 mol/l {1 N} Sodium Hydroxide Solution Use the sodium hydroxide solution prepared in accordance with JIS K 8001 by dissolving sodium hydroxide prescribed in JIS K 8576, and standardized with 0.1 mol/l {0.1 N} and 1 mol/l {1 N} hydrochloric acid prepared in (2).

(4) 10 % Aqueous Solution of Ammonium Chloride Use the solution prepared by using ammonium chloride prescribed in JIS K 8116.

6.6.3 Procedure Weigh out accurately the sample containing approximately 0.1 to 0.3 g of formaldehyde into the ground-stoppered Erlenmeyer flask, and add 50 ml of water and stir.

Add 2 drops of indicator and after neutralizing the solution with 0.1 mol/l {0.1 N} hydrochloric acid or 0.1 mol/l {0.1 N} sodium hydroxide solution, add 10 ml each of ammonium chloride solution and 1 mol/l {1 N} sodium hydroxide solution. Then stopper, shake and allow it to stand for 30 min at 25°C with occasional shaking. Then titrate it with 1 mol/l {1 N} of hydrochloric acid taking the point as the end point where the colour of the solution changes from green to grayish blue in the process of the colour change from green to grayish blue and then to reddish purple.

Carry out a blank test and obtain the free formaldehyde from the following formula (2). Carry out at least two tests on the same sample, and obtain their average to the second decimal point.

$$H = \frac{0.045\,0\,(A-B)\,f}{S} \times 100 \quad \cdots\cdots (2)$$

where H : free formaldehyde (%)

A : amount of 1 mol/l {1 N} hydrochloric acid consumed in the blank test (ml)

B : amount of 1 mol/l {1 N} hydrochloric acid consumed by the sample (ml)

f : factor of 1 mol/l {1 N} hydrochloric acid

S : weight of the sample (g)

6.7 Adhesive Strength Class 1 shall be tested by the testing method for compressive shearing adhesive strength described in 6.7.1 and Class 2 by the testing method for wood tensile shear adhesive strength described in 6.7.2. In either case, the test shall be performed in normal state and for warm water resistance.

6.7.1 Compressive Shearing Adhesive Strength Compressive shearing adhesive strength shall be tested as follows:

(1) Material of Test Piece Use a straight grained birch block (4) dried to a water content of 6 to 15 % and having a volume density of 500 to 800 kg/m³ {0.5 to 0.8 g/cm³} and a thickness of 10 ± 0.5 mm, with the surface for adhesion finished flat. Make the direction of its main fibers parallel with the axis of material as shown in Fig. 1.

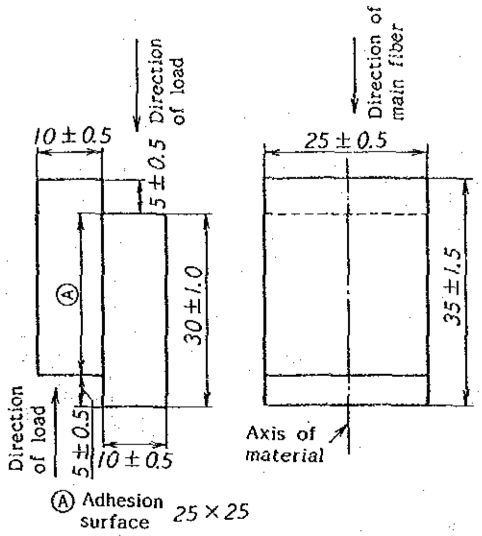
Note (4) Woods other than birch may be used. However, in such a case, a statement to that effect must be made in the report.

(2) Preparation of Test Piece Add water and flour of Hakuriki Grade 3 so as to obtain the ratio of 55 % between the amount of nonvolatile matter of the sample and the total amount of the compound and also to adjust its viscosity to be suitable for coating. Then the compound adhesives are prepared by adding ammonium chloride prescribed in JIS K 8116 by the amount equal to 0.5 to 2.0 % of the sample to the above mixture.

