OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

E. KARP

2. OVERVIEW OF THE AFRICAN FERTILIZER INDUSTRIAL SYSTEMS

2.1. Introduction

17877

Foremost in our minds must be concern how to feed an ever-expanding world population, this problem being the most urgent for low-income economies of developing countries where great share of the new food demand is located.

The FAO states that the world has the potential to feed a population of 6.2 billion in the year 2000 moderately better than it fed 4.4 billion in 1984. In order to achieve this, developing countries will have to double their food production to keep pace with their population growth.

Conditions in the world are ripe for a sustained take-off in food production. Advances in food production technology make it possible for mankind to wipe out hunger within the next 10-20 years. Sufficient fertilizer supplies are available along with technologies which can dramatically increase yields. International assistance mechanisms can now provide funds and technical assistance to increase food production.

If these goals cannot be achieved, the number of seriously undernourished people in the world could be as high as 600 million by the year 2000, the Far East and Africa being the worst hit.

With its population 1986 over 570 mln, projected to increase by the year 2000 to around 870 mln, Africa must intensify its agriculture to produce additional food, but not only.

In many African countries, agricultural export is the principal source of foreign exchange earnings. Therefore ability of agriculture to cover domestic demand, to cut-off food import and to produce a surplus for export is of vital importance for the African nations.
With energy prices continuing to go upwards, agriculture must produce also additional materials, for instance for energy (methane-biogas, alcohol, biomass) and for fibre, in order to substitute petroleum, very costly and not available in some countries.
Thus, agriculture must become more intensive and productive primarily by increasing the yields on land already under cultivation, all the more that expansion of cultivated land and changes in cropping intensity will have much lesser impact to increases in agricultural production to match dynamic population growth in Africa.
Both increasing the acreage and increasing the yield of existing land will require large quantities of fertilizers, considered to be the key input to agriculture and food production. Increasing amounts of the right kinds of fertilizers must be available to farmers in proper time in those areas where agricultural goals are to be attained.
These increased quantities will be used only if the fertilizers are effective and thus economical for the farmer.

./.

Fertilizers and fertilizer practices that meet the specific needs of the African countries must be tailored to the crop, soil, climate, and socioeconomic factors that prevail. With increasing costs of raw materials, processing, and transportation, more attention must be given to the increased efficiency and recovery of applied nutrients and greater utilization of indigenous resources must be encouraged.
Biological fixation of nitrogen, conservation and recycling of nutrients and organic matter including green manures should be encouraged. Chemical fertilizers and management practices must be devised as strong supplementary inputs to these sources and practices and not only as their total replacement.

Not the only one, but one of the most important factors and in many cases sine qua non condition for fertilizers to be effective is proper amount of water in the soil. Therefore, complex approach to intensification of agricultural production through the development of fertigation (fertilizer + irrigation) systems would rather be much more appropriate answer than fertilizer consumption increase only, this statement being more than true for rice production, any substantial increase of which will come from an expansion in the area of irrigated rice and additional use of fertilizer.

Consumption of the principal fertilizer nutrients - Nitrogen (N), Phosphate (P) and Potassium (K) - has risen seventeenfold in the last 40 years, from 7.5 million tons in 1945 to 129 million tons in 1985.

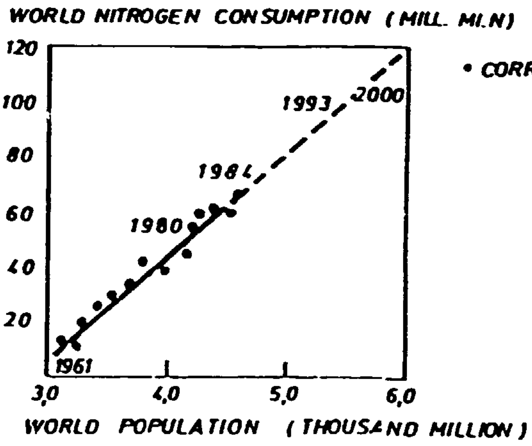
Consumption of NPK fertilizers, in terms of kg per hectare of arable land and permanent crops, is highly differentiated in the world, and by 1985 amounted to:

	N	P205	K20	NPK
World	47.4	22.4	17.4	87.1
Developed Countries	57.1	32.8	31.3	121.3
Developing Countries	39.2	13.6	5.6	58.3
Total Africa	10.8	6.7	2.6	20.1
Africa without South Africa	9.4	5.1	2.1	16.6

As can be seen from the a.m. comparison, the worst situation in the consumption of fertilizers is in Africa, and, as will be discussed in the following sections, the lowest rates of fertilization are connected with Sub-Saharan African countries.

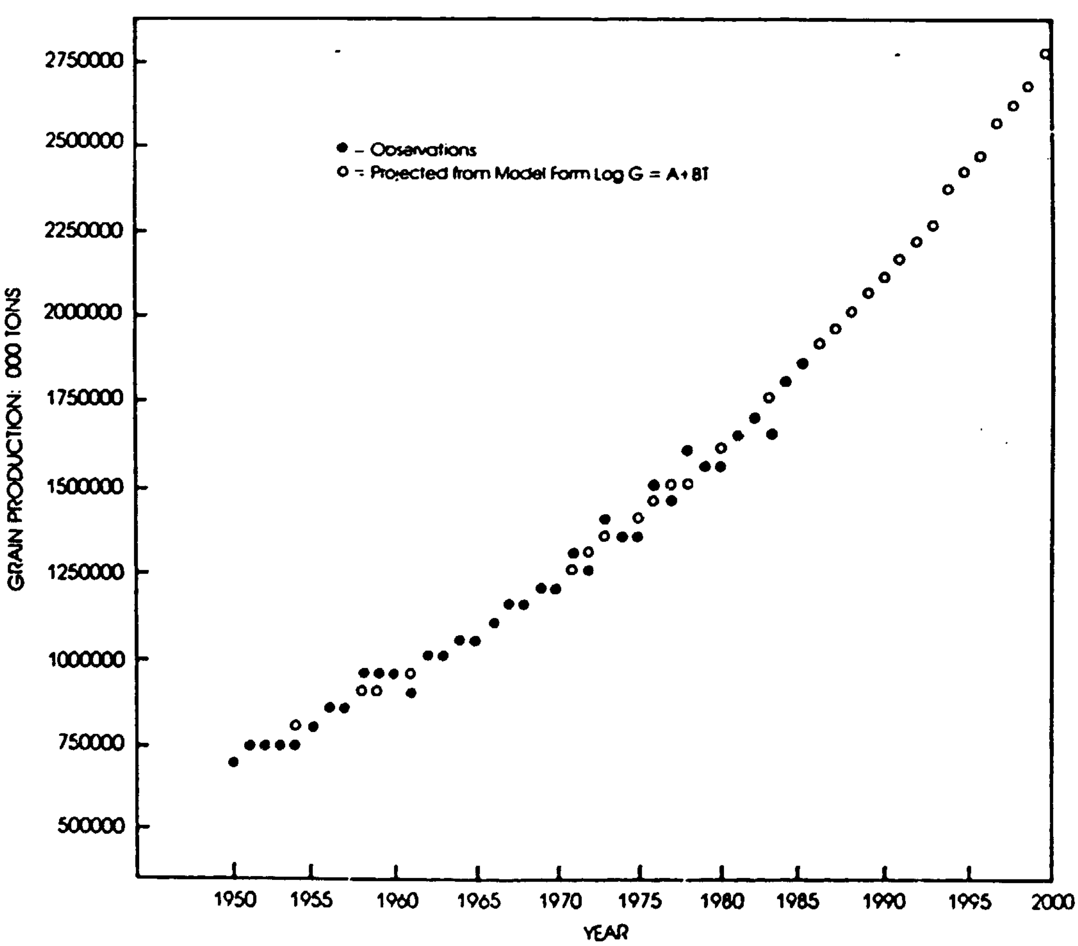
Forecasts by the UNIDO/FAO/World Bank Joint Working Group on Fertilizers suggest, that over next ten years, NPK consumption will grow at an annual rate of 3 to 4 per cent, of that 40% increase for nitrogen (N).
FAO believes that fertilizer consumption growth rates will have to be maintained and even increased by the year 2000, if the world food production targets by regions are to be achieved.

There is so close linear correlation between world population increase and increase in consumption of nitrogen fertilizers that population levels alone can be used to determine future nitrogen demand. This is illustrated in Figure 2.1 below, from which it can clearly be seen that if the trend line is extrapolated to the estimated population of 6.2 billion in 2000, correspondingly the nitrogen use will amount to over 120 million tonnes (ref. FAO source).

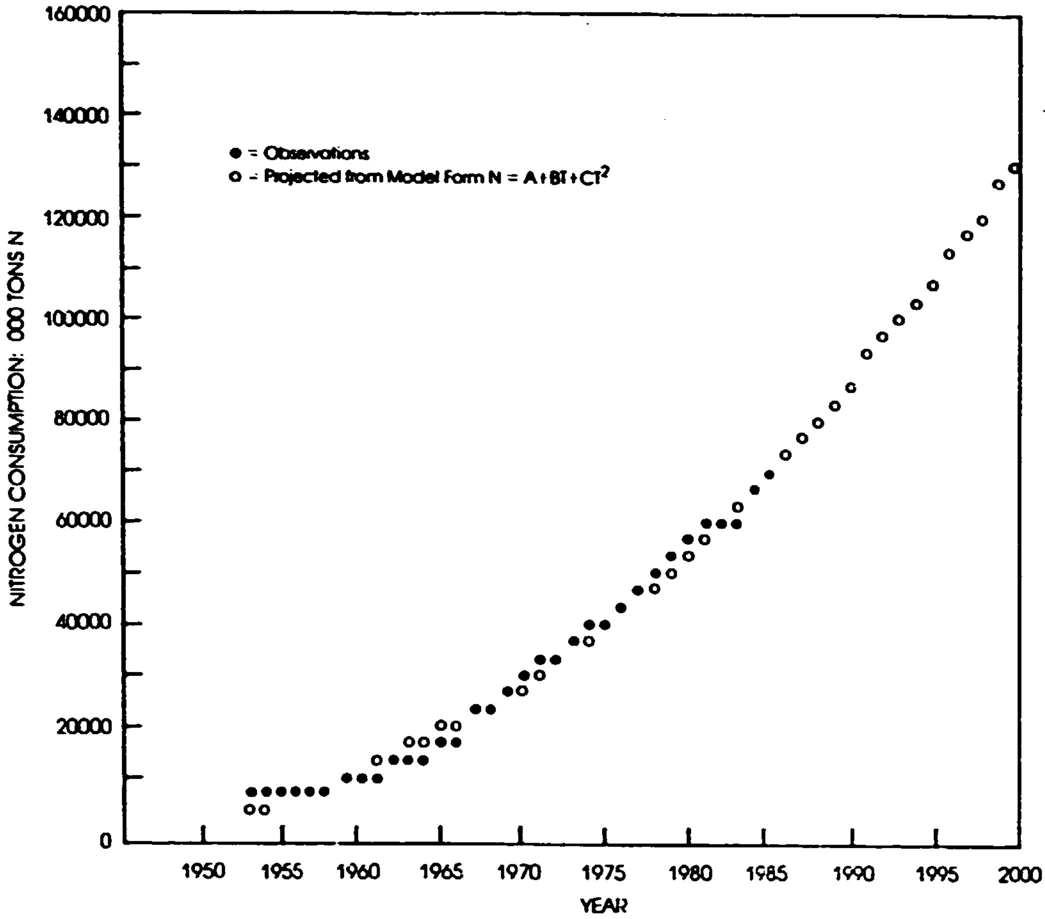


From the World Bank data, see Figures 2.2 and 2.3, a similar correlation emerges between grain production and nitrogen consumption against time, indicating that as much as 130 mln of N may be needed by the year 2000.

GRAIN PRODUCTION AGAINST TIME



NITROGEN CONSUMPTION AGAINST TIME



If, in global terms, fertilizer consumption by 2000 is to grow at the annual rate of between 3 and 4 %, the total world consumption of fertilizer nutrients should be estimated by 2000 in the range of 201 mln MTPY to 230 mln MTPY of NPK.

If 1986 figures were taken as the basis of the projection, the following would be result of NPK consumption by 2000 (in mln MTPY of pure nutrients):

	N	P2O5	K2O	NPK
Consumption 1986	72	35	26	133
Consumption 2000	120	58	43	221
N:P:K ratio	1.00	0.48	0 .36	

This projection seems to be realistic, as it based on the actual N:P:K ratio 1986, and takes more conservative nitrogen consumption 2000 into consideration, namely 120 mln MTPY of N.
Thus, for the future analyses of the fertilizer industry development in Africa, we can assume that the world fertilizer consumption 2000 will be minimum 221 mln MTPY of NPK.
Correspondingly, the increase in fertilizer consumption 1986 til 2000 can be estimated in the global scale for minimum 221-133 = 88 mln MTPY of NPK.

The future of the international industry is assured if we are to continue to feed a growing world population. To do this, there is a need to continuously increase the facilities for producing the three major nutrients nitrogen, phosphate and potash.

2.2. The Position of Africa in Relation to the World Fertilizer Industry

2.2.1. General remarks

In order to characterize the position of Africa to the world fertilizer industry, the year 1986 has been selected as the time-base in the study. Whenever there were no data for 1986, the data for 1985 have been used.
Nigeria is the only exception in this study as far as the time-base is concerned. In 1986 the huge nitrogen fertilizer complex at Onne was not yet operational and therefore Nigeria, with its production of NPK fertilizers 1986 close to zero, cannot be compared with the state of 1988/1989 when this country joined the group of the strongest African producers of NPK fertilizers. Hence, some comments, whenever applicable.
Because of the lack of data, out of 50 African countries, 7 countries: Cape Verde, Comoros Islands, Djibouti, Equatorial Guinea, Guinea-Bissau, Sao Tome and Principe and Seychelles have not been included in the final results of the classification of African countries according to the development of their fertilizer industrial systems.

2.2.2. Production of NPK fertilizers in the world and in Africa

Data on the world production of NPK fertilizers in 1986 by regions are presented in Table 1 below (in 000 MTPY of pure nutrients):

	N	P205	K20	NPK	Share %
Western Europe	11.282	4.717	4.897	20.896	14.6
Eastern Europe	22.306	11.597	13.713	47.615	33.4
AFRICA	1.664	1.832	0	3.496	2.4
North America	13.642	8.513	8.251	30.406	21.3
Central America	1.674	263	0	1.937	1.4
South America	1.358	1.654	11	3.022	2.1
Middle East	1.761	720	1.926	4.406	3.1
Asia CPEs	12.231	2.521	25	14.776	10.4
South and East Asia	11.291	3.859	0	15.149	10.6
Oceania	253	788	0	1.041	0.7
WORLD TOTAL	77.459	36.463	28.821	142.744	100

When African production of NPK fertilizers is taken without South Africa (N - 366, P205 - 365, K20 - 0; NPK - 733), resulting NPK production 1986 will be 2.763.000 MTPY, and the share in the world NPK production will go down to 1.9%.

2.2.3. Consumption of NPK fertilizers in the world and in Africa

Data on the world consumption of NPK fertilizers 1986 by regions are presented in Table 2 below (in 000 MTPY of NPK):

	N	P205	K20	NPK	Share %
Western Europe	11.684	5.356	5.231	22.271	16.7
Eastern Europe	16.548	11.507	10.076	38.131	28.7
AFRICA	1.899	1.218	416	3.534	2.6
North America	10.407	4.297	4.792	19.495	14.7
Central America	1.962	586	425	2.973	2.2
South America	1.891	2.224	1.591	5.706	4.3
Middle East	1.076	704	80	1.859	1.4
Asia CPEs	14.223	3.164	654	18.041	13.6
South and East Asia	12.182	4.752	2.528	19.463	14.6
Oceania	400	942	217	1.559	1.2
WORLD TOTAL	72.273	34.749	26.009	133.033	100

When consumption of NPK fertilizers in South Africa is excluded (N - 361, P205 - 337, K20 - 119; NPK - 817), the resulting consumption will be 2.717.000 MTPY of NPK, and the African share in the world fertilizer consumption with South Africa not being counted drops down to about 2%.

2.2.4. Trade of NPK fertilizers in the world and in Africa

Data on the world imports of NPK fertilizers 1986 by regions are presented in Table 3 below (in 000 MTPY of NPK):

	N	P205	K20	NPK	Share %
Western Europe	4.991	2.784	4.004	11.778	27.9
Eastern Europe	608	994	3.161	4.763	11.3
AFRICA	653	412	465	1530	3.6
North America	2.841	301	4.525	7.667	18.2
Central America	588	312	461	1.359	3.2
South America	822	574	1.805	3.199	7.6
Middle East	694	593	65	1.353	3.2
Asia CPEs	2.067	654	699	3440	8.1
South and East Asia	2.557	1.144	2.807	6.508	15.5
Oceania	164	188	183	535	1.2
WORLD TOTAL	16.004	7.955	18.174	42.133	100

When imports of NPK fertilizers in South Africa is excluded (N - 0, P205 - 0, K20 - 138; NPK - 138), the resulting imports will be 1.392.000 MTPY of NPK, and the African share in the world fertilizer imports with South Africa not being counted will be around 3.3%.

Data on the world exports of NPK fertilizers 1986 by regions are presented in Table 4 below (in 000 MTPY of NPK):

	N	P2O5	K2O	NPK	Share %
Western Europe	4.512	1.967	3.286	9.765	22.6
Eastern Europe	4.819	729	5.993	11.541	26.7
AFRICA	413	929	15	1.358	3.1
North America	3.242	3.468	7.464	14.174	32.7
Central America	291	16	8	316	0.7
South America	152	0	1	153	0.4
Middle East	1.456	607	1.781	3.844	8.9
Asia CPEs	7	34	0	41	0.1
South and East Asia	1.325	610	86	2021	4.7
Oceania	46	0	0	46	0.1
WORLD TOTAL	16.263	8.359	18.635	43.258	100

Exports of NPK fertilizers from South Africa, reported in 1986, was negligible in comparison to exports from Africa, and therefore the share of Africa in the world exports remains around 3%.

2.2.5. Position of Africa in the world fertilizer industry

As illustrated above for the base year 1986, the position of Africa in the world fertilizer industry is not very important, as the share of African production, consumption, import and export of NPK fertilizers is embraced within the range of 2.4% (production) to 3.6% (import) in relation to corresponding world data.
When South Africa is excluded from the account, the range of the African share in world production and import of NPK fertilizers will accordingly be equal to 1.9% and 3.3%, the share of consumption and export being 2.0% and 3.0%.

When overall equation of apparent consumption of NPK fertilizers in Africa is examined (C = P + I - E) for the year 1986, the following conclusions emerge:

- consumption of NPK fertilizers is approximately balanced by production of NPK fertilizers (C = 3.534 mln MTPY of NPK is approximately equal to P = 3.496 mln MTPY of NPK),

- import of NPK fertilizers is approximately balanced by export of NPK fertilizers (I = 1.530 mln MTPY of NPK is at the export level equal to E = 1.358 mln MTPY of NPK).

Similar conclusions can be drawn when South Africa is exluded from the NPK balance, which is then located at the level lower by some 0.8 mln MTPY of NPK (consumption of around 2.7 mln MTPY instead of around 3.5 mln MTPY of NPK would then be discussed).