Immediately spread the prepared compound adhesives uniformly over each of the surfaces for adhesion of (1) at a rate of approximately 100 g per 1 m², and cause each surface for adhesion to come into close contact in such a way that both sides parallel to the axis of material coincide with each other. Then press the test piece with a load of 0.98 to 1.47 GPa {10 to 15 kgf/cm²} and allow it to stand under the load for 24 h at 20 to 25°C, and then remove the load. Further allow it to stand at the same temperature for 48 to 72 h, finish it to the shape and dimensions shown in Fig. 1, then scrape off the excessive adhesives from the periphery of the surfaces for adhesion and prepare twelve test pieces for each treatment. In this process, measure each of the actual adhesion areas.

Fig. 1. Shape and Dimensions of Test Piece

Unit: mm



(3) Treatment of Test Piece

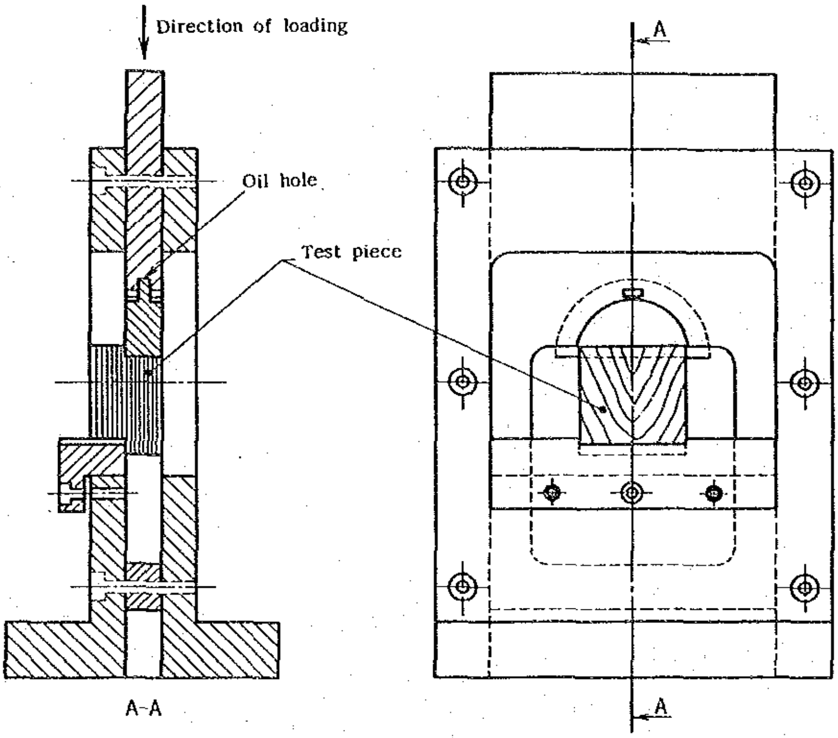
(a) Normal State Submit the test piece to a test in normal state immediately after the test piece is prepared.

(b) Warm-water Resistance After immersing 12 test pieces in warm water at 60 ± 3°C for three hours and then dipping them in room temperature water to cool down, subject them to the test while still wet.

(4) Testing Machine The testing machine shall be so selected that the breaking load of the test piece falls in the range of 15 to 85 % of its loading capacity and its standard error is ± 1 % of its standard load. Its loading rate shall be not more than 9.8 kN {1000 kgf} per minute, or else the moving speed of its crosshead be 0.5 to 2.0 mm per minute.

(5) Fixture Use a fixture which can concentrate the stress on the adhesion surface as shown in Fig. 2.

Fig. 2. Fixture



(6) Measurement Attach the test piece to the fixture so that its surface to be loaded is in alignment with the direction of load, then measure the maximum load N {kgf} shown till the breaking of the test piece takes place with the tester of (4), and calculate the adhesive strength N/mm² {kgf/cm²} by dividing the load by the adhesion area that was measured actually. In this operation, obtain the ratio of the broken area in the wood part to the sheared area by a multiple of 10 %, and record it as the percentage of wood failure (%). Test 12 test pieces in turn, and take the respective mean values as the compressive shearing adhesive strength and the percentage of wood failure.