The picture is, however, quite different when apparent consumption balances of each of the nutrients are prepared separately, as follows (in 000 MTPY of pure nutrients):

	C	=	P	+	I	-	E
N	1899	=	1664	+	653	-	413
P205	1218	=	1832	+	412	-	929
K20	416	=	0	+	465	-	15
NPK	3534	=	3496	+	1530	-	1358

From the a.m. apparent consumption balances (in which there are unavoidable discrepancies because of the differences in the stocks of fertilizers, calculation of NPK consumption by calendar or fertilizer year in different countries, as well as because of some roundings in figures), one can easily draw the following conclusions:

- There is shortage of nitrogen production in Africa as compared to its consumption; P/C coverage is around 87%; nitrogen shortage is covered by imports.

  * Note: Nigerian nitrogen complex of the capacity 272.000 MTPY of N, fully operational since 1988, improves nitrogen balance for Africa, as even with the capacity utilization rate around 75% it adds some 200.000 MTPY of N more to the balance on nitrogen production side.

- There is evident surplus of phosphate production over consumption in Africa; P/C coverage is around 150%; phosphate surplus is being exported.

- There is no production of potash in Africa at all; P/C coverage is then equal to 0%; all potassium consumed is being imported, with a small export of potash included in complex NPK fertilizers.

In order to analyze in a more complex way apparent consumption of each of the components of the NPK balance, also sulphur - being of the great importance to production of the phosphate fertilizers - should be included in this examination.
The apparent consumption balance for sulphur in Africa in 1987 (there were no complete data available for 1986) is as follows (in 000 MTPY of S):

	C	=	P	+	I	-	E
Sulphur in all forms	4958	=	1142	+	3905	-	0

From the above, a very important conclusion emerges:

Africa is heavily dependent on sulphur imports, own production of sulphur in all forms covering sulphur consumption only in 23%.
When native sulphur, i.e. brimstone, is only considered, Africa is even in much worse situation then, as own production of brimstone in Africa covers sulphur consumption only in about 4%.

From the above mentioned conclusions, regarding both N,P,K,S balances and the position of Africa in the world fertilizer industry, a very concrete strategy should emerge for the fertilizer industry development in Africa, namely:

A. There is a great need to boost overall NPKS fertilizer potential in Africa for a higher level of production in order to decrease a very high gap to the world average NPK production and consumption indices per capita and per hectare of arable land.
In the year 2000, Africa with its population as high as 870 mln inhabitants, that is around 14% of the total world population, will share in the global NPK production balance approximately ~~in~~ 2%, unless there is a significant shift to reverse present trends.

B. High priority should be given to the development of potash and sulphur natural resources hampering the development of the fertilizer industry in Africa.

Special attention should be attached to the analyses of technical and economical viability of potash extraction from potash ores and brines in Ethiopia, Congo, Botswana, Tunisia and elswhere.

Priority should be given to the economically viable investment projects connected with the development of pyrites and sulphide ores deposits, as well as to projects related to desulphurization of smeltering S-off-gases from the copper/nickel/zinc industry, desulphurization of crude oil, sour gases and coal.

2.2.6. Comparison of the world and African fertilizer leaders

In order to illustrate the position of Africa in relation to the world fertilizer industry, a comparison of the twelve African fertilizer producers with the twelve world fertilizer leaders is presented below. Production of fertilizers 1986 is expressed in terms of 000 MTPY of NPK:

1.	Tunisia	862	1.	USSR	33.761
2.	Egypt	730	2.	United States	20.429
3.	Morocco	526	3.	China P.R.	13.942
4.	Libya	240	4.	Canada	9.978
5.	Algeria	166	5.	India	7.097
6.	Zimbabwe	121	6.	Germany D.R.	5.046
7.	Senegal *	16	7.	France	4.079
8.	Zambia	14	8.	Germany F.R.	3.613
9.	Tanzania	10	9.	Romania	2.690
10.	Mauritius	10	10.	Indonesia	2.476
11.	Nigeria **	5	11.	Brazil	2.250
12.	Cote D'Ivoire	4	12.	Netherlands	2.067
AFRICAN LEADERS		2.704	WORLD LEADERS		107.428

The production share of the twelve African leaders in the total production of NPK fertilizers in Africa (3.496 mln MTPY of NPK including South Africa) is around 77%. When South Africa is included, it should be ranked second after Tunisia among the 13 producers.
The 12 mentioned African leaders, cover 100% of NPK production in the analyzed group of 43 African countries.

Both Senegal and Nigeria did not develop their full operational capacities in 1986, and therefore they are ranked lower (Senegal in production level; Nigeria in production level and inthe position at the list, where it should be ranked around the 5th place).

It should be stressed that the ranking list does not include the production of fertilizer related raw materials and intermediaries, such as natural gas, phosphate rock, ammonia and phosphoric acid, exported from Africa in large quantities.

The share of the biggest 12 world producers in the total world production of NPK fertilizers is around 75%.
No one of fertilizer "giants" from Africa: Tunisia, Egypt, Morocco, Libya, Algeria, (Nigeria), or South Africa, can match with the NPK production level to any of the 12 world fertilizer leaders. Cumulative NPK production of the 12 world leaders is 40 times higher than that of the all analyzed NPK producers in Africa.

When consumption of NPK fertilizers, expressed in 000 MTPY, is compared in **between** 12 African biggest consumers (excluding South Africa) and the 12 world leading fertilizer consumers, the following picture emerges:

1.	Egypt	807	1.	USSR	26.506
2.	Morocco	323	2.	United States	17.300
3.	Nigeria	295	3.	China P.R.	16.782
4.	Algeria	272	4.	India	9.622
5.	Zimbabwe	158	5.	France	4.172
6.	Kenya	123	6.	Brazil	3.988
7.	Tunisia	106	7.	Poland	3.583
8.	Ethiopia	93	8.	Germany F.R.	3.143
9.	Sudan	83	9.	United Kingdom	2.666
10.	Zambia	77	10.	Italy	2.039
11.	Cameroon	52	11.	Indonesia	2.025
12.	Tanzania	40	12.	Mexico	1.826
AFRICAN LEADERS		2.429	WORLD LEADERS		93.652

The 12 African leading consumers shared in 1986 in 88% in overall consumption of NPK fertilizers among the 43 analyzed African countries (and in 68% when South Africa is included).
The remaining 31 African countries consume only 12% of fertilizers. The most important consumers that follow are: Libya, Mali, Malawi, Cote D'Ivoire, Mauritius.

No one of African fertilizer "giants" can match in the NPK consumption level with any of the world leading consumers.
The share of the 12 world leaders in the world NPK consumption 1986 was about 70%.

2.2.7. Trends and projections to the year 2000.

FAO and UNIDO projections of the demand for NPK fertilizers in Africa by 2000 are presented in Table 5 below. FAO projections were complemented by UNIDO forecasts whenever there were no data.

Table 5

DEMAND FOR NPK FERTILIZERS BY THE YEAR 2000 (in 000 MTPY)

1	2	3		4		5	
NO.	COUNTRY	DEMAND 2000 ACCORDING TO FAO SCENARIO "A" – 1980		DEMAND 2000 ACCORDING TO LATEST FAO ESTIMATIONS–1988		DEMAND 2000 ACCORDING TO UNIDO SCENARIO " C" – 1983	
		N P K	NPK	N P K	NPK	N P K	NPK
1.	ALGERIA	450+552.4+186 =	1188.4	248.7+286.4+99.2 =	634.3	266+270+130 =	666.0
2.	ANGOLA	16.3+14.2+13.1 =	43.6	5.8+5.6+0.6 =	12.0	25.0+11.0+9.0 =	45.0
3.	BENIN	6.2+4.7+6 =	16.9	8.1+4.1+1.5 =	13.7	4.7+3.8+2.7 =	11.2
4.	BOTSWANA	2+2+1.2=	5.2	2+2+1.2 =	5.2	2+2+1.2=	5.2
5.	BURKINA FASO	3.2+2.5+0.8 =	6.5	10.3+9.8+7.1 =	27.2	2.6+2.7+1.7 =	7.0
6.	BURUNDI	2.9+2.9+1.0 =	6.8	1.8+1.2+1.3 =	4.4	2.3+2.3+0.9 =	5.5
7.	CAMEROON	38.3+31.2+47.8 =	117.3	51.4+15.4+32.3 =	99.1	39.0+21.0+38.0 =	98.0
8.	CAPE VERDE						
9.	CENTRAL AFR. REP.	4.0+4.4+2.3 =	10.7	1.5+0.1+0.2 =	1.8	2.8+2.3+1.4 =	6.5
10.	CHAD	18.8+13.5+5.6 =	37.9	5.2+3.5+3.9 =	12.6	8.8+ 6.8+4.5 =	20.1
11.	COMOROS ISLANDS						
12.	CONGO	14.7+15.7+8 =	38.4	2.0+0.0+2.5 =	4.5	7.0+6.2+6.0 =	19.2
13.	COTE D'IVOIRE	115.4+70+157.2 =	342.6	20.2+14.4+44.4 =	79.0	80.0+49.0+89.0 =	218.0
14.	DJIBOUTI						
15.	EGYPT	566.6+455+214.9 =	1236.5	1202+297+32 =	1530.0	1120+320+80 =	1520.0
16.	EQUAT. GUINEA						
17.	ETHIOPIA	80.5+93.3+18.1 =	191.9	38.7+59+0.3 =	98.0	64.0+71.0+14.5 =	149.5
18.	GABON	0.5+0.3+0.5 =	1.3	1.1+1.0+2.3 =	4.5	0.5+0.3+0.4 =	1.2
19.	GAMBIA	1.3+1.1+0.5 =	2.9	3.4+4.0+0.6 =	8.0	3.0+2.8+0.5 =	6.3
20.	GHANA	48.1+38.6+27.7 =	114.4	31.1+14+12.8 =	57.9	34.0+23.0+19.0 =	76.0
21.	GUINEA	4.1+2.9+2.5 =	9.5	0.7+0.3+0.4 =	1.5	3.3+2.3+2.0 =	7.6
22.	GUINEA-BISSEAU						
23.	KENYA	172+129.1+35.0 =	336.1	94.6+108.5+14.1 =	217.2	120.0+90.0+32.0 =	242.0
24.	LESOTHO	6+12+2=	20.0	6+12+2 =	20.0	6+12+2=	20.0
25.	LIBERIA	3.3+2.3+8.5 =	14.1	2.1+1.8+0.8 =	4.7	3.3+2.3+2.3 =	7.9
26.	LIBYA	45.8+52.8+17.9 =	116.5	(69.0+93+12.0 =	174.0)	69.0+93+12.0 =	174.0
27.	MADAGASCAR	22.1+15.2+7.9 =	45.2	19.7+7.9+14.8 =	42.4	15.0+11.0+7.9 =	33.9
28.	MALAWI	40.9+35.3+14.0 =	89.6	56.8+25.8+10.7 =	93.4	40.3+25.0+14.0 =	79.3
29.	MALI	18.5+15.4+6.6 =	40.5	20.3+7.9+6.8 =	34.9	15.0+10.2+6.6 =	31.8
30.	MAURITANIA	5.7+3.8+1.7 =	11.2	2.0+0.3+0 =	2.3	4.0+2.2+1.4 =	7.6
31.	MAURITIUS	25.7+17.4+11.4 =	54.5	(25.7+12.0+18.0 =	55.7)	25.7+12.0+18.0 =	55.7
32.	MOROCCO	320+418.3+109 =	847.3	264.7+257.6+103.4 =	625.7	260+290+135 =	685.0
33.	MOZAMBIQUE	10.8+14.4+11.8 =	37.0	21.7+16.9+11.0 =	49.5	35.0+21.0+9.5 =	65.5
34.	NIGER	1.8+1.6+0.5 =	3.9	4.5+1.4+0.8 =	6.7	2.5+2.3+0.5 =	5.3
35.	NIGERIA	101.9+81.3+40.9 =	224.1	451.1+304.8+90.3 =	846.2	210+140+410 =	391.0
36.	RWANDA	0.8+1.2+0.2 =	2.2	1.9+0.9+0.5 =	3.3	0.7+0.7+0.2 =	1.6
37.	SAO TOME AND PRINC.						
38.	SENEGAL	87.1+78.7+38.7 =	204.5	25.5+32.9+19.4=	77.9	60.0+54.0+31.0 =	145.0
39.	SEYCHELLES						
40.	SIERRA LEONE	26.1+17.7+5.3 =	49.1	0.6+0.5+0.7 =	1.8	8.4+4.6+3.7 =	16.7
41.	SOMALIA	13.8+10.1+4.5 =	28.4	4.2+0.9+0.8 =	5.9	11.0+8.0+3.6 =	22.6
42.	SUDAN	239.7+204.2+79.2 =	523.1	(180.0+50.0+20.0 =	250.0)	180.0+50.0+20.0 =	250.0
43.	SWAZILAND			10.7+6.7+3.7 =	21.1		
44.	TANZANIA	110.3+78.8+45.6 =	234.7	(88.0+39.0+26.0 =	153.0)	88.0+39.0+26.0 =	153.0
45.	TOGO	4.3+3.4+2.7 =	10.4	4.4+4.6+2.7 =	11.7	3.5+2.7+2.0 =	8.2
46.	TUNISIA	186+220+77.1 =	483.1	80.2+112.6+11.1 =	203.9	130+154+42 =	326.0
47.	UGANDA	10.3+8+3.6 =	21.9	1.1+0.3+0.0 =	1.4	7.0+3.7+3.0 =	13.7
48.	ZAIRE	5.8+5.6+3.4 =	14.8	8.5+7.1+4.3 =	19.9	6.0+4.5+3.2 =	13.7
49.	ZAMBIA	139.3+119.5+60.9 =	319.7	130.2+41.6+19.1 =	190.9	128+61.0+20.0 =	209.0
50.	ZIMBABWE	229.9+164.3+40.7 =	434.8	271.9+131.2+68.8 =	471.9	184+115.0+64.0 =	363.0
	AFRICA	Summary Totals N + P + K = NPK 3200+3015+1319=7538		Summary Totals N + P + K = NPK 3479+1996+704=6179		Summary Totals N + P + K = NPK 3269+2005+902=6176	

The three projections of NPK demand 2000 : FAO 1980 - Scenario A; UNIDO 1983 - Scenario C, and the latest FAO 1988 estimations of the fertilizer demand 2000 in Africa, differ among each other, both in quantities of NPK fertilizers and in resulting N:P:K ratios.

There is no space in this study to comment in detail on the NPK demand 2000 of each of 43 analyzed countries, therefore the most important issues will only be discussed:

A. The highest NPK demand 2000 for Africa was projected by FAO in 1980 in Scenario "A". The total NPK demand 2000 for the 43 analyzed countries derived from this scenario amounts to around 7.5 mln MTPY of NPK fertilizers.
In Scenario "A" the objective is to improve trends in self-sufficiency in basic foods and to increase supplies for export. In projection of production inputs to crop production, FAO estimated growth rate in NPK fertilizer consumption for 8.5% per year.
FAO Scenario "B", extrapolated from past trends, assumed lower inputs to agriculture, of that demand for NPK fertilizers approximately 80% of that projected in Scenario "A". Thus, NPK demand 2000 corresponding to FAO Scenario "B" would be around 0.8 * 7.5 mln MTPY = 6 mln MTPY of NPK.
According to these scenarios, resulting N:P:K ratio for analyzed 43 African countries would be as 1.00 : 0.94 : 0.41.

B. The total NPK demand 2000 for the analyzed 43 African countries, derived from UNIDO Scenario "C" 1983, amounting to around 6.2 mln MTPY of NPK fertilizers, would be more conservative than in FAO Scenario "A", and much closer to FAO Scenario "B", as far as fertilizer quantities are considered.
According to UNIDO Scenario, resulting N:P:K ratio for the analyzed 43 African countries would be as 1.00 : 0.61 : 0.28, that is much closer to the present N:P:K ratio in that group of countries, amounting in 1986 as 1.00 : 0.47 : 0.21 (much more in favour to nitrogen).

C. The latest FAO estimations 1988, assume, in the majority of analyzed 43 African countries, the most conservative NPK demand 2000, and, if it were not for Nigeria (where FAO estimations 1988 are very high in comparison to those from 1980), the latest FAO estimations would be the lowest of all discussed here projections.

NPK fertilizer demand 2000, derived from FAO estimations 1988, amounts to around 6.2 mln MTPY of pure nutrients, that is similar to that of UNIDO Scenario "C", and FAO Scenario "B".
Resulting N:P:K ratio is 1.00 : 0.57 : 0.20, and is the closest to the present N:P:K ratio in analyzed countries (1.00 : 0.47 : 0.21).

Out of the three above mentioned projections of the NPK fertilizer demand 2000, the latest FAO ESTIMATIONS 1988 have been selected in this study.

When NPK demand 2000 is compared with NPK production 1986, the very important data related to the NPK gap 2000 can be derived for the analyzed 43 African countries.
As can be seen from Table 6 presented below, the total NPK gap 2000 for analyzed countries amounts to around 3.5 mln MTPY of NPK fertilizers. The analysis of the NPK gap 2000 for the examined 43 African countries gives very valuable indications for the strategy of fertilizer industry development in Africa.

Table 6

THE GAP 2000 IN NPK FERTILIZERS
(expressed in 000 MTPY of pure nutrients)

Country	NPK Demand 2000	NPK Prod. 1986	NPK GAP 2000
Algeria	634.3	166.2	468.1
Angola	12.0	0	12.0
Benin	13.7	0	13.7
Botswana	5.2	0	5.2
Burkina Faso	27.2	0	27.2
Burundi	4.4	0	4.4
Cameroon	99.1	0	99.1
Cape Verde			
CARepublic	1.8	0	1.8
Chad	12.6	0	12.6
Comoros			
Congo	4.5	0	4.5
Cote Divoire	79.0	3.7	75.3
Djibouti			
Egypt	1530.0	729.9	800.1
Equatorial Guinea			
Ethiopia	98.0	0	98.0
Gabon	4.5	0	4.5
Gambia	8.0	0	8.0
Ghana	57.9	0	57.9
Guinea	1.5	0	1.5
Guinea-Bissau			
Kenya	217.2	0	217.2
Lesotho	20.0	0	20.0
Liberia	4.7	0	4.7
Libya	174.0	239.9	(65.9)
Madagascar	42.4	0	42.4
Malawi	93.4	0	93.4
Mali	34.9	0	34.9
Mauritania	2.3	0	2.3
Mauritius	55.7	10.1	45.6
Morocco	625.7	525.5	100.2
Mozambique	49.5	0	49.5
Niger	6.7	0	6.7
Nigeria	846.2	5.0	841.2
Rwanda	3.3	0	3.3
Sao Tome and Principe			
Senegal	77.9	15.6	62.3
Seychelles			
Sierra Leone	1.8	0	1.8
Somalia	5.9	0	5.9
Sudan	250.0	0	250.0
Swaziland	21.1	0	21.0
Tanzania	153.0	10.3	142.7
Togo	11.7	0	11.7
Tunisia	203.9	862.4	(658.5)
Uganda	1.4	0	1.4
Zaire	19.9	0	19.9
Zambia	190.9	14.3	176.6
Zimbabwe	471.9	121.0	350.9
TOTAL 43 COUNTRIES	6179	2704	3475

NOTE: Expected NPK Surplus in Libya and Tunisia.

The gap 2000 in NPK fertilizers, equal to 6.2 - 2.7 = 3.5 mln MTPY, can be divided by the three nutrients, as follows:

Nitrogenous fertilizers - 2.2 mln MTPY of N
Phosphatic fertilizers - 0.6 mln MTPY of P_2O_5
Potassic fertilizers - 0.7 mln MTPY of K_2O.