Represent the mean percentage of wood failure by a multiple of 5 % by counting fraction of 0.3 or over as a unit and cutting away the rest. Concerning the compressive shearing adhesive strength, calculate the standard deviation from the following formula (3).

$$S=\sqrt{\frac{n\Sigma x^2-(\Sigma x)^2}{n\cdot(n-1)}} \quad \cdots\cdots (3)$$

where S : standard deviation (N/mm^2) {kgf/cm^2}

x : individual adhesive strength (N/mm^2) {kgf/cm^2}

n : number of test pieces

When the mean percentage of wood failure is 50 % or more and the mean adhesive strength is the standardized value or less, carry out a retest with newly prepared test pieces.

In the test report of adhesive strength, the following items shall be stated.

(a) Standard condition of the laboratory

(b) Blending percentage of adhesives

(c) Kinds of tree, volumetric density, and water content of test piece

(d) Type of test

6.7.2 Wood Tensile Shear Adhesive Strength Wood tensile shear adhesive strength shall be tested as follows:

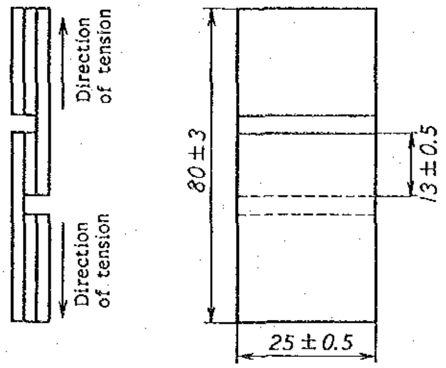
(1) Material of Test Piece Use a rotary veneer of South Sea Island lumber having a thickness of 1.2 to 1.5 mm, water content of 8 ± 2 % and a volume density of 450 to 600 kg/m^3 {0.45 to 0.60 g/cm^3} as the material of the test piece.

(2) Preparation of Test Piece Compound adhesives are prepared by adding to the sample the flour of Hakuriki No. 3, water and ammonium chloride prescribed in JIS K 8116 whose amount is equal to 0.2 to 1.0 % of the sample so as to make the amount of the nonvolatile matter in the sample 35 % of the total amount of the compound and also to make its viscosity suitable for coating.

Immediately spread the prepared compound adhesive on both surfaces of the core veneer of (1) to be tested at a rate of 160 ± 10 g per 1 m^2, overlap the front veneer and the back veneer on it so as to make the sap-side of the veneer face outward and, at the same time, arrange the direction of the fiber to be at right angles with the core veneer. Then apply to them uniformly the pressure of 0.98 ± 0.10 N/mm^2 {10 ± 1 kgf/cm^2} at room temperature for 30 ± 10 minutes, place them between hot press kept at 115 ± 2°C, apply uniformly the pressure 0.78 ± 0.10 N/mm^2 {8 ± 1 kgf/cm^2} for about 2 minutes to prepare three sheets of sample plywood each of which is composed of three veneers, and then allow them to stand to cool to room temperature. Each of these three sheets of sample plywood shall be given cuts having shapes and dimensions shown in Fig. 3 and fitting individual treatments of test pieces so as to facilitate the application of shearing force in the same direction as the reverse check of the core veneer and in the opposite direction, thus to provide 5 test pieces for each direction, or 10 pieces in all. The total sum of test pieces out of the three sheets shall be 30.

Fig. 3. Shape and Size of Test Piece

Unit: mm



(3) Treatment of Test Piece The treatment of test pieces shall be as follows:

(a) Normal State Submit the test pieces to the normal state test after allowing them to stand for not less than 48 hours after preparing them.