This gap in NPK fertilizers can either be filled by increased imports of fertilizers to Africa (in particular to Sub-Saharan countries, as the North-African countries are much stronger in the fertilizer industry and may substitute import, some of them: Libya, Tunisia, will even remain net exporters of fertilizers by 2000), or through the investment actions in the fertilizer industry in Africa.

The issues connected with those two different options will be discussed in the further chapters of this study.

There is a need, however, to point out in this chapter for some most important relations that come out from the comparison of the NPK demand 2000, NPK production 1986 and the NPK gap 2000 in the group of 43 analyzed African countries, namely:

There is a very great differentiation in the scale of production, demand and resulting gap in NPK fertilizers among the analyzed countries.

Production of fertilizers is located only in 12 countries and oscillates between 0 to 0.9 mln MTPY of NPK (Tunisia).

Only 7% of the NPK production balance 1986 was located in Sub-Saharan Africa (therefore of a great value nitrogen fertilizer complex in Nigeria put into operation in 1987/88), the remaining 93% of the NPK production is located in five North-African countries:Tunisia, Egypt, Morocco, Libya and Algeria.

NPK demand 2000 is differentiated even in a higher degree, the maximum NPK demand ratio between Egypt and as many as 22 Sub-Saharan countries, with the demand lower than 30.000 MTPY of NPK, being higher than 50 times.

The highest NPK gap 2000 is located in the following countries:

1. Egypt; 2. Nigeria (if the new nitrogen complex is not included, Nigeria should be ranked the first in the NPK gap)
3. Algeria; 4. Zimbabwe; 5. Sudan; 6. Kenya; 7. Zambia
8. Tanzania; 9. Morocco; 10. Cameroon; 11. Ethiopia; 12. Malawi.

The total NPK gap 2000 of those 12 countries amounts to 3.637.000 MTPY of pure nutrients, and is higher than the cumulative NPK gap for all the examined 43 African countries, which is equal to 3.475.000 MTPY of NPK. This is possible, as the expected NPK surplus 2000 in Tunisia and Libya, equal to 724.000 MTPY of NPK, is much higher than the NPK gap in the remaining 29 Sub-Saharan countries.

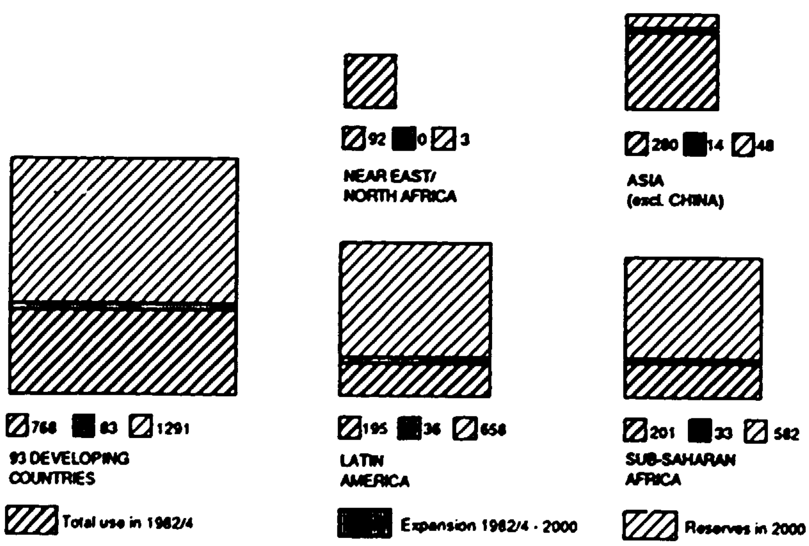
The African NPK gap 2000, i.e. 3.5 mln MTPY, constitutes only 4% of the world fertilizer gap 2000, estimated for 88 mln MTPY of NPK.

2.3. The State of Agriculture and Fertilizers in Africa.

Growth in crop production may be ascribed to changes in three factors: arable land, cropping intensity and yields. Historically, expansion of arable area has been the main source of growth. Since 1950, however, higher yields have increasingly become the only or the major source of output growth in a number of developing countries.

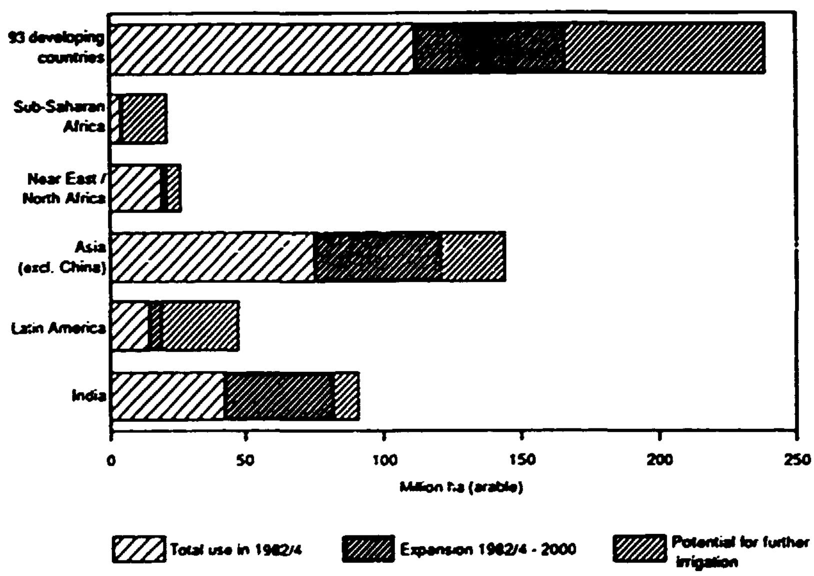
According to an FAO Study: WORLD AGRICULTURE TOWARD 2000, increases in average yields will be the main sources of crop production growth in the developing countries over the next 15 years.
Contributions to crop production increases in the different world regions (1982/84 - 2000) are illustrated in Figure 2.4 below (in percent):

Land use and reserves (million ha, arable land), illustrated in Figure 2.5 below, suggest the existence of substantial production potential in the year 2000 in most regions.



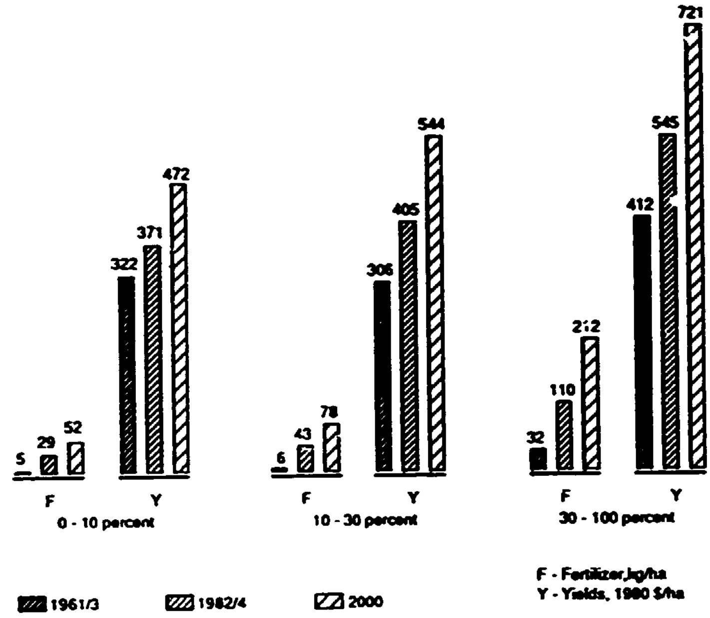
Such is not the case, because the reserves are concentrated in a few countries, for example Zaire in Africa. Most of the reserves have soils of marginal quality. Some soils are suited to perennial tree crops, other have very unreliable rainfall, and almost all are dependent on the introduction of existing technologies or the development of the new ones before they can be cultivated on a sustainable basis.
Relative land scarcity, determined both by the magnitude and the quality of land reserves, will play a role in the future in fertilizer use and irrigation development.

By the year 2000, about two-thirds of the increase in arable lands will be accounted for by expansion of irrigation in developing countries. Unfortunately, in Sub-Saharan Africa irrigated land expansion will be a minor part of land increase, because of the relatively larger reserves of rain-fed land, higher costs of irrigation development and shortage of technical manpower. Hence, the expansion of land in the higher rainfall regions of good rainfall land and problem land takes place mostly in Sub-Saharan Africa.
In the North Africa, potential rain-fed agricultural land is utilized almost fully. Therefore, rain-fed and desert lands must be drawn on for irrigation. With the higher cropping intensity associated with irrigated areas, this will actually be the sole source of expansion of harvested land in this region.
Irrigated land use and potential in developing countries is illustrated in Figure 2.6 below.



It is water rather than land which is binding constraint for agricultural production in millions of hectares of potentially suitable arable land. It is only when this water constraint is released that other technical constraints such as nutrients and pests become important.
Higher rates of fertilizer use and, consequently, higher yields prevail in irrigated agriculture. In Africa, only Egypt has more than 30 percent of arable land under irrigation; Morocco, Madagascar, Mauritius, Swaziland and Sudan have 10-30 percent of arable land under irrigation; Algeria, Tunisia, Libya and all the remaining Sub-Saharan countries have less than 10 percent of arable land under irrigation.

Figure 2.7 shows how average fertilizer use per hectare of total area and average yields tend to increase with the share of irrigated land in total arable land.

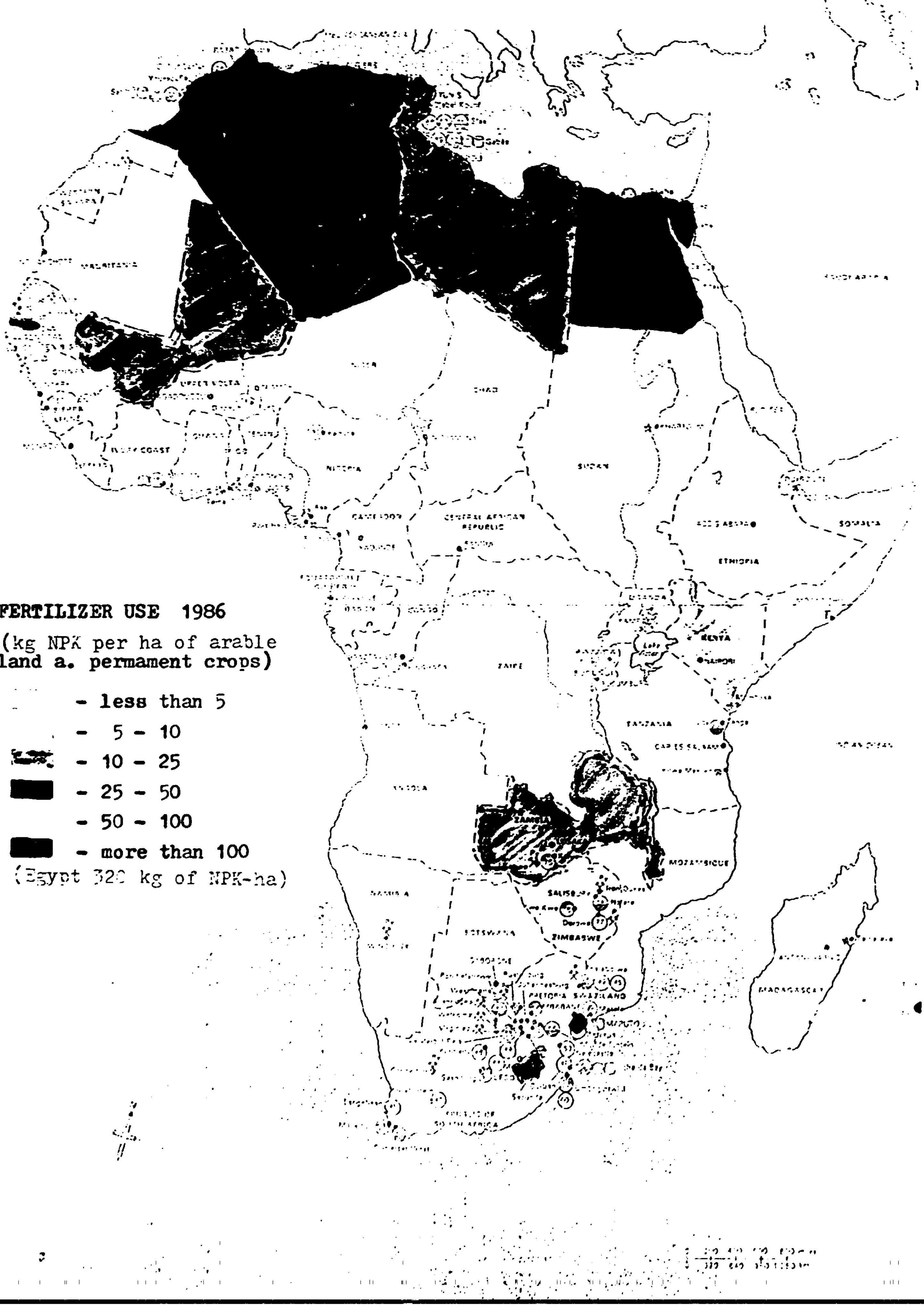


In North Africa most of the fertilizer , about 80 percent of total consumption, is used for irrigated agriculture, where it is in widespread use for industrial crops: cotton, sugar-cane, sugar-beet and fodder crops. For rain-fed crops, however, the bulk of fertilizer is used for cereals. In all, rain-fed or irrigated cereals account for 30 percent of fertilizer consumption, with most of this being used on large-scale modern farms.
In North Africa, fertilizer accounted for 15-20 percent of the increase in cereal production during the last 20 years. The land under cereals has virtually remained stable for this period in North Africa, and production increase has been achieved through higher yields in cereals because of fertilizer use.

In Sub-Saharan Africa fertilizer were introduced mainly to intensify export crops, especially cotton and ground nuts. Some countries have used fertilizers for cereals, particularly maize in Kenya, Zimbabwe, Zambia, Malawi and Tanzania, and for rice in West Africa. Fertilizers tend to be used primarily by state and modern farms. In Zimbabwe and Kenya, progress in fertilizer use has also been made by small farmers. Food crop fertilizer consumption in Sub-Saharan Africa is still very low, around 5 kg/ha. Fertilizer consumption for export and industrial crops is around 30 kg/ha of arable land.
Fertilizers account for about 40-60 percent of the increased food crops yields observed in Sub-Saharan Africa. The overall impact of fertilizer use, however, is very weak. Food crop fertilizers have often been misused, either because the technical difficulty has not been overcome or because there has been waste. There is also poor fertilizer response of certain crops in certain conditions.

Fertilizer use in 43 analyzed African countries in 1986, expressed in terms of kg of NPK per ha of arable land and permanent crops, has been illustrated on the map of Africa in Figure 2.8 below.

FERTILIZER USE 1986 Figure 2.8



The bulk of increased food production in Africa would have to come from the intensification of rain-fed agriculture through the wider use of improved seeds, fertilizer, pesticides and mechanization in areas with reliable rainfall. Where rainfall is unreliable, new technologies and new food varieties would be needed.

These developments would require a substantial increase of fertilizer use in Sub-Saharan Africa. Fertilizer imports in Sub-Saharan Africa would have to grow at about 7 percent a year, but debt problems are likely to make such imports difficult if not impossible. Therefore fertilizer aid should increase substantially.

The potential benefits of such increases in fertilizer use are easily demonstrated. Many small-scale maize growers in Malawi and Zimbabwe use improved varieties and high levels of fertilizer very profitably, achieving the average maize yield about 5 tonnes/ha.
There are, however, more than 100 mln ha of land in the subhumid and semi-arid parts of Africa which produce maize yields of less than 1 tonne/ha.
Cote D'Ivoire, using fertilizers, achieves one of the highest in the world yields in cocoa and oil-palm production.

Fertilizer aid could gradually replace structural and some emergency food aid in many countries. For example, 200 000 tonnes of fertilizer (product) aid in Ethiopia in 1985-86 could have replaced 700 000 tonnes of food - equivalent to the food aid pledged for 1986 - if it had been applied in the higher rainfall areas and had producer prices been favourable.

Per capita dietary energy supply (DES) in kcals/day, reported after FAO for Africa for the year 1984 and presented in Figure 2.9 below, gives concrete indications for the future food/fertilizer aid strategy and complex development actions in agriculture.

As can be seen from the map of Africa in Figure 2.9, the most urgent actions, among them UNIDO actions, should be directed to such countries as Ethiopia, Sudan, Chad and Mozambique, this two first countries having substantial future demand for NPK fertilizers and important NPK gap 2000 to be filled through import substitution.

Fertilizer is a vital component of an improved crop technology package including modern varieties, water, insecticides and fertilizer, and therefore the contribution of fertilizer to agricultural production and to yields in Africa is expected to increase over time, as it has in other developing and developed countries of the world.

Fertilizer consumption in kg of NPK per hectare of arable land (A)and per capita (B), in the world and in Africa, was as follows in the past:

	1975		1980		1985	
	A	B	A	B	A	B
WORLD	63.2	22.2	80.1	26.2	87.1	26.6
AFRICA	13.4	5.7	18.4	6.9	20.1	6.7
AFRICA WITHOUT S.A	9.9	4.3	13.8	5.1	16.6	5.5

Data corresponding to the year 2000 are presented in Table 7 below.

PER CAPITA DIETARY ENERGY SUPPLY 1984

Figure 2.9

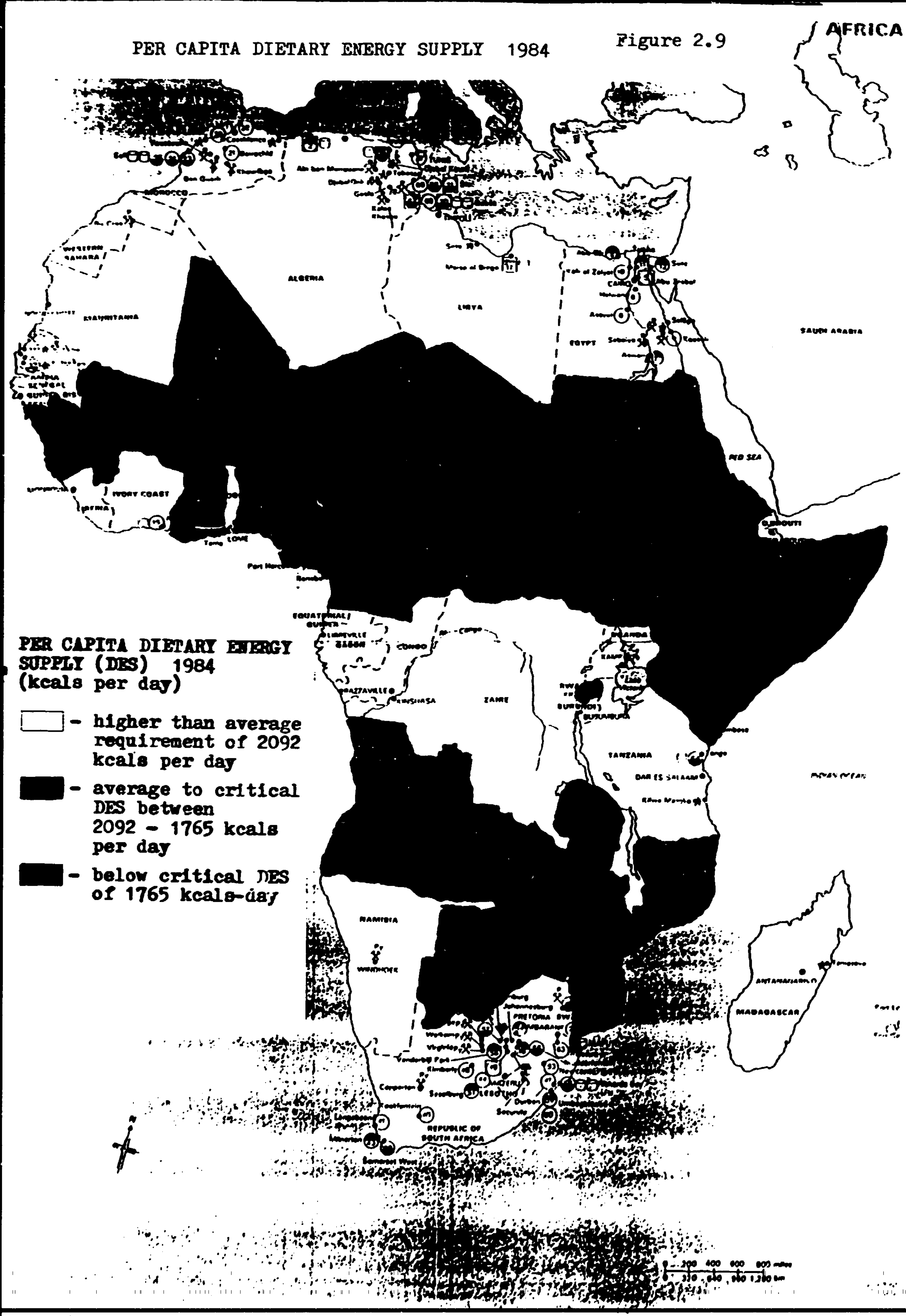


Table 7

FERTILIZER DEMAND 2000 PER HECTARE OF ARABLE LAND AND PER CAPITA
(expressed in kg of NPK fertilizers per ha and per capita 2000)

		NPK demand per ha	NPK demand per capita
	WORLD	145.0	35.6
	AFRICA	37.5	8.6
	COUNTRY		
1.	ALGERIA	78.4	19.2
2.	ANGOLA	3.4	0.9
3.	BENIN	6.6	2.0
4.	BOTSWANA	3.4	2.6
5.	BURKINA FASO	8.5	2 .3
6.	BURUNDI	3.0	0.6
7.	CAMEROON	12.3	5.8
8.	CENTR. AFR. REP.	0.8	0.5
9.	CHAD	3.5	1.8
10.	CONGO	6.1	1.5
11.	COTE D'IVOIRE	19.2	4.6
12.	EGYPT	677.2	22.8
13.	ETHIOPIA	6.8	1.5
14.	GABON	6.7	4.5
15.	GAMBIA	38.8	8.0
16.	GHANA	18.5	2.9
17.	GUINEA	0.9	0.2
18.	KENYA	82.2	6.0
19.	LESOTHO	79.3	10.0
20.	LIBERIA	12.5	1.6
21.	LIBYA	65.7	29.0
22.	MADAGASCAR	11.0	2.7
23.	MALAWI	35.9	7.8
24.	MALI	14.3	3.2
25.	MAURITANIA	16.0	0.8
26.	MAURITIUS	515.7	55.7
27.	MOROCCO	71.6	20.9
28.	MOZAMBIQUE	15.6	2.3
29.	NIGER	1.3	0.7
30.	NIGERIA	25.8	5.2
31.	RWANDA	2.0	0.3
32.	SENEGAL	13.5	7.8
33.	SIERRA LEONE	0.8	0.4
34.	SOMALIA	5.1	0.7
35.	SUDAN	19.0	7.3
36.	SWAZILAND	100.4	21.1
37.	TANZANIA	27.4	4.1
38.	TOGO	8.0	2.3
39.	TUNISIA	42.2	20.3
40.	UGANDA	0.2	0.1
41.	ZAIRE	2.6	0.4
42.	ZAMBIA	35.4	17.4
43.	ZIMBABWE	151.2	36.3
	TOTAL	33.3	7.6

In order to work-out the frame for the future strategies related to both recommendations of fertilizer use and specific N:P:K ratios of fertilizers to be applied by type of crop, an indicative list of principal crops grown in the analyzed 43 African countries is presented below in Table 8 for reference.

1. ALGERIA	WHEAT	GRAPES	BARLEY	POTATOES	
2. ANGOLA	COFFEE	COTTON	MAIZE	SISAL	BANANAS
3. BENIN	COCOA	COTTON	COFFE	GR. NUTS	
4. BOTSWANA	SORGHUM	MILLET	MAIZE	BEANS	
5. BURKINA FASO	MILLET	COTTON	MAIZE	GR. NUTS	
6. BURUNDI	COFFEE	COTTON	TEA	CASSAVA	BANANAS
7. CAMEROON	COFFEE	COTTON	COCOA	BANANAS	GR. NUTS
8. CENTR. AFR. REP.	COTTON	COFFEE	CASSAVA	GR. NUTS	MAIZE
9. CHAD	COTTON	GR. NUTS	MILLET	SORGHUM	RICE
10. CONGO	COFFEE	CASSAVA	MAIZE	SUG.CANE	
11. COTE D'IVOIRE	COCOA	COFFEE	YAMS	CASSAVA	RICE
12. EGYPT	RICE	WHEAT	COTTON	MAIZE	SUG.CANE
13. ETHIOPIA	COFFEE	MAIZE	MILLET	SORGHUM	
14. GABON	OIL PALM	CASSAVA	COCOA		
15. GAMBIA	GR. NUTS	COTTON	RICE	SORGHUM	MILLET
16. GHANA	COCOA	CASSAVA	MAIZE	YAMS	
17. GUINEA	RICE	CASSAVA	BANANAS	COFFEE	PINEAPPLE
18. KENYA	COFFEE	TEA	MAIZE	SUG.CANE	WHEAT
19. LESOTHO	MAIZE	SORGHUM	WHEAT	POTATOES	
20. LIBERIA	COFFEE	COCOA	CASSAVA	RICE	BANANAS
21. LIBYA	BARLEY	OLIVES	WHEAT	FRUITS	
22. MADAGASCAR	RICE	CASSAVA	BANANAS	SUG.CANE	COFFEE
23. MALAWI	TOBACCO	TEA	MAIZE	GR. NUTS	
24. MALI	GR. NUTS	COTTON	TOBACCO	MILLET	MAIZE
25. MAURITANIA	DATES	MILLET	SORGHUM	RICE	MAIZE
26. MAURITIUS	SUG.CANE	TEA	TOBACCO	RICE	
27. MOROCCO	WHEAT	BARLEY	MAIZE	ORANGES	BEANS
28. MOZAMBIQUE	CASSAVA	MAIZE	SORGHUM	SUG.CANE	SISAL
29. NIGER	GR.NUTS	COTTON	MILLET	YAMS	COWPEAS
30. NIGERIA	CASSAVA	COCOA	GR.NUTS	TOBACCO	MILLET
31. RWANDA	COFFEE	TEA	CASSAVA	PLANTAIN	SW.POTAT.
32. SENEGAL	GR.NUTS	RICE	MILLET	SORGHUM	CASSAVA
33. SIERRA LEONE	COFFEE	RICE	COCOA	OIL PALM	COCONUT
34. SOMALIA	BANANAS	MILLET	SORGHUM	MAIZE	WHEAT
35. SUDAN	MILLET	SORGHUM	WHEAT	COTTON	SESAME
36. SWAZILAND	MAIZE	COTTON	TOBACCO	PINEAPPLE	
37. TANZANIA	MAIZE	SISAL	COFFEE	TEA	COTTON
38. TOGO	COCOA	COFFEE	GR.NUTS	COTTON	YAMS
39. TUNISIA	WHEAT	OLIVES	BARLEY	CITRUS	POTATOES
40. UGANDA	COFFEE	COTTON	TEA	GR.NUTS	MILLET
41. ZAIRE	COFFEE	RICE	CASSAVA	OIL PALM	RUBBER
42. ZAMBIA	MAIZE	CASSAVA	SUG.CANE	SORGHUM	
43. ZIMBABWE	MAIZE	TEA	MILLET	SUG.CANE	TOBACCO

I don't see the applicability [illegible]

2.4. Structure of Fertilizer Industry in Africa

2.4.1. Raw materials

The purpose of this section is to identify the main raw materials that are required for fertilizer production and to present general information regarding potential resources, the adequacy and location of known reserves, present extraction level, as well as their future possible use and constraints limiting their future development.

It is worth noting, that the manufacture of fertilizers uses the following proportions of world production of raw materials:

- approx. 3% of natural gas and about 0.5% of oil products and coal for nitrogen fertilizers,

- about 85% phosphate rock and 40% of sulphur for phosphate fertilizers,

- about 95% of of potash ores for potash fertilizers.

A. Nitrogen related raw materials

Natural gas, naphta, fuel oil and coal are the major raw materials for the manufacture of nitrogen fertilizers. All of them are hydrocarbons, that are the source of hydrogen and fixed carbon. These raw materials are not renewable, and the size of a deposit to be explored is of great importance before any final investment decisions are taken.

But there are also, not so important, but instead, renewable source of nitrogen related raw materials. These are:

a). water (with hydroelectic power used for electrolysis of water to produce hydrogen) and air (that is a source of nitrogen to be captured from the air and combined with hydrogen to produce ammonia). This source cannot yield carbon dioxide.

b). biomass (wood wastes, sugar cane wastes, straw, euphorbia etc) that can be gasified to yield synthesis gas for ammonia production. This is renewable source of fixed carbon, what means, that similarly to natural gas, oil and coal, this feedstock can be processed simultaneously to ammonia and carbon dioxide, raw materials leading to urea production.

Processes proven on a full industrial scale in ammonia plants with capacities up to 1500 TPD* are connected first of all with natural gas, and then with naphta, fuel oil and coal, however with somewhat lower capacities.
There are also other, intermediary products, such as coke oven gas or refinery gas, that can be used for ammonia production in specific locations. These will not be discussed in this study.

*

Ammonia production through water electrolysis is also fully proven industrially, however, for smaller capacities and minifertilizer plants, as this process, in contrast to other processes, is not very much subject of economy of scale.

Biomass gasification technologies are still not fully proven industrially, and, in spite of many trials and pilot plants tested in many countries, this process cannot compete with natural gas, oil and coal-based processes.

Thus, in the field of nitrogen fertilizers, that start with ammonia production, there are all raw materials potentially available for fertilizer industry in Africa, namely:

- the most effective, competitive, reliable, simple and large-scale processes based on natural gas, as for instance in Libya (Marsa el Brega) or Algeria (Arzew),

- less effective processes based on naphta or fuel oil, as for instance smaller, not yet operational, ammonia units in Sudan (Khartoum) and Somalia (Mogadishu),

- less effective coal-based ammonia processes, as for instance in Zambia (Kafue) or South Africa (Sasolburg),

- water electrolytic process to ammonia based on hydroelectricity potential, as for instance in Zimbabwe (Que, Que) or Egypt (Aswan).

Africa is endowed with all ammonia related raw materials: natural gas, crude oil, coal and hydroelectricity, this being a very strong enhancement for nitrogen fertilizer industry development in the most regions.

As natural gas is the dominant and unquestionably the most competitive feedstock for effective ammonia production in the world, there is a need to compare its proven reserves in Africa with those in the world (in terms of billion of cubic meters), as well as to illustrate potential of Africa in oil (million tons) and coal reserves (billion tons):

	NATURAL GAS	OIL	COAL
WORLD TOTAL	65,881	87,938	9,230
AFRICA	5,923	8,299	21
Algeria	3,564	932	
Angola	42	166	
Congo	1	39	
Egypt	79	267	
Gabon	71	291	
Libya	731	3,494	
Morocco	1	0	
Nigeria	1,246	2.672	
Tunisia	187	370	
Zaire	1	68	

There are many other findings of natural gas and crude oil deposits in the last years in other African countries, to mention only: Cameroon, Cote D'Ivoire, Sudan, Tanzania, Mozambique, Madagascar, Ghana, Ethiopia, Senegal and Rwanda.

Natural gas remains the principal feedstock for ammonia manufacture accounting for about 70% of world production. The widespread ocurence of natural gas coupled with the relative ease of transporting it by pipeline, continues to offer considerable flexibility and the opportunity for the establishment of new ammonia plants.
In this respect the industry has acquired mobility in contrast to coal based ammonia manufacture which firmly located it at or near the sources of coal supplies. Also, in comparison to coke oven gas and refinery gas, natural gas used as a feedstock gives better flexibility in location of ammonia plants and downstream nitrogen fertilizer units.

As an example, the Zimbabwean situation may be quoted here. Zimbabwe produces ammonia at Que Que with very good results through electrolysis of water, importing some liquid ammonia to balance production of nitrogen fertilizers. Intensification of ammonia plant is hampered by the electricity price; other option, i.e using coke oven gas from the near-by source is possible, but it does not assure full flexibility of ammonia plant at Que Que.

Being short of ammonia, and having no natural gas deposits, Zimbabwe very seriously considers the construction in the future a coal-based ammonia plant of large capacity.

Two other possibilities can be analyzed, both connected with the cooperation in between Zimbabwe and Mozambique.

1. Pipelining Mozambican, high quality natural gas to Zimbabwe (which for sure be more able to manufacture ammonia from it than Mozambique at these days),

2. Transmitting the surplus of very cheap hydroelectricity from Mozambican Cabora Bassa hydropower plant to Zimbabwe, where electrolytic process of ammonia manufacture is very well known, ammonia plant achieving excellent results.

B. Phosphate related raw materials

World phosphate reserves and resources are dominated by Africa, what can be seen from the following data (reserves in million tons of phosphate rock equivalent to 30% P2O5 concentrate):

WORLD	144212
AFRICA	67189

Algeria	1000
Angola	120
Burkina Faso	4
Egypt	2800
Liberia	2
Mali	20
Mauritania	5
Morocco	40000
West Sahara	16600
Senegal	3390
Tanzania	10
Togo	300
Tunisia	1300
Uganda	200
Zaire	83
Zimbabwe	20
South Africa	1435

There are also phosphate rock deposits reported in Niger, Gabon, Congo, Burundi, Nigeria, Benin, Cameroon, Gambia, Madagascar, Chad and Central African Republic.

In the long term the vast reserves of Morocco will become increasingly important to satisfy world demand. In the short term the growing output of Egypt as a phosphate rock supplier of domestic and export market is also promising, however, production of phosphate concentrate from Tunisia, Togo, Senegal and Algeria are even more or similarly important.

World phosphate rock production in 1986 amounted to 144 mln tonnes product, of that Africa 37 mln tonnes, with Morocco (21 mln tonnes) absolutely dominating over Tunisia (4.5), Togo (2.3), Senegal (2.0), Egypt (1.3) and Algeria (1.2 mln tonnes).

High-analysis phosphate rock concentrates from Togo, Senegal, Western Sahara/Morocco are attracting the attention of importers because they offer the opportunity of expanding nominal capacity of many phosphoric plants in the world.

Morocco, Tunisia and Senegal have tremendously expanded their own down stream phosphoric acid capacities contributing in 60% in the total world phosphoric acid trade in 1986-1987 (World 6.25; Morocco 2.61; Tunisia 0.59; Senegal 0.3 mln tonnes solution of merchand grade phosphoric acid).

As far as the second raw material for phosphate fertilizer industry is concerned, i.e. SULPHUR, Africa, as already mentioned is poorly endowed with sulphur-bearing raw materials, not mentioning brimstone.
In 1986 the total world sulphur production was reported for 57 mln tonnes of S equivalent, of that Africa only 1 mln tonnes (of that South Africa 0.8 mln tonnes). Brimstone production 1986 equalled to 36 mln tonnes, of that Africa 0.12 mln tonnes (of that South Africa 0.11 mln tonnes).

Thus, in contrast to potential of phosphate deposits, phosphate rock and phosphoric acid production in Africa, being great enhancemants for fertilizer industry development, sulphur deposits and sulphur production scale are great constraints to the development of fertilizer industry in Africa. Therefore sulphur recovery from sour natural gas and at oil refineries, as well as from copper - nickel smeltering facilities should be given the highest attention in the course of fertilizer industry development in Africa.

The possibilities of using as an attacking agent for phosphate rock dissolving either nitric acid or hydrochloric acid instead of sulphuric acid, should be very attentively examined in the course of the strategy formulation for the fertilizer industry development in Africa.

Location of major phosphate rock and sulphur production facilities in the world, together with phosphate concentrate and sulphur production data for 1984, is presented in Figure 2.10. Newcomers in the family of phosphate rock producing countries are illustrated in Figure 2.10 A.

C. Potash related raw materials

World total potash reserves are estimated for about 113 billions of K2O equivalent in potash ores and brines.

The only African country included in the world potash statistics is Congo with its reserves estimated in the range of 17 - 70 millions tonnes of K2O equivalent.
Congo was producing muriate of potash till 1975, when the mine was flooded. Production records, as for African yearly consumption in the range of 0.4 - 0.5 mln K2O, was high as it had been recorded for almost 0.3 mln tonnes of K2O in 1975.

Other potash deposits are reported in Ethiopia, Botswana, Tunisia and possibly in Libya, Algeria, Morocco, Nigeria, Uganda and Kenya, this latter group being considered as deposits to be either too small, too poor or too unfavourably located to make exploitation worthwile. These deposits are not being mined or explored from the potash brines, therefore their estimate, as well as analyses of techno-economic viability of their exploration should be given special attention, first of all in Ethiopia, Botswana and Tunisia.

Today, none of the African countries produces potash and Africa is totally dependent on imoprts of muriate, sulphate and nitrate of potash, this being, together with sulphur shortage, a great constraint for the fertilizer industry development in Africa.

Location of major potash production facilities in the world, together with potash production data 1984, is presented in Figure 2.11 for reference.

And, to sum up, important reserves for the production of fertilizers in Africa south of the Sahara, i.e. natural gas, phosphates and potash have been illustrated in Figure 2.12.