(b) Warm-water Resistance After immersing test pieces in warm water of 60 ± 3°C for three hours and then dipping them in room-temperature water to cool down, subject them to the test while still wet.

(4) Testing Machine The testing machine shall be so selected that the breaking load of the test piece falls in the range of 15 to 85 % of its loading capacity and its standard error is ± 1 % of its standard load.

Its loading rate shall be not more than 5.88 kN {600 kgf}, or else the moving speed of its crosshead be 0.5 to 2.0 mm per minute.

(5) Fixture Use a fixture of structure that will giving no stress such as twisting or peeling.

(6) Measurement After tightly attaching both ends of the test piece to grips, measure the maximum load N {kgf} shown until the breaking of the test piece takes place with the tester of (4), and obtain adhesive strength N/mm^2 {kgf/cm^2} by dividing the load by adhesion area which was measured actually between two cuts.

In this operation, obtain the ratio of the broken area in the wood part to the sheared area by a multiple of 10 %, and record it as the percentage of wood failure (%). Test 30 test pieces in turn, and take the respective mean values as the wood tensile shear adhesive strength and the percentage of wood failure.

Represent the mean percentage of wood failure by a multiple of 5 % after counting fraction of 0.3 or over as a unit and cutting away the rest.

Concerning the wood tensile shear adhesive strength, calculate the standard deviation from the formula (3) in 6.7.1 (6).

When the mean percentage of wood failure is 50 % or more and the mean adhesive strength is the standardized value or less, carry out a retest with newly prepared test pieces.

In the test report of adhesive strength, the same items as given in 6.7.1 (6) shall be stated.

7. Marking

Each container shall be marked with the following information.

In the case of large-sized transportation container such as a tank truck and tank lorry, the accompanying "weight document of product" or "test report of product", *if equipped with the following items from (1) to (7), may go as the* regular markings.

(1) Name

(2) Class

(3) Nonvolatile matter

(4) Net mass

(5) Date of manufacture (or its abbreviation)

(6) Lot number

(7) Manufacturer's name or its abbreviation

8. Caution for Handling

Adhesives, because of its changeable tendency, should be stored in cold and dark places at about 20°C of temperature.

Reference Test:

1. Viscosity

Follow the description in 6.3 of JIS K 6833.

2. Gelation Time

2.1 Apparatus Apparatuses shall be as follows:

(1) Thermostat Capable of keeping 25 ± 0.5°C at bath temperature.

(2) Test Tube Measuring 18 by 165 mm, specified in JIS R 3503.

(3) Glass Stirring Rod Measuring 4 mm in diameter and about 30 cm in length.

(4) Balance With a reciprocal sensibility of 100 mg or coarser.

(5) Thermometer Thermometer (TAG 50) for tag-type low flash point tester specified in JIS B 7410.

2.2 Operation The test tube, sample, and stirring rod to be used in the test shall be maintained at 25 ± 0.5°C in advance.

Weigh 10 g of the sample in a test tube, and add 1 ml of 20 % solution of ammonium chloride specified in JIS K 8116. Stir quickly with a stirring rod and at the same time record the time when it starts. Immediately immerse the test tube in a thermostatic bath kept at 25 ± 0.5°C so that the sample level is about 2 cm below the liquid level of the bath. Stir the sample from time to time, and measure time interval to the time point when threads no longer take place as the rod dipped a little in the sample is pulled up. Carry out the operation at least two times and express the gelation time in minutes by the mean value of these measurements.

3. Miscibility with Vinyl Acetate

Miscibility test with vinyl acetate shall be carried out on Class 1.

3.1 Apparatus Apparatuses shall be as follows:

(1) Balance With a reciprocal sensibility of 100 mg or coarser.

(2) Beaker A 100-ml beaker specified in JIS R 3503.

(3) Glass Plate A transparent and flat glass plate measuring about 10 by 10 cm.

(4) Glass Rod About 5 mm in diameter.