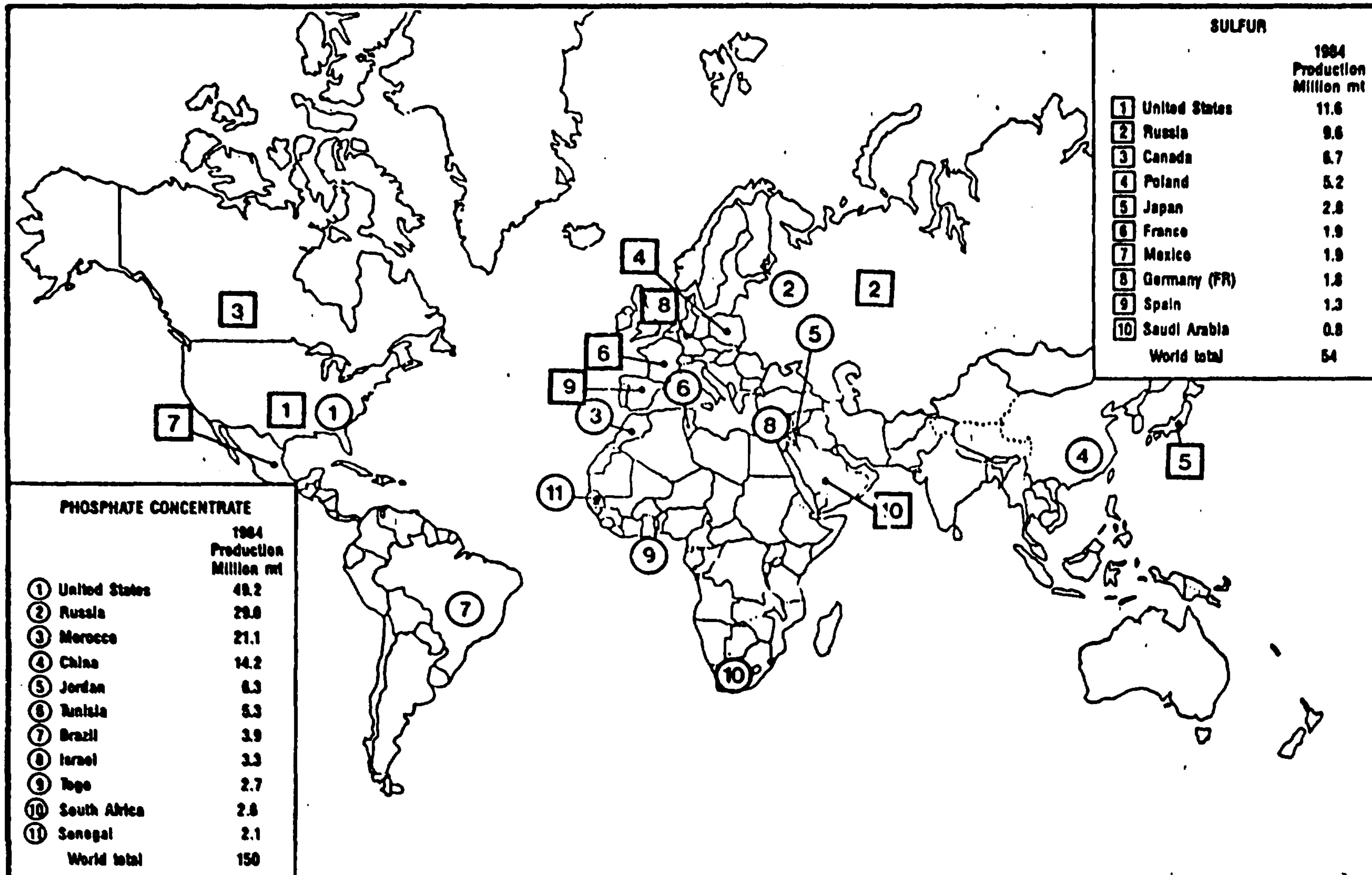

SULFUR
1984 Production Million mt
1 United States 11.6
2 Russia 9.6
3 Canada 6.7
4 Poland 5.2
5 Japan 2.8
6 France 1.9
7 Mexico 1.9
8 Germany (FR) 1.6
9 Spain 1.3
10 Saudi Arabia 0.8
World total 54
PHOSPHATE CONCENTRATE
1984 Production Million mt
1 United States 49.2
2 Russia 29.8
3 Morocco 21.1
4 China 14.2
5 Jordan 6.3
6 Tunisia 5.3
7 Brazil 3.9
8 Israel 3.3
9 Togo 2.7
10 South Africa 2.6
11 Senegal 2.1
World total 150

Figure 2.10

Phosphate Rock Producing Countries

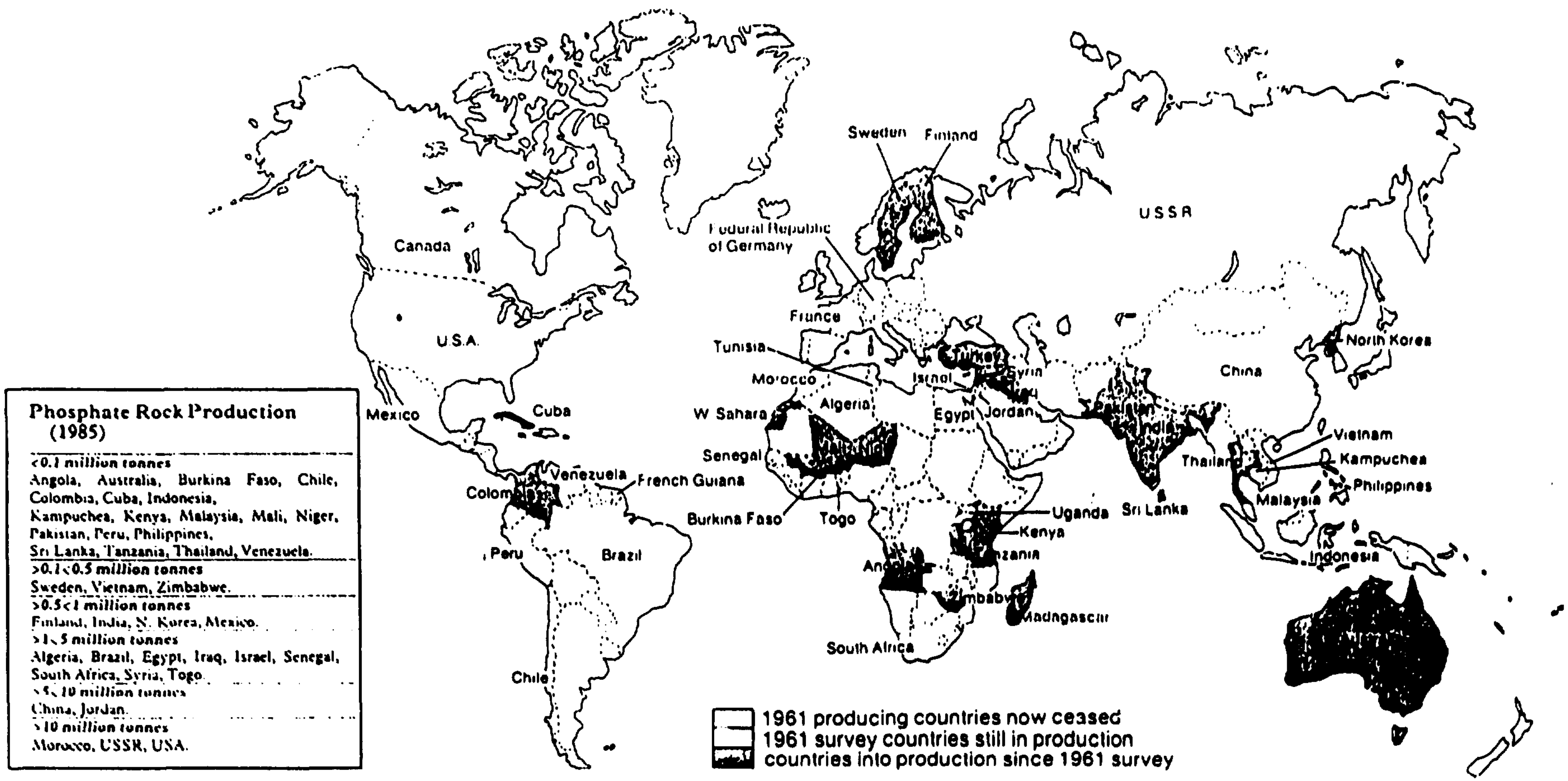
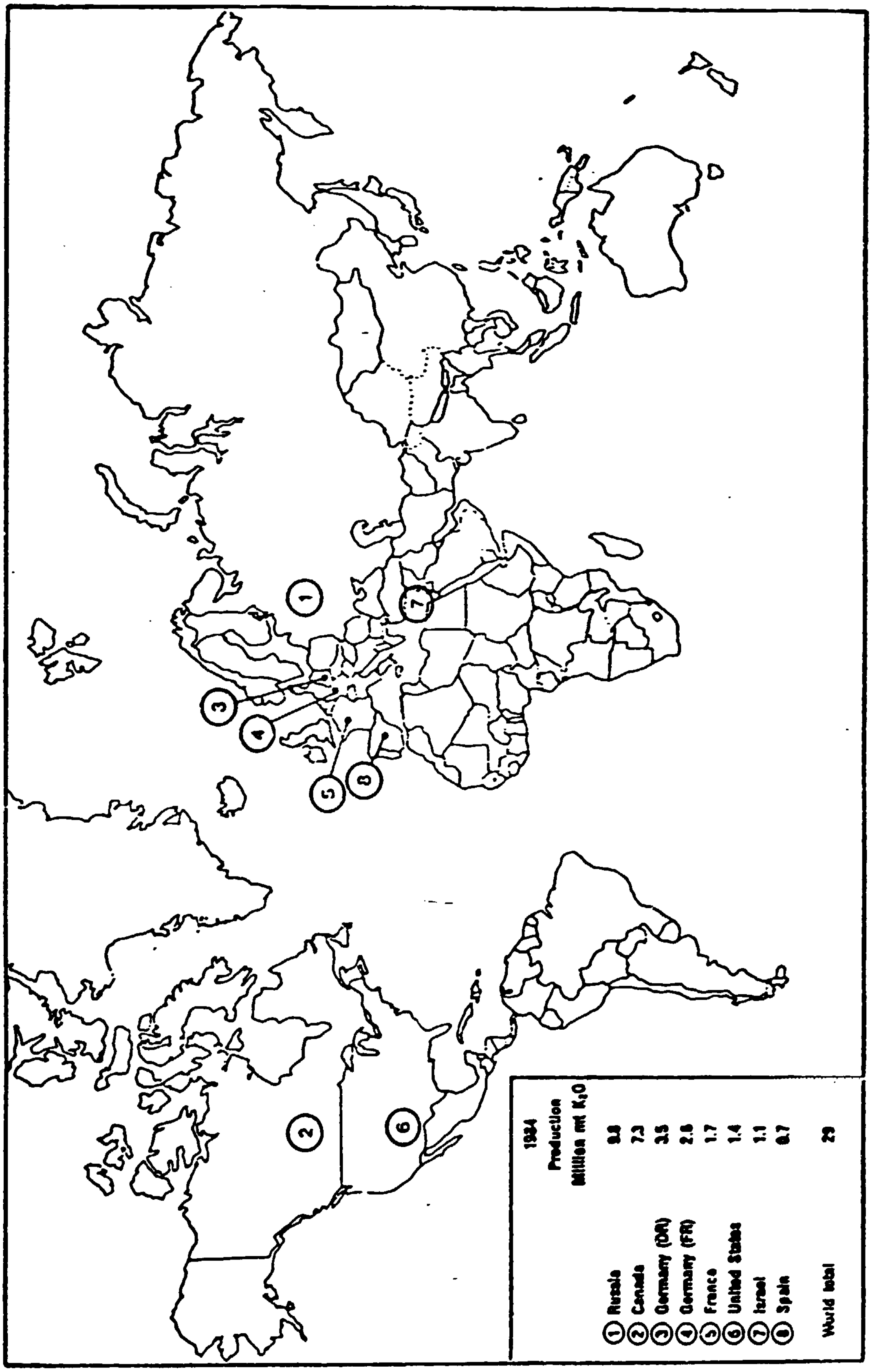


Figure 2.10 A.

Figure 2.11



1984
Production
Million mt K_2O
1 Russia 9.8
2 Canada 7.3
3 Germany (DR) 3.5
4 Germany (FR) 2.6
5 France 1.7
6 United States 1.4
7 Israel 1.1
8 Spain 0.7
World total 29

Figure 2.12

IMPORTANT RESERVES FOR THE PRODUCTION OF FERTILIZERS
IN AFRICA SOUTH OF THE SAHARA

● PHOSPHATES

○ NATURAL GAS

POTASH

As the prices of raw materials and intermediaries such as natural gas/oil, sulphur, phosphate rock, potash as well as ammonia, sulphuric acid and phosphoric acid are subject to changes, it is of course advisable to follow movements of prices which are sometimes very drastic (e.g. ammonia prices in Januaries of: 1972 - 32; 1973 - 36; 1974 - 165; 1975 - 395; 1976 - 95; 1977 - 100; 1978 - 84; 1979 - 103; 1980 - 152; 1981 - 158; 1982 -147; 1983 - 128; 1984 - 185; 1985 - 165; 1986 - 118 USD/ ton FOB US Gulf).

Of the same importance is, however, to know of which raw materials the various fertilizer products consist. The production of one metric ton of each of the following products requires approximately:

AMMONIA

32 - 35 m.m. Btu of natural gas (1 Btu = 0.252 kcal), which is about 1000 cubic meters of high quality natural gas; or:
0.9 MT of naphta, or 1.05 MT of fuel oil, or 1.9 MT of coal; or:
5,000 - 6,000 kWh of electricity in water electrolysis process.

NITRIC ACID (100% HNO_3)

0.29 MT of ammonia.

AMMONIUM NITRATE (33.5% N)

0.21 MT of ammonia and 0.77 MT of 100% HNO_3.

UREA (46.3% N)

0.59 MT of ammonia and 0.77 MT of carbon dioxide.

SULPHURIC ACID (100% H_2SO_4)

0.35 MT of sulphur, or 0.76 MT of pyrites (48% S), or 0.74 MT of spent sulphur oxide, or 1.2 MT of zinc ores, or 1.7 MT of anhydrite, or 2.2 MT of gypsum.

PHOSPHORIC ACID (wet process - 100% P_2O_5)

3.1 MT of phosphate rock 75% BPL, i.e. about 33% P_2O_5, and:
2.7 MT of 100% sulphuric acid, or 3.5 MT of 100% nitric acid, or 2.3 MT of 100% hydrochloric acid (HCl).

TRIPLE SUPERPHOSPHATE (46% P_2O_5)

0.42 MT of phosphate rock 75% BPL and 0.33 MT of 100% P_2O_5 as phosphoric acid.

DI-AMMONIUM PHOSPHATE (18-46-0)

0.23 MT of ammonia and o.47 MT of 100% P_2O_5 as phosphoric acid.

Therefore, if the NPK Gap 2000 for 43 analyzed countries, equal to 3.5 mln MTPY of NPK, is to be filled through investment in fertilizer industry, it would involve additional consumption of approximately: 2.2 bln cu m per year of natural gas; 1.9 mln MTPY of phosphate rock concentrate; 0.6 mln MTPY of sulphur, and 1.2 mln MTPY of muriate of potash (60% KCl).

2.4.2. Inputs and Services

There are very many important inputs and services that must be available for the fertilizer industry to function properly.
Since there is no possibility to present them all in this chapter, therefore, only the most important inputs and services playing role in the whole fertilizer industry can be briefly discussed here.

A. INDUSTRIAL INFRASTRUCTURE

a. Chemical Industry, Process Equipment Industry, Packaging Industry

The level of the develpoment of the chemical industry in Africa is extremely differentiated; chemical industry practically does not exist in some Sub-Saharan countries or is weakly developed there, and, on the other hand, it is quite well developed in some other countries, in particular in North Africa.

Well developed chemical industry is the highly diversified subsector, with processing chains and interlinkages, comprising thousands of chemical products. A major part of the chemical industry output serves as an intermediate input into chemical processes, agriculture and other subsectors of the economy.

In Africa, chemicals with outlets in agriculture appear to be the most important ones, and it is the fertilizer (and/or mining) industry that in many cases was the nucleus of the development of the chemical industry subsector in Africa, and not vice versa.

The fertilizer industry cannot develop rapidly if there is no parallel development in the agricultural sector, but the fertilizer industry cannot also properly function without chemical industry being developed, at least on a moderate level.

Each of the fertilizer industrial sub-sector, be it nitrogen or phosphate/sulphur or potash industry, can be characterized by their specific requirements, as for instance several different types of sophisticated catalysts for ammonia, nitric acid and sulphuric acid production, or special anticorrosive agents, antifoam additives and different clays, fillers and fertilizer anticaking additives.
All of them can either be delivered by the national chemical industry or must be imported.
Secondary nutrients (Ca, Mg) amd micronutrients (Bo, Zn, Fe, Cu, Mo, Mn, Co), slow release fertilizers and other agents must be delivered from the chemical inorganic and organic industries.
Ammonium sulphate is obtained as a byproduct in the caprolactam production process.
Some fertilizer processes require raw materials which may be obtained from salt, or sodium carbonates. Various secondary sources of hydrocarbons may be used for ammonia feedstock, such as coke oven gas, liquefied petroleum gas, refinery tail gas, byproduct hydrogen from electrolytic chlorine production.

Polyethylene or polyethylene bags for fertilizer packing are delivered from the petrochemical and plastics chemical industries.

The chain of the uses of industrial inorganic acids, hydrochloric, nitric and, by far the most important, sulphuric acid, is so diversified, that it is even difficult sometimes to make a clear parting line in between the fertilizer and the other chemical industries, in particular in huge, diversified fertilizer/inorganic or fertilizer/petrochemical complexes.

Also fertilizer intermediaries and products serve in many other subsectors of the chemical industry, to mention only ammonia (refrigeration, dyestuffs), urea (melamine, urea-formaldehyde resins), ammonium nitrate (explosives) and phosphoric acid (washing powders).

A wide ranging effort is needed in most of the African countries to establish a reasonable degree of technological independence in the chemical and fertilizer industries. Because of the significant economies of scale that characterize research, development and process engineering in the fertilizer industry, these functions can be successfully undertaken only in close association of chemical research at universities, process engineering institutions and engineering enterprises with the technical staff and management from the fertilizer industry.
Research and developmet activities, technological improvements, engineering, maintenance, staff training and management capabilities in the fertilizer industry should have a very strong background in and support from both chemical and enginnering industries. Some African countries, to mention: Egypt, Tunisia, Morocco, Zimbabwe, Algeria, Libya, Zambia, Nigeria, Senegal, Tanzania and Mauritius have already made a substantial progress in this directions. Egypt and Tunisia in North Africa, and Zimbabwe Senegal and (lately) Nigeria in Sub-Saharan Africa seem to have developed the best their complex capabilities in services in the fertilizer industry, such as research, training facilities, engineering capabilities, fertilizer equipment and spare parts manufacturing, maintenance and equipment assembly capabilities.

In the engineering and allied metal working industries it is rather the peripheral engineering industry that is closely connected with the fertilizer industry.
The interlinkage between the peripheral engineering industries producing capital goods and services, in particular such as:

- conventional and special-purpose machine tools and metal working equipment for the manufacture of specific parts and components;

- various fabricated welded parts from the fabrication shop;

- nickel-chrome, phosphate, anodized and other metal-coated parts and components from the metal-coating shop;

- reconditioning facilities for worn-out machinery and equipment from the heavy repair and maintenance shop;

and the fertilizer industry, to which it is a major source of input materials: machinery, equipment and spare parts, may be regarded as one of the most important conditions of the fertilizer industry to function at all.
Without the domestic engineering industry, the fertilizer industry cannot practically exist, and will constantly be dependent on the deliveries of even small spare parts from abroad.
This, cannot be at all the guarantee of achieving on-stream factors and capacity utilization ratios in fertilizer plants even at a moderate level.

It is also obvious, that the fertilizer industry cannot be established or function without a parallel packaging industry, or appropriate packaging facilities established within the fertilizer complex. In most of the African countries fertilizers cannot be transported in bulk, in particular to the more remote agricultural areas. Therefore, either paper bags, natural fibres bags, or preferably polyethylene bags, must be delivered to, or manufactured directly in the fertilizer industrial complex.
Double bags with woven polypropylene or jute or sisal outer bag and a polyethylene or other moisture-proof inner bag may be required for transport within several African countries, where manual handling is involved.
Once again, it is another integrative chain of raw materials, processes and equipment in the packaging industry that has much in common with the chemical and fertilizer industries.

In order to fill the NPK gap 2000 (even not mentioning the demand), Africa will have to pack additionally some 7 million MTPY of fertilizer product. This is equal to approx. 150 million (50 kg) polyethylene bags per year, equivalent to the construction of 3 large-scale polyethylene bags facilities, not mentioning about the up-stream ethylene and polyethylene petrochemical plants.

Packages cannot be underestimated in the strategy of the development of the fertilizer industry in Africa, as their unit cost is frequently located on the second or third position in the fertilizer manufacturing cost, after the unit cost of raw material and energy.

b. Energy and water supply

Fertilizer industry belongs to high energy consuming subsectors, therefore energy self-sufficiency and energy supply reliability is sine qua non condition for the fertilizer industry to function at all.
Primary energy carriers: coal, fuel oil, natural gas to produce steam and deliver process energy, as well as electricity, cooling water, process water and industrial gases (compressed air, nitrogen) should be considered.
In practice, most of the process inputs (steam, cooling water, process water , compressed air) must be generated, at least partly, within the fertilizer complex, or in nearby location. Electricity is usually partly generated within fertilizer complex, however, it may also be sent from longer distances.

Ammonia process uses mostly primary energy (natural gas), and in modern plant both steam and electricity should be close to balance. Cooling water use (over 200 cubic meters per ton) and demineralized water are another important inputs.

Modern urea plant uses approx. 0.8 - 1.0 ton of steam, 125 kWh of electricity and 70 cubic meters of cooling water per one ton of product.

Phosphoric acid plant uses approx. 1.5 - 1.8 ton of steam, 150 kWh of electricity and 150 cubic meters of cooling water per ton of produced P2O5.

These examples show, how strongly dependent is the fertilizer industry on reliable energy supply. It is impossible to properly operate fertilizer plants and facilities, without energy sector being developed and stabilized first. Poor on-stream coefficients, emergency situations and deterioration of fertilizer equipment is inevitable when any fertilizer plant is coupled with inefficient energy supplies.

Fortunately, very many African countries are endowed with huge hydroelectricity potential, to mention only the Congo-river tremendous hydroelectricity potential estimated for about 25% of the world total potential, Kariba Dam on the boundaries of Zambia and Zimbabwe, Kafue Dam in Zambia, Cabora Bassa Dam in Mozambique, Aswan Dam in Egypt, Akasombo Dam in Ghana, Kainji Dam in Nigeria, and many others. The total hydro-electric power in Africa is estimated for 350,000 megawatts, this being one of the greatest enhancement to the fertilizer industry development in Africa.

Energy self-sufficiency in African countries is broadly analyzed in chapters 3 and 4 of this study.

Water is a frequently underestimated input when planning fertilizer industry development. Large scale ammonia-urea comlpex uses around 200 cubic meters of water per hour. These large quantities of water are not always readily available, particularly in arid African climate.

Water delivered to ammonia process is a raw material in strict sense of the word as it is the source of more than half of hydrogen needed to make ammonia in steam - natural gas reforming process (and the source of all the hydrogen in water electrolysis ammonia process).

This water must be of a very high quality, decarbonized and demineralized.

Cooling water may pose also problems in some locations, in particular when sea water, with high concentration of chloride ion, responsible for the chloride corrosion of stainless steel in the fertilizer industry, is used in sea-side locations.

c. Environmental protection

More and more stringent regulations and trends in the world in pollution control, will involve the necessity of supplying for very many African producers, in particular those located at the Mediterranean Sea, but not only, new technologies and equipment to protect natural environment. Closures of some fertilizer plants in North Africa caused by excessive pollution, is the best proof of that trend.

Gaseous effluents, such as: ammonia, nitric oxides, sulphur oxides, fluorine off-gases, as well as mists, fumes and dusts from the fertilizer plants are of the concern at the first place.

Liquid effluents from nitrogen and phosphate fertilizer industries, in particular those with phosphate and fluosilicic acid must be reckoned as the most dangerous ones for the natural environment, therefore improved drainage and sewage systems must be planned, in particular for slowly-moving shallow waters, where vegetational pollution is a serious problem.

Phosphogypsum from the wet phosphoric acid process is by far the most harmful solid waste to be mentioned here. By-produced in the quantity of approx. 6 tons per one ton of phosphoric acid, piled up or washed out into a sea, poses another threat for the natural environment, which should be regarded as the second important after gaseous effluents.

New packages of pollution combating technologies will have to be introduced with costly and very frequently economically uneffective (for the fertilizer industry!) additional facilities, in particular in the obsolete fertilizer complexes with already very high concentration of the fertilizer manufacture at one location.

d. Manpower

There are two options related to the gap 2000 in NPK fertilizers, either to cover NPK demand by imports of fertilizers, or through the investment actions in the fertilizer industry in Africa.

In this second option, the demand for at least partly qualified manpower to operate new fertilizer complexes and facilities would be very significant.

The following, approximate manpower requirements are estimated for this scenario:

- manpower to operate 7 new nitrogen fertilizer complexes - 4200 persons, of that at least 30 % of the staff educated in secondary technical schools and 10 % of the technical management with technical university educational level. At least 50% of that staff should be trained in fertilizer training centres and at similar nitrogen fertilizer facilities;

- manpower to operate 3 world-scale phosphate fertilizer complexes - 3000 persons, of that at least 20% of the staff educated in the secondary technical schools, and 5% of the technical management, both groups with the same training ratio as above for nitrogen fertilizer industry.

- manpower to operate 2 new potash extraction/production plants - 800 persons with the qualifications similar to those in the phosphate fertilizer industry.

Altogether 8,000 persons would be needed to operate new fertilizer facilities in Africa by 2000, of that some 600 chemical, mechanical, electrical, instrument engineers with at least some industrial practice in similar fertilizer facilities.

Manpower requirements, in particular as far as the new staff technical and professional experience is concerned, is considered to be constraint to the fertilizer industry development in Africa.

B. GENERAL INFRASTRUCTURE

Apart from the industrial infrastructure, of great concern to fertilizer industry development in Africa should also be the general infrastructure and plans of its development.

Transportation infrastructure, including port facilities and ships, railways and railway rolling stock, roads and navigable rivers, is a sine qua non condition of fertilizer and fertilizer raw materials deliveries to agricultural and industrial locations, and is quoted here as the most important input for the fertilizer industry and agriculture.

If only demand 2000 for NPK fertilizers equal to around 6 mln MTPY of pure nutrients is taken into account, even without raw materials and intermediary products that must be transported as well, either for domestic or international markets, it should be borne in mind that as much as about 12 million tons per year of fertilizer product will have to be handled in Africa.

Transport of some 35 million tons per year of phosphate rock and phosphoric acid, poses for some African countries, in particular for Morocco, even much higher challenge.

Marketing infrastructure, with storage facilities and a distribution network that would make it possible for the fertilizer product to reach the farms should also be included in the general infrastructure connected with the fertilizer industry supplying agriculture.

3.1. Present Production of Fertilizers in Africa

There are three most distinct routes of straight nitrogen fertilizers manufacturing:

- ammonia (A) with carbon dioxide to urea (U)
- ammonia to nitric acid (NA) ammonium nitrate (AN)/calcium ammonium nitrate (CAN)
- ammonia (A) with sulphuric acid (SA) to ammonium sulphate (AS).

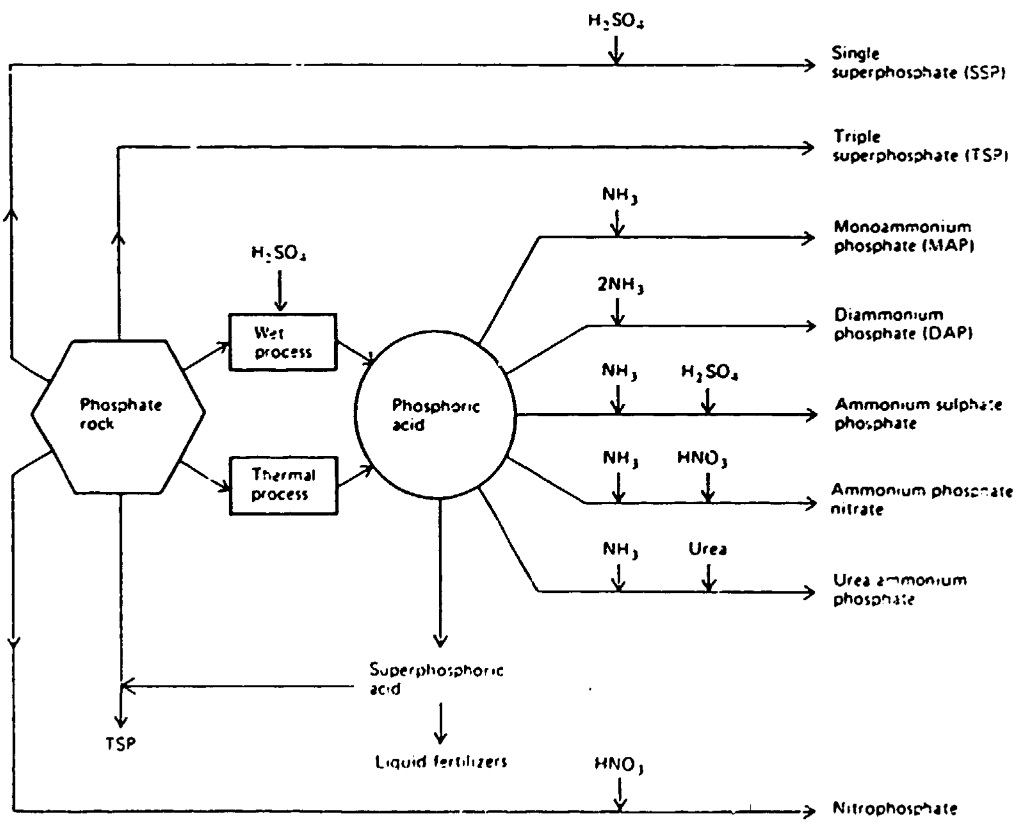
All of these routes are used in Africa. The routes to urea and ammonium nitrate are almost balanced. There is, however, slight advantage of AN/CAN products that can be manufactured more flexibly also from imported ammonia and from ammonia produced through water electrolysis, since there is no need to use carbon dioxide byproduced locally from ammonia plant.

Ammonium sulphate, largely byproduced in developed countries in caprolactam process, is manufactured in Africa through synthesis of ammonia and sulphuric acid. Though the importance of ammonium sulphate is much lower than that of ammonium nitrate or urea, still it is used in African, sulphur deficient, soils.

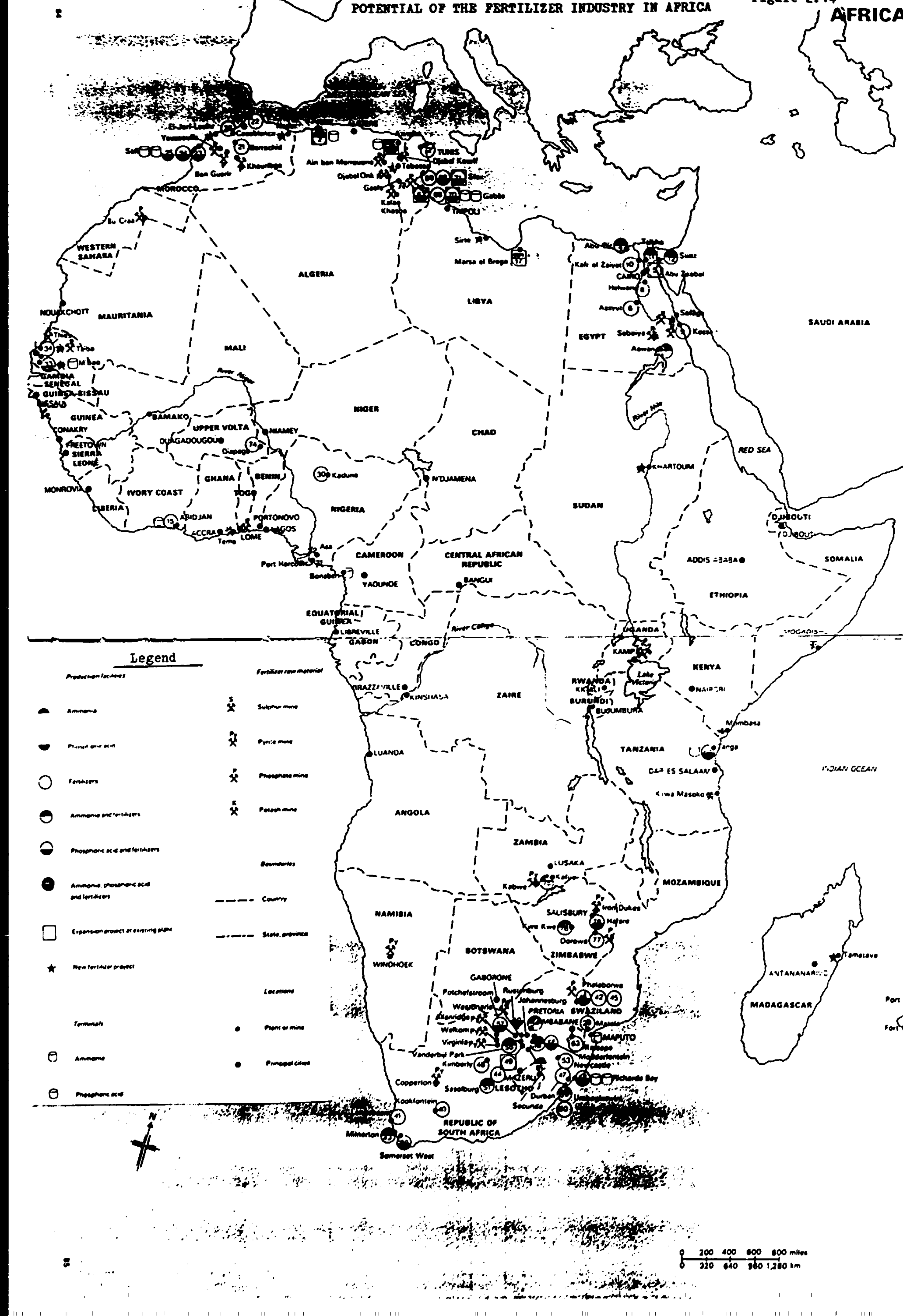
The balance of nitrogen fertilizers manufactured in Africa comes out from the production of complex NP and NPK fertilizers, mostly through the reaction of ammonia with phosphoric acid to yield di-ammonium phosphate (DAP) or mono-ammonium phosphate (MAP).

Superphosphates, single (SSP), double (DSP) and triple (TSP) are straight phosphate fertilizers widely produced in Africa, DSP being of lesser importance.

There are many possibilities to produce complex fertilizers based on phosphate rock and phosphoric acid, as illustrated in Figure 2.13 below. Wet phosphoric acid technology, based on reaction of phosphate rock with sulphuric acid is practically the only process used in Africa.



POTENTIAL OF THE FERTILIZER INDUSTRY IN AFRICA



POTENTIAL OF THE FERTILIZER INDUSTRY IN AFRICA

Algeria

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5) NH_3	SPA* PA	Products AS	AN	U	SS	TS	CX	Others	Projects/Expansions ('000 t.p.a.) (N/P_2O_5) NH_3	PA	Products
1. Sonatrach	Annaba	272	165		•			•	•			165	CX
2. Sonatrach	Arzew	544			•								U‡
Project													
3. Sonatrach	Tebessa											165	TS

Egypt

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5) NH_3	SPA* PA	Products AS	AN	U	SS	TS	CX	Others	Projects/Expansions ('000 t.p.a.) (N/P_2O_5) NH_3	PA	Products
4. Abu Qir Fertilizers & Chemical Products	Abu Qir	328				•							
5. Abu Zaabal Fertilizer & Chemical Co.	Abu Zaabal						•					66‡	TS
6. Assyut Fertilizer & Chemical Industries	Assyut						•						
7. Egyptian Chemical Industrial Co. (KIMA)	Aswan	119			•								
8. General Organisation for Industrialisation	Helwan				•								
9. Government of Egypt	Kosseir									GR			
10. Sté Financière et Industrielle d'Egypte SA	Kafr el Zaiyat						•						
11. Sté el Nasr d'Engrais et Industries Chimiques SAE	Talkha	424			•	•							U‡
12. Sté el Nasr d'Engrais et Industries Chimiques SAE	Suez	48			•								
Project													
13. Safaga Fertilizer Co.	Safaga										272	346	U,CX

Ghana

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5) NH_3	SPA* PA	Products AS	AN	U	SS	TS	CX	Others	Projects/Expansions ('000 t.p.a.) (N/P_2O_5) NH_3	PA	Products
Project													
14. Ghana Fertilizer Co. Ltd.	Tema												CX

Ivory Coast

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5) NH_3	SPA* PA	Products AS	AN	U	SS	TS	CX	Others	Projects/Expansions ('000 t.p.a.) (N/P_2O_5) NH_3	PA	Products
15. Sté Ivoirienne d'Engrais	Abidjan			•					•				

Kenya

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5) NH_3	SPA* PA	Products AS	AN	U	SS	TS	CX	Others	Projects/Expansions ('000 t.p.a.) (N/P_2O_5) NH_3	PA	Products
Project													
16. National Chemicals & Fertilizers Ltd.	Mombasa												AN,CX

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5)		Products							Projects/Expansions ('000 t.p.a.) (N/P_2O_5)		
		NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Libya													
17. Libyan National Oil Corp.	Marsa el Brega	272				•					272‡		U‡
Project 18. Libyan National Oil Corp.	Sirte										732		U,AN
Madagascar													
Project 19. Usines d'Engrais Chimique de Tamatave	Tamatave										73‡		U‡
Mauritius													
20. Mauritius Chemical & Fertilizer Industry Ltd.	Fort Georges				•				•				
Morocco													
21. Fertima	Berrechid									GR			
22. Fertima	Kenitra									GR			
23. Maroc-Chemie SA	Safi		360					•	•				
24. Maroc-Phosphore I	Safi		825							MP			
25. Maroc-Phosphore II	Safi		495										
26. Sté Chérifienne d'Engrais et de Produits Chimiques	Casablanca						•						
Projects 27. Maroc-Phosphore III	El-Jorf-Lasfar											1320/ 231*	
28. Maroc-Phosphore IV	Nador											660	
Mozambique													
29. Quimica Geral Sarl.	Matola			•			•						
Nigeria													
30. Federal Superphosphate Fertilizer Co. Ltd.	Kaduna						•						

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5)		Products							Projects/Expansions ('000 t.p.a.) (N/P_2O_5)		
		NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Projects													
31. Nigerian Government	Port Harcourt										272		AN,CX,U
32. Webb Fertilizers Ltd.	Asa											40	CX,TS

Senegal

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
33. Sté Industrielle d'Engrais au Sénégal (SIES)	M'bao		23				•	•	•				
34. Sté Senegalaise des Phosphates de Thies	Thies									FP			
Projects													
35. Sté Industrielle Chimiques du Senegal	M'bao												TS,CX
36. Sté Industrielle Chimiques du Senegal	Taiba											264	

Somalia

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Project													
37. Ministry of Agriculture	Mogadishu										40		U