3.2 Material Materials shall be as follows:

(1) Adhesive Conforming to Class 2 specified in JIS K 6804.

(2) Hardener 20 % solution of ammonium chloride specified in JIS K 8116.

3.3 Operation Operation, classified into the case of hardener added and that of hardener not added, shall be carried out principally at 23 ± 2°C of temperature.

(1) Case of Hardener Added Weigh out 20 g of vinyl acetate resin emulsion adhesive for wood in a beaker, add 20 g of sample, immediately stir well with a glass rod, and further add 1 g of hardener, followed by stirring similarly. After letting it stand for 10 minutes, place about 2 g of the mixture on the glass plate, and observe the miscibility when it is spread all over the plate. When the mixture looks uniform and flows smoothly, pass a judgment of adequate miscibility.

(2) Case of Hardener Not Added Weigh out 20 g of vinyl acetate resin emulsion adhesive for wood in a beaker, and add 20 g of the sample, immediately stir well with a glass rod and, after letting it stand it for 6 h, place about 2 g of the mixture on the glass plate. After spreading the mixture all over the plate, judge the miscibility similarly to (1) by ascertaining if it looks uniform and can flow smoothly.

Applicable Standards:

JIS B 7411-Etched-Stem Liquid-in-Glass Thermometers, Total Immersion Type

JIS K 6833-General Testing Methods for Adhesives

JIS K 7100-Standard Atmospheres for Conditioning and Testing of Plastics

JIS K 8001-General Rules of Testing Methods for Reagents

JIS K 8116-Ammonium Chloride

JIS K 8180-Hydrochloric Acid

JIS K 8576-Sodium Hydroxide

JIS R 3503-Glass Apparatus for Chemical Analysis

JIS R 3505-Volumetric Glassware

JIS Z 8703-Standard Atmospheric Conditions for Testing

Reference Standards:

JIS B 7410-Liquid-in-Glass Thermometers for Testing of Petroleum Products

JIS K 6804-Polyvinyl Acetate Emulsion Adhesives for Woods

JIS Z 8203-SI Units and the Use of their Multiples and of Certain other Units

UDC 678.652'41.072

JAPANESE INDUSTRIAL STANDARD

J I S

Urea-Formaldehyde Molding Compounds

K 6916-1975

1. Scope

This Japanese Industrial Standard specifies the urea-formaldehyde molding compounds, hereinafter referred to as the "molding compound". Molding compound mentioned in this standard shall be that which is composed of urea resin as the main binder and pulp and other fibrous materials as the main basic material and can be hardened by hot compression after putting it in a mold to make molded goods.

2. Classification and Mark

Classifications and marks of the molding compounds shall be as shown in Table 1.

Table 1. Classifications and Marks of Urea-Formaldehyde Molding Compounds

Classification	Mark	Main use
For general use	UM-G	Suitable for the manufacture of molded goods for general use.
For electrical and mechanical uses	UM-E	Suitable for the manufacture of molded goods of which primary object is their electrical and mechanical properties.

Applicable Standard:

JIS K 6911-Testing Methods for Thermosetting Plastics

Reference Standards:

JIS Z 8203-SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units

JIS Z 8438-Kilogram Force-Newton Conversion Tables

3. Quality

Qualities of the molding compound shall be tested by the methods described under 4 and the results should conform to the specifications shown in Table 2. But a part of the tests may be omitted according to the agreement between the parties concerned.