South Africa

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
38. AECI Ltd.	Modderfontein	320			•	•							
39. AECI Ltd.	Umbogintwini	148				•				DC			
40. Chemfos Ltd.	Kookfontein									FP			
41. Chemfos Ltd.	Langebaan									GR			
42. Chemical Industries of South Africa	Phalaborwa									DC			
43. Fedmis (Pty) Ltd.	Milnerton	75			•								
44. Fedmis (Pty) Ltd.	Sasolburg				•		•	•					
45. Fedmis (Pty) Ltd.	Phalaborwa									DC			
46. Fedmis Bosveld Fertilisers (Pty.) Ltd.	Phalaborwa		321					•		MP			
47. Kynoch Feeds (Pty) Ltd.	Durban									DC			
48. Kynoch Feeds (Pty) Ltd.	Kimberly									DC			
49. Omnia Landbou Beleggings Ltd.	Sasolburg						•			MP			AN,CX
50. Omnia Phosphates (Pty) Ltd.	Rustenburg		30										
51. South African Coal Oil & Gas Corp. (SASOL) I	Sasolburg	47		•	•								
52. South African Coal Oil & Gas Corp. (SASOL) II	Secunda	274											
53. South African Iron & Steel Corp. (ISCOR)	Newcastle			•									
54. South African Iron & Steel Corp. (ISCOR)	Pretoria	5		•									
55. South African Iron & Steel Corp. (ISCOR)	Vanderbijl Park	5		•									
56. Triomf Fertilizer (Pty) Ltd.	Modderfontein		43				•	•	•				
57. Triomf Fertilizer (Pty) Ltd.	Potchefstroom		42				•	•	•	MP			
58. Triomf Fertilizer (Pty) Ltd.	Richards Bay		396							MP			
59. Triomf Fertilizer (Pty) Ltd.	Somerset West		27				•	•	•				
60. Triomf Fertilizer (Pty) Ltd.	Umbogintwini						•		•				

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5)		Products							Projects/Expansions ('000 t.p.a.) (N/P_2O_5)		
		NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Project 61. South African Coal, Oil & Gas Corp. (SASOL) III	Secunda										200		

Sudan

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Project 62. Sudan-ren Chemicals & Fertilizers	Khartoum										109‡		U‡

Swaziland

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
63. Swaziland Chemical Industries	Matsapa				•								

Tanzania

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
64. Tanzania Fertilizer co. Ltd.	Tanga		27	•				•	•				
Project 65. Kilwa Ammonia Co.	Kilwa Masoko										312		U

Tunisia

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
66. Granuphos	Sfax									GR			
67. Industries Chimiques Maghrebines	Gabès		260					•		DC		165‡	CX
68. NPK-Engrais SAT	Sfax		70					•					
69. Ressource Tunisie SA	Gabès									MP			
70. Sté Arabes des Engrais Phosphates et Azotes (SAEPA)	Gabès		330						•				AN‡,CX
71. Sté Industries d'Acide Phosphorique et d'Engrais (SIAPE)	Sfax		99					•				231*/ 165	TS
72. Sté Tunisienne d'Engrais Chimiques	Tunis						•						
Project 73. Industries Chimiques de Gasfa	Gasfa											158	TS

Upper Volta

Company	Location	NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Project 74. Phosphate (R.F.A.)	Diapaga									GR			

Table 9 (cntd)

Company	Location	Annual capacity ('000 t.p.a.) (N/P_2O_5)		Products							Projects/Expansions ('000 t.p.a.) (N/P_2O_5)		
		NH_3	SPA* PA	AS	AN	U	SS	TS	CX	Others	NH_3	PA	Products
Zambia													
75. Nitrogen Chemicals of Zambia Ltd.	Kafue	79		•	•				•				
Zimbabwe													
76. Sable Chemical Industries Ltd.	Kwe Kwe	58			•								
77. Zimbabwe Phosphate Ltd.	Dorowa									DC			
78. Zimbabwe Phosphate Industries Ltd.	Harare		20				•	•					

Glossary

PLANT CAPACITY: Rated annual capacities of ammonia plants (thousand tonnes N) and phosphoric acid plants (thousand tonnes P_2O_5) are presented. Expansion figures show net increase.

FERTILIZER PRODUCTS: For individual producers the main product range is indicated.

TERMINOLOGY:

- AC Ammonium chloride
- AN Ammonium nitrates (including calcium ammonium nitrate and ammonium sulphate nitrate)
- AS Ammonium sulphate
- CC Calcium cynamide
- CN Calcium nitrate
- CX Binary and Ternary complex and compound fertilizers; ammonium phosphates
- DC Dicalcium phosphate
- FP Fused phosphate
- GR Ground phosphate rock
- KN Potassium nitrate
- KS Potassium sulphate
- NH_3 Ammonia
- PA Phosphoric acid ('wet' acid only is indicated)
- SPA Superphosphoric acid
- SS Single superphosphate
- TS Triple superphosphate
- U Urea
- ‡ Plant under construction

Source:

Out of the three straight potash fertilizers, i.e. muriate of potash (MOP), sulphate of potash (SOP) and nitrate of potash (NOP), none is produced in Africa, the most widely being used potassium chloride (KCl), known as muriate of potash (MOP).

As far as sulphuric acid is concerned, dominating in Africa is the process of sulphur (brimstone) burning with air, sulphuric acid is, however, also produced from pyrites and through utilization of S-bearing smelter off-gases though at a much lower scale.

2.4.3.1 Primary nutrients - synthesis

The potential of the fertilizer industry in Africa is illustrated both in Figure 2.14 and Table 9, that present (after the World Fertilizer Atlas, 1983) on country by country basis: African companies manufacturing fertilizres, locations, annual capacities, fertilizer products manufactured, and plans on new projects or expansions in existing capacities.

As there is large coverage of information in chapter 4 on fertilizer production in selected groups of African countries, together with the information on capacity utilization rates, below are presented only some most important data related to production of fertilizers in 1986.

As mentioned in section 2.2.6 and Table 6 above, there are twelve producers of NPK fertilizers among the 43 analyzed African countries, that manufactured altogether 2.7 mln MTPY of NPK fertilizers in 1986, and more strictly speaking 2.7 mln MTPY of NP fertilizers, as there was no potash production in Africa.
These are, in alphabethical order: Algeria, Cote D'Ivoire, Egypt, Libya, Mauritius, Morocco, Nigeria, Senegal, Tanzania, Tunisia, Zambia and Zimbabwe.

Algeria

Algeria produces both ammonia and phosphoric acid.
Production of fertilizers 1986 was equal to 166.000 MTPY of NP, of that dominating nitrogen fertilizers 112.000 MTPY, the balance being 54.000 MTPY of phosphate. Fertilizer production covers local consumption only in 61%. Export of nitrogen 12.000 MTPY was lower than its import - 19.000 MTPY, however, Algeria is self-sufficient in nitrogen fertilizers. Production of phosphate covers its consumption only in 50%. Potash was imported in 100%.

Cote D'Ivoire

Cote D'Ivoire does not produce ammonia or phosphoric acid.
Production of nitrogen fertilizers (AS) is based on imported ammonia and sulphur. Single superphosphate (SSP), and compound granulated NPK are produced as well. Fertilizer production covered local consumption only in 12% in 1986. At the same time, export of fertilizers, bigger than production was reported for 1986, this making fertilizer balance in this country unclear.

Egypt

Egypt is producer of nitrogen fertilizers on a large scale, over 80% of its total production in 1986, the balance being phosphate fertilizers. Potash was imported. Fertilizer production equal to 730.000 MTPY of NP covered local consumption in over 90%. There is small export of phosphate and import of nitrogen fertilizers. Egypt is important producer of ammonia, phosphoric acid being produced in small amount.

Libya

Libya is strong producer of ammonia and nitrogen fertilizers (urea). Production of nitrogen fertilizers covered local consumption in almost 1000%, great surplus of nitrogen being exported, with small import of phosphate and potash. There is no production of phosphate or potash fertilizers in Libya.

Mauritius

Mauritius produced about 10.000 MTPY of nitrogen fertilizers (AN) based on imported ammonia. Being self-sufficient in nitrogen, Mauritius imports straight phosphate and potash fertilizers for its downstream NPK compound granulation plant.

Morocco

Morocco is strong producer of phosphoric acid and phosphate fertilizers. Nitrogen fertilizers (MAP/DAP) are produced on the basis of imported ammonia. Production of phosphate fertilizers (around 470.000 MTPY) covered local consumption in 400%, surplus being exported. Total production of NPK fertilizers amounted to 525.000 MTPY. Nitrogen was partly, and potash totally imported in 1986.

Nigeria

Nigeria was reported in 1986 as a small producer of phosphate fertilizers, 5.000 MTPY of P2O5 in SSP, and as a huge importer of nitrogen, phosphate and potash (altogether over 220.000 MTPY of NPK). With its new nitrogen complex at Onne (ammonia plant capacity of 272.000 MTPY of N, with downstream urea and NPK plants) put into exploitation in 1987/88, Nigeria covers its consumption of NPK reported in 1986 for 295.000 MTPY. Nigeria is still dependent, however, on imports of phosphoric acid and potash.

Senegal

Senegal, similarly as Morocco, is producing phosphoric acid, basing its production of nitrogen fertilizers on imported ammonia and potash. Total production of NP (DAP and TSP) was around 16.000 MTPY and, with small import of nitrogen and export of phosphate and nitrogen, almost covered local consumption of NPK (21.000 MTPY of NPK in 1986).

Tanzania

Tanzania produced in 1986 only 10.000 MTPY of NPK fertilizers, which covered local consumption in 25%. Production is based on imported ammonia, sulphur and potash, phosphate rock being delivered from own mine. Ammonium sulphate and small phosphoric acid unit are coupled with down-stream NPK compound granulation plant.

Tunisia

Tunisia based its NPK production on own phopsphate rock and phosphoric acid, ammonia, sulphur and potash being totally imported. Total production NPK 1986, equal to 860.000 MTPY, was eightfold higher than consumption, surplus being exported. Tunisia is the biggest producer and exporter of NPK fertilizers in analyzed group of 43 African countries.

Zambia

Zambia based its production on own ammonia derived from coal. It is the only coal gasification plant in analyzed 43 African countries (South Africa having much greater potential here). With production of nitrogen fertilizers (AN and AS) around 14.000 MTPY of N, Zambia covered in 1986 local nitrogen consumption only in 25%. Both potash and phosphate fertilizers, with remaining 75% of nitrogen, were imported. Sulphuric acid is produced based on local pyrites.

Zimbabwe

Zimbabwe based its NPK production on own ammonia produced by electrolysis of water, and on phosphoric acid based on own phosphate and sulphuric acid produced from own pyrites.
Potash was imported in 100%, and if it were not for this, Zimbabwe might have been totally self-sufficient in fertilizers. With its production of 120.000 MTPY of NP fertilizers in 1986, and import of potash around 30.000 MTPY of K2O, Zimbabwe covered its total consumption of NPK fertilizers in 1986, small amounts of nitrogen being imported and nitrogen and phosphate exported.

World ammonium nitrate and urea fertilizer plant capacities show, that urea capacities are growing much quicker. In 1976, world AN capacities were estimated at 15 million MTPY of N and world capacities of urea at 21 million MTPY of N. Projections for 1990 show that world AN capacities may grow at most to 20 mln MTPY of N, while those of urea to as much as 45 mln MTPY of N.

Ammonium nitrate continues to be directed to domestic consumption rather than trade, and static or falling capacity is expected in all regions, except Africa and Western Europe. African total AN capacity is forecast to rise by some 30% in the period of 1986 - 1990, up to around 1.25 mln MTPY of N.

More and more frequently, in tropical, subtropical and warm temperate regions, certain agronomic advantages are claimed for urea compared with ammonium nitrate, for instance in the cultivation of flooded rice, as the plant nutrient supply of the urea fertilizer is quickly available to crops.

Urea capacity in the world in the years 1986 - 1990 - 1995 is estimated for around 40 - 45 and 50 mln MTPY of N. The share of Africa is not high, and urea capacities are estimated correspondingly at 1.3 - 1.4 and 1.4 mln MTPY of N in this period.

Global world ammonia capacity in the years 1986 - 1990 - 1995 is estimated at 118 - 127 and 136 mln MTPY of N, of that Africa correspondingly 3.4 - 3.9 and 4.6 mln MTPY of N.

The balance of nitrogen capacities in Africa in 1990 is then estimated approximately for: Ammonia 3.9 mln MTPY of N = Ammonium nitrate 1.25 mln MTPY of N + Urea 1.4 mln MTPY of N + 1.25 mln MTPY of N shared between AS (ammonium sulphate) and MAP/DAP complex fertilizers and ammonia surplus for export.

The expansion in nitrogen capacity was expected mainly in three countries, Algeria, Nigeria and Egypt. In Nigeria and Egypt the additional nitrogen capacity was planned for the domestic market.

In Nigeria, the ammonia/urea complex that came on stream in 1987 at Onne, added 200.000 MTPY of N urea capacity, and there are already plans for an additional 228.000 MTPY urea plant at the same site expected to come on stream in the early 1990s.

In Egypt, 747.000 MTPY of N ammonia capacity is planned to come on stream during the early 1990s. Much of this excess capacity will be directed towards AN manufacture as there are also two ammonium nitrate projects at Abu Quir and Suez with total capacity of 464.000 MTPY of N expected on stream during the early 1990s.

The additional ammonia capacity in Annaba, Algeria is likely to be directed towards the export market, as Algeria is already an ammonia exporter. The new plant has capacity of 272.000 MTPY of N and was due on stream during 1987/1988.

Also Zambian coal based ammonia plant is currently revamped to 80.000 MTPY of N, together with the down-stream units at Kafue: nitric acid (NA), ammonium nitrate (AN), ammonium sulphate (AS) and NPK fertilizer plant.

Ammonia/urea complex at Kilwa Masoko, Tanzania of the capacity 330.000 MTPY of N ammonia and 250.000 MTPY of N urea, planned already at the beginning of 1980s, has still not get off the ground.

Another important nitrogen complex at Sirte, Libya, planned at the total ammonia capacity 750.000 MTPY of N in two plants, with down-stream units of urea, two NPK plants, sulphuric acid plant and ammonium sulphate plant is suspended.

Small ammonia/urea complexes in Sudan and Madagascar, each of the capacity 49.000 MTPY of N ammonia and 42.000 MTPY of N urea, are suspended.

Mozambican ammonia/urea complex of the capacity 300.000 MTPY of N ammonia and 225.000 MTPY of N urea is still being studied.

Di-ammonium phosphate (DAP) and NPK plants under construction in Morocco and Tunisia, will for sure be using, at least partly, ammonia manufactured from the new African plants.

In contrast to the very rapid consumption growth of nitrogen in the global world scale (index for 1986 = 567, when 1963 =100), both consumption growth of phosphate and potash was much slower (corresponding 1986 indexes: 303 and 280, when 1962 = 100). And, though the world's consumption of P2O5 had grown substantially from 11 mln tons in 1963, up to 34 mln tons in 1986, this was the first indication that new capacities would not be so much needed as in nitrogen fertilizers.

However, phosphate and potsh consumption growth in Africa was fortunately higher than the average (when 1963 index =100, 1986 indexes for nitrogen, phosphate and potash consumption were correspondingly 581, 425 and 484), and in particular, consumption of P2O5 had grown from 0.3 mln tons in 1963, up to 1.3 mln tons in 1986. This was an indication that there was a room in Africa for investment not only in nitrogen, but in phosphate as well.

Following this trend, the state-controlled giant phosphate rock producers in North Africa have developed downstream phosphoric acid and phosphate fertilizer production, breaking the long-established predominance of the United States in phosphate fertilizer export market.
Leading the way has been Morocco, investing heavily into downstream phosphate production. The boom in P2O5 prices and higher demand in 1970s, led Morocco to develop ambitious plans for an export oriented phosphoric acid and phosphate fertilizer industry. Even before the first phase of the giant Jorf Lasfar project came on stream in 1986/87, Morocco had won supremacy from the United States as the leading exporter of merchant-grade phosphoric acid.
In other African countries, as Tunisia and Senegal, similarly state-controlled phosphate fertilizer producers have been given priority for development.

Today, with the stagnation in global demand for phosphate fertilizers, there is disequilibrium in phosphate market with excess supply capability. World wide consumption of phosphate fertilizers has settled at around 34 mln MTPY of P2O5, with consumption growth forecasts 2-3% per annum. Thus, phosphate fertilizer producers are faced, in global terms, with considerable excess capability, all the more that further additional P2O5 capacity (planned when outlook for global demand and prices was more favourable) is due to come on stream before 1990, including 2 million MTPY of P2O5 phosphoric acid and 1.5 mln MTPY of P2O5 in DAP.

Plants and projects related to phosphate fertilizer industry in Africa (including sulphuric acid plants) are reported to be completed or studied in:

Algeria, Tebessa - where SA (sulphuric acid), PA (phosphoric acid) and TSP (triple superphosphate) complex with the capacity of 165.000 MTPY of P2O5 is studied.

Burundi, Matango-Bandaga - where phosphate and NPK fertilizer facilities are studied.

Congo, Pointe Noire - where phosphate fertilizer plant is studied.

Egypt, Abu Zaabai - where SA, PA, TSP complex with the capacity of 66.000 MTPY of P2O5 has lately been completed.

Morocco, Jorf Lasfar - where very huge phosphate complex of the total capacity of 1320.000 MTPY of P2O5, combined with 8 PA plants, 6 SA plants, 2 SPA (super-phosphoric acid) and 4 DAP/TSP/ASP integrated plants were put on stream in 1986-87.

Morocco, Nador - where 4 PA plants, each of the capacity of 165.000 MTPY of P2O5 are planned.

Morocco, Youssouffia - where 3 phosphate rock (PR) calcination units, each of the capacity 1.2 mln MTPY rock concentrate were completed in 1987.

Morocco, Khouribga, Meskala, Sidi Hajjaj - where another PR facilities of the total capacity of 21 mln MTPY rock concentrate are planned.

Nigeria, Onne - where downstream DAP and NPK plants were added to ammonia/urea complex and came on stream in 1987/88.

Senegal, Taiba - where phosphate rock enrichment and phosphate fertilizer plants are planned.

Togo, Kpeme - where PA plant of the capacity 165.000 MTPY of P2O5, with downstream TSP and DAP/NPK units is studied.

Tunisia, Gabes - where DAP and NPK plants wer put on stream in 1987.

Tunisia, La Skhirra - where 2 SA, 2 PA and one SPA plants with the total P2O5 capacity of 330.000 P2O5 were put into exploitation in 1987.

Tunisia, different locations - where there are SA, PA, TSP, NPK and PR facilities planned or studied.

In spite of such an important phosphate production development, mostly in North Africa, the majority of Sub-Saharan African countries have yet to see a take-off in their agricultural development, as traditional agricultural techniques may no longer be appropriate to feed their growing populations. ahowever, even with growing P2O5 demand, prospects for rapid growth of phosphate fertilizer consumption in developing Africa with rudimentary fertilizer distribution system remain uncertain, especially in the Sahel region facing additionally climatic and geological difficulties.

Overall situation in the phosphate industry in the world and in Africa, together with closely related sulphur industry, is presented below in Figure 2.15 and Figure 2.16 for reference.

Figure 2.15 illustrates: Net phosphate balance by region -1987; World P2O5 exporters 1987 with trends for 1992; World phosphoric acid production forecast 1987 to 1992.

Figure 2.16 illustrates situation in 1987 and trends to 1992 in: World phosphate production - by product type; World sulphur consumption by region; World sulphur production by type; World sulphur production - by region.

As far as plans of the new potash plants are concerned, the following countries and locations are considered for the development:

Botswana, Sua Pan - where studies are carried out in cooperation with South Africa on the possibilities of potash production through solar evaporation of the brines, rich in salt, soda ash, sodium sulphate, potassium chloride, bromine and lithium compounds. No details are revealed on these studies.

Congo, Pointe Noire - where geological and geophysical research is being carried out on reviving production from the potash deposit at Holle, near Pointe Noire. Flooding of the mine in 1977 brought operations to a premature end (Congo had produced 270.000 MTPY of K2O before 1977). It has yet to be decided whether to recommend a resumption of conventional mining or to develop a solution mine, and whether to exploit the carnallite instead of the sylvinite.