Table 2. Qualities of Urea-Formaldehyde Molding Compound

Testing item	Unit	Treatment(1)	UM-G	UM-E
Plasticity	—	—	It can be easily detachable from mold and its appearance is good.	
Voltage resistance	—	C-90/20/65	—	To withstand the test voltage corresponding to potential gradient in Table 3 for 1 minute.
Insulation resistance (normal state)	Ω	C-90/20/65	10^9 and over	10^9 and over
Insulation resistance (after boiling)	Ω	C-90/20/65 +D-2/100	—	10^5 and over
Arc-proof property	Second	C-90/20/65	—	80.0 and over
Bending strength (normal state)	kgf/mm^2 $\{N/mm^2\}$(2)	A	6.0 and over {58.8 and over}	8.0 and over {78.4 and over}
Charpy impact strength	$kgf\cdot cm/cm^2$ $\{N\cdot cm/cm^2\}$(2)	A	2.0 and over {19.6 and over}	2.0 and over {19.6 and over}
External appearance after heating	—	A	No marked change in appearance is observed at test temperature given in Table 4.	
Water absorption	%	E-24/50 +D-24/23	2.0 and under	1.5 and under
Specific gravity(3)	—	A	(1.45 ~ 1.55)	

Note (1) (i) The letters of alphabet show the classifications of treatments of the test piece.

A : Leave intact as it is accepted and no treatment is performed.

C : Perform the treatment in the air kept at constant temperature and humidity.

D : Perform the steeping treatment in the water maintained at constant temperature.

E : Perform the treatment in the air maintained at constant temperature.

(ii) First figure shows the time required for treatment.

(iii) Second figure shows the temperature of treatment.

(iv) Third figure shows the relative humidity of treatment.

(v) Letter of alphabet and figure are separated by a cross line and figure and figure are separated by an oblique line.

(vi) When more than 2 kinds of treatments are performed, connect them with (+) sign and perform treatment according to their order.

Example: C-90/20/65+D-2/100

Treatment is performed in the air maintained at 20°C and 65 % RH for 90 hours. Then the steeping in the boiling water is performed at 100°C for 2 hours.

(2) Numerical value enclosed in the braces shows the expression and reduced value according to the international system of units.

(3) Numerical value of the specific gravity enclosed in the brackets is that shown as the reference.

4. Testing Method

4.1 Sampling Method Refer to that described under 2 in JIS K 6911-Testing Methods for Thermosetting Plastics.

4.2 Preparation of Test Piece Refer to that deseribed under 3 in JIS K 6911.

4.3 General Conditions of the Test Refer to that described under 5.1 in JIS K 6911.

4.4 Plasticity Refer to that described under 5.4.1 in JIS K 6911. But, it may be permitted to substitute the molding of the real thing for this test.

4.5 Voltage Resistance Refer to that described under 5.8.2 in JIS K 6911. But, the test voltage shall be that obtained by multiplying the potential gradient in Table 3 by the thickness (mm) of the test piece.

Table 3. Potential Gradient in Voltage Resistance Test of Urea-Formaldehyde Molding Compounds

Mark	UM-E
Potential gradient (kV/mm)	10

4.6 Insulation Resistance Refer to that described under 5.12.2 in JIS K 6911.

4.7 Arc-Proof Property Refer to that described under 5.15.2 in JIS K 6911.

4.8 Bending Strength Refer to that described under 5.17.2 in JIS K 6911.

4.9 Charpy Impact Strength Refer to that described under 5.20.2 in JIS K 6911. But the notch of the test piece shall be made by molding.

4.10 External Appearance after Heating Refer to that described under 5.23.1 in JIS K 6911. But the temperature of the test shall be as shown in Table 4 and the change in the external appearance shall be inspected with the naked eye.

Table 4. Temperature of the Test for the External Appearance of Urea-Formaldehyde Molding Compounds after Heating

Mark	UM-G	UM-E
Temperature of test (°C)	110 ± 2	110 ± 2

4.11 Water Absorption Refer to that described under 5.26.2 in JIS K 6911.

4.12 Specific Gravity Refer to that described under 5.28.1 in JIS K 6911.

5. Packaging and Packing and Marking

Molding compounds shall be packed to avoid the possibility of the moisture absorption and the following items shall be marked at a place on the container where it can be easily seen.

(1) Nomenclature

(2) Classification and mark

(3) Color

(4) Net weight

(5) Date of manufacture and lot of manufacture or mark

(6) Manufacturer's name or mark