Ethiopia, Dallol - where the first stage of the feasibility study on the potential for exploiting the Danakil potash deposits in the Dallol area, 9o km from the Red Sea coast, was completed in 1986. It has been estimated that up to 1.5 million MTPY of KCl could be mined. Political unstability in this territory hampered further studies.

Nigeria, Port Harcourt - where a raw materials commitee has been formed at the local University, which, in the hope of substituting imported potash used in fertilizer complex at Onne, is liasing with other research institutes to seek potash resources in the country.

Tunisia, Zarzis - where potassium sulphate project of the capacity of 140.000 MTPY of SOP is planned. The major concern of the project has been the development of a suitable process for the recovery of SOP from the underground potash-rich brines in the Zarzis area. Some 60.000 MTPY of MOP (KCl) would have to be imported to make a marketable product. No decision has yet been reached on the best way to exploit these deposits, containing also other inorganic salts, in addition to SOP. Commercial production is unlikely to begin before the mid-1990s.

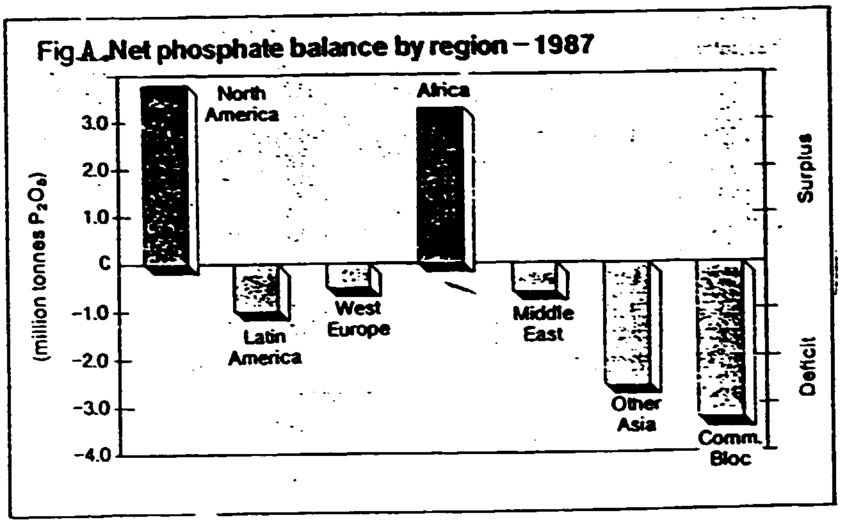


Fig.A.Net phosphate balance by region – 1987
(million tonnes P_2O_5)
3.0
2.0
1.0
C
-1.0
-2.0
-3.0
-4.0
North America
Latin America
West Europe
Africa
Middle East
Other Asia
Comm. Bloc
Surplus
Deficit

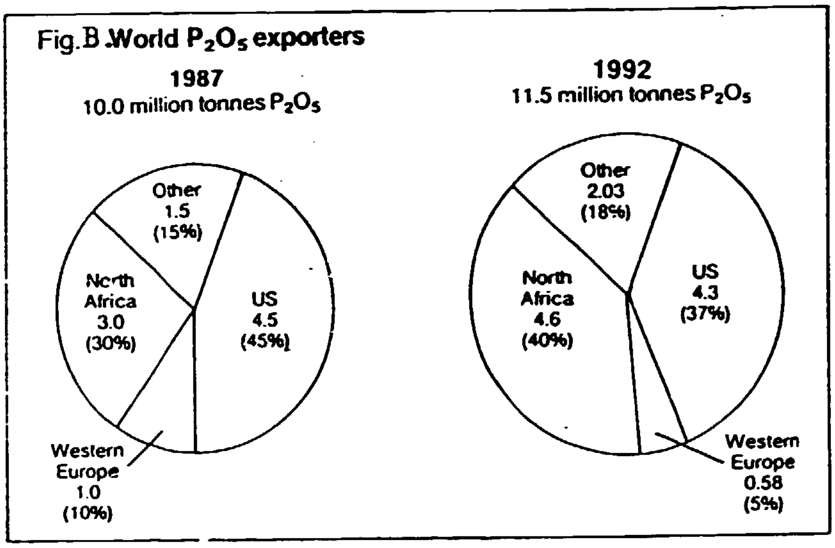


Fig.B.World P_2O_5 exporters
1987
10.0 million tonnes P_2O_5
Other 1.5 (15%)
North Africa 3.0 (30%)
US 4.5 (45%)
Western Europe 1.0 (10%)
1992
11.5 million tonnes P_2O_5
Other 2.03 (18%)
North Africa 4.6 (40%)
US 4.3 (37%)
Western Europe 0.58 (5%)

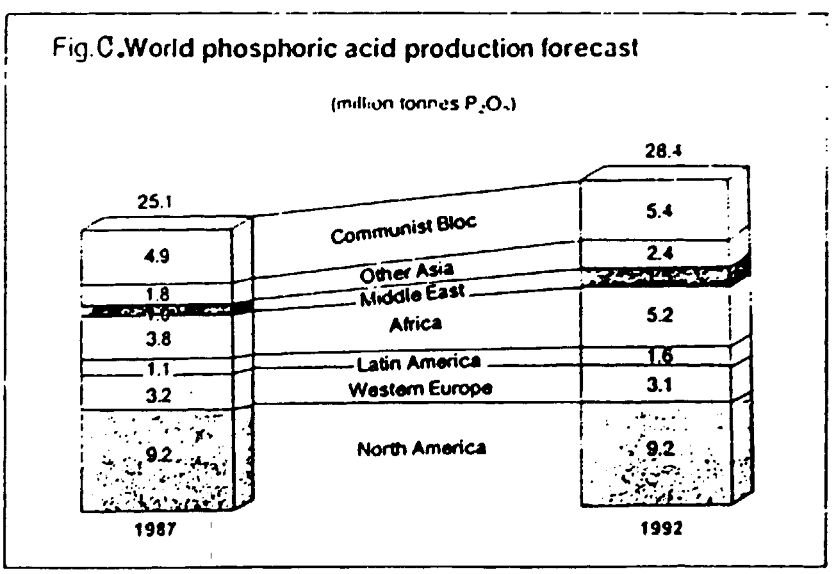


Fig.C.World phosphoric acid production forecast
25.1
28.4
4.9
1.8
3.8
1.1
3.2
9.2
5.4
2.4
5.2
1.6
3.1
9.2
Communist Bloc
Other Asia
Middle East
Africa
Latin America
Western Europe
North America
1987
1992

Table I: World phosphate production – by product type
(million tonnes P_2O_5)

	1987	1992	% change
Wet phosphoric acid	25.1	28.4	3.3
Non-wet phosphoric acid			
Normal super	6.6	6.9	0.3
Rock in triple	2.2	2.3	0.1
Electric furnace	2.0	1.9	-0.1
Nitro phosphate	3.0	3.2	0.2
Direct application	3.3	3.6	0.3
Total non-wet	17.1	17.9	0.8
Total P_2O_5 production	42.2	46.3	4.1

Table II: World sulphur consumption – by region
(million tonnes)

	1987	1992	Tonnage change
North America	13.0	13.1	0.1
Latin America	3.5	4.1	0.6
Western Europe	9.4	9.1	-0.3
Africa	5.2	6.6	1.4
Middle East	1.0	1.4	0.4
Other Asia	6.2	7.1	0.9
Total Western World	38.2	41.3	3.1
Total Eastern Bloc	18.9	20.8	1.9
Total World	57.1	62.1	5.0

Table III: World sulphur production – by type
(million tonnes)

	1987	1992	Tonnage change
Elemental			
Frasch and mined	14.4	15.3	0.9
Other elemental	23.2	28.2	5.0
Total elemental	37.6	43.5	5.9
Non-elemental			
Pyrite	10.2	11.4	1.2
Other forms	9.9	11.7	1.8
Total non-elemental	20.1	23.1	3.0
Total sulphur	57.5	66.6	8.9

Table IV: World sulphur production – by region
(million tonnes)

	1987	1992	Tonnage change
North America	17.2	18.5	1.3
Latin America	2.9	4.0	1.1
Western Europe	7.8	7.9	0.1
Africa	1.1	1.2	0.1
Middle East	3.0	4.3	1.3
Other Asia	3.7	3.9	0.2
Total Western World	35.7	39.8	4.1
Total Eastern Bloc	22.0	26.8	4.8
Total World	57.7	66.6	8.9

2.4.3.2 Primary nutrients - bulk blending

As a general rule, the creation and the development of the fertilizer industry goes according to four distinct and progressive phases:

- imports of food and at the same time introduction and demonstration of effects from applied fertilizers;
- imports of fertilizers to satisfy local demand and to prepare conditions that enable the development of domestic ferilizer industry;
- construction of fertilizer plants and facilities with the aid and foreign technical assistance;
- domestic production of fertilizers through unaided exploitation of fertilizer plants and complexes, imports being limited only to raw materials or intermediaries not available domestically.

North African countries are, in principle, located in the fourth phase, still, however, significant foreign technical assistance is needed in very many cases (phase 3).

Some of Sub-Saharan countries, to mention: Zimbabwe, Senegal, Nigeria, Mauritius can also be located in between phase 4 and 3 of the development of their domestic fertilizer industries. Other, as for instance Zambia or Tanzania, are better fit to the phase 3.

The majority of Sub-Saharan African countries should be, however, located either in phase 1, or more frequently in phase 2, some of them only trying to join phase 3 of the development of their fertilizer industry.
It should also be mentioned here, that some countries that had once reached higher level of the development of their fertilizer industry, to mention only: Swaziland, Mozambique and Cameroon, for different reasons failed to keep on stream their fertilizer facilities. There are also difficulties observed in some other countries with putting on stream new fertilizer plants and complexes there, as for instance Somalia, Sudan, Kenya, Madagascar.

In order to create domestic fertilizer industry (phase 3), it is necessary to pass through phase 2, i.e. import of fertilizers. The affinity of fertilizers to local soils must be checked, response of crops grown for used fertilizers should be analyzed, fertilizer distribution network should be created, and, as one of the many possibilities, local phosphate rock grinding, compound granulation or bulk-blending and packing of imported fertilizers should be tried as well.

The world chemical industry offers many fertilizer processes and equipment, not necessarily connected with fertilizer synthesis which, in some cases may not be the best answer to fertilizer industry development, either because of the scale of fertilizer domestic market or because of other reasons.

The compatibility of the demand 2000 for NPK fertilizers with the capacities used in Bulk-Blending plants, Ground-Phosphate-Rock facilities, Minifertilizer plants, and with the minimum economically justified capacities of straight N,P,K fertilizers is illustrated in Figure 2.17 for reference.

POTENTIAL OF THE FERTILIZER INDUSTRY IN AFRICA — Figure 2.17

COMPATIBILITY OF THE DEMAND 2000 FOR NPK FERTILIZERS WITH THE CAPACITIES USED IN BULK-BLENDING PLANTS, GROUND-PHOSPHATE-ROCK FACILITIES, MINIFERTILIZER PLANTS AND WITH THE MINIMUM ECONOMICALLY JUSTIFIED CAPACITIES OF STRAIGHT N, P, K FERTILIZERS

OPERATIONAL MINIMUM CAPACITIES EXPRESSED IN TERMS OF 000 MTPY OF N, P_2O_5, (S), K_2O

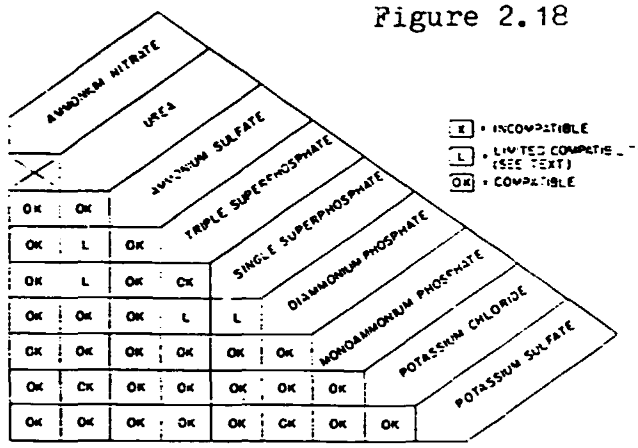
OPERATION / NUTRIENT	BULK-BLENDING	GRINDING PHOSPHATE ROCK	MINIFERTILIZER PLANTS	STRAIGHT FERTILIZERS
N	Wide range of capacities and large blending flexibility (see NPK and PRODUCT)	Does not concern	The Smallest Plants - 4 Small Plants - 40 Larger Miniplants - 70	Small Plants - 80 (000 MTPY of N) Larger Plants - 135 (000 MTPY of N) Very Large Plants - 270 (000 MTPY of N)
P_2O_5	- " -	Small Units 1.5 - 2 Larger Units 4.5 - 6	The Smallest Plants (see Ground Pb.R) Small Plants - 30 Larger Miniplants - 75	Small Plants - 45 (000 MTPY of P_2O_5) Larger Plants - 75 (" " " ") Very Large Plants - 165 (" " ")
(S)	- " -	Does not concern	The Smallest Plants - 20 (SA), 7 (S) Small Plants - 60 (SA), 21 (S) Larger Miniplants - 200 (SA), 70 (S)	Small Plants - 100 (SA), 35 (S) Larger Plants - 300 (SA), 105 (S) Large Plants - 500 (SA), 165 (S)
K_2O	- " -	Does not concern	Potash component is not limiting factor of plant capacity.	Potash component is not limiting factor of plant capacity, up to 100 (000 MTPY of K_2O) in the biggest plants.
NPK	Small plants 0,4 - 2 Moderate 4 - 8 Medium 10 - 40 Large 40 - 80 and over	Does not concern	Minifertilizer Plants producing straight fertilizer may be combined with larger Bulk-Blending or NPK Granulation Plants. Cacacity around 80 /000 MTPY of NPK/	NPK Compound Plants - the range of industrial capacities 80-250 (000 MTPY of NPK)
PRODUCT	Small plants 1 - 5 Moderate 10 - 20 Medium 25 - 100 Large 100 - 200 and over	Small Units 5 - 7 Larger Units 15 - 20	As above - Capacity around 200 (000 MTPY Product)	NPK Compound Plants - the range of industrial capacity 160 - 500 (000 MTPY Product)
REMARKS	Bulk-Blending Plants may be combined with NPK Granulation Plants with the range of capacities from 10-40. (000 MTPY of NPK)	Ground Phosphate Rock can be on hills uplands and slope fields, esp. when P_2O_5 component is in shortage (see Lesotho for ref.). Suitable for low quality Phosphate Rock.	The smallest Minifertilizer Plants may be installed for A, NA, AN production through water electrolysis process. Small Minifertilizer Plants may produce SSP, larger PA and TSP, MAP, DAP, NPK.	Apart from the alternative of producing NPK compounds, straight fertilizers from larger plants may as well be used in Bulk-Blending and NPK granulation plants.

All those operations that are not directly connected with the synthesis of NPK fertilizers, cannot be included in the class of fertilizer production processes, partial acidulation of phosphate rock (PAPR) process being on the border with that class.

These operations are also discussed in chapters 3 and 4 hereabove. However, as the exemplary one, Bulk-Blending process should be mentioned here, both because it gives good prospects for the development in some African countries and because it is very dynamically developing in some other countries in the world, as show the examples of the United States and Ireland quoted here.

The chemical compatibility of some common fertilizer materials used in bulk blends and schematic diagram of typical Blending & Bagging plant are shown in Figure 2.18 and Figure 2.19 below:

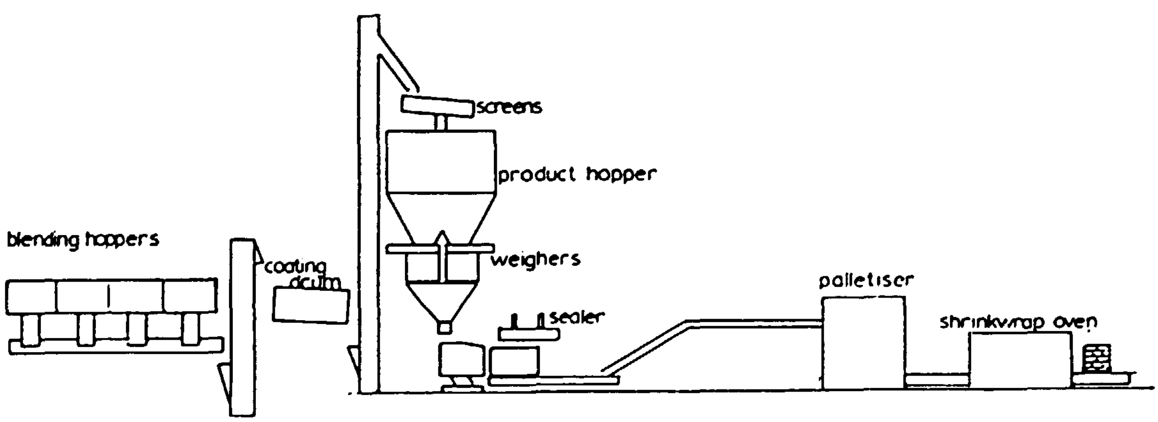
Figure 2.18



Chemical Compatibility of Blend Materials

Figure 2.19

Schematic Diagram of typical Blending & Bagging Plant.



The trend in the United States, shown in Figure 2.20 below, clearly confirms a very dynamic development of bulk-blending operations in the years 1960-1985. Both solid blends and liquid fertilizers have been enjoing ever increasing volume while granulated NPK fertilizers have been continuously declining. In the course of 1960-1985, the number of Bulk-Blending plants has increased from some 300 units up to over 5,000 units. At the same time the number of NPK granulation plants decreased from some 300 to below 100 plants.
The 5,000 Bulk-Blending plants have an average output of 2,500 tons per annum, and usually the distribution centre also sells other types of fertilizer such as straight solid and fluid fertilizers as well as other agricultural supplies (pesticides, seeds, animal feeds, implements, etc.). Typical Bulk-Blending plant operates his mixing system the equivalent of 10 days per year. Usually, all the blending is done during peak seasons.

Ireland is the best example of the development of Bulk-Blending operations in Europe. As shown in Figure 2.21, growth of fertilizer blending in Ireland was very dynamic in the last 15 years.
Most Bulk-Blending plants are located close to deep water ports and these plants (altogether 9 units) are strategically located so that all parts of the market are within easy reach of at least one of these plants.
Modern Irish Bulk-Blending plants are simple, yet sophisticated.
Typical output of a Bulk-Blending plant is 60 MTPH, with on stream time of over 90%.
Main features of Irish Bulk-Blending plants are presented in Figure 2.22 (see also Figure 2.19 for reference).

It is believed that these examples might be of some use when planning the development pattern of the fertilizer industry development in Africa, in particular in some sea-side located Sub-Saharan countries.

2.4.3.3 Secondary nutrients and micro nutrients

Sulphur, Calcium and Magnesium are commonly recognized as Secondary Nutrients.
Many parts of African soils are sulphur deficient, and therefore the usage of sulphur in Africa is relatively high in comparison to primary nutrients N,P, and K.
Sulphur is carried into soil with such fertilizers as: ammonium sulphate (AS), single superphosphate (SSP) and potassium sulphate (SOP). All of them are used in African agricultural practice.
Of a lesser importance are ammonium phosphate sulphate (APS) and ammonium sulphate nitrate (ASN).

Both calcium and magnesium are required in large quantities for efficient crop production. The conventional wisdom in the developed countries is that these nutrients can best be supplied as soil amendments by liming and at the same time adjusting the pH (i.e. acidity level) of the soil.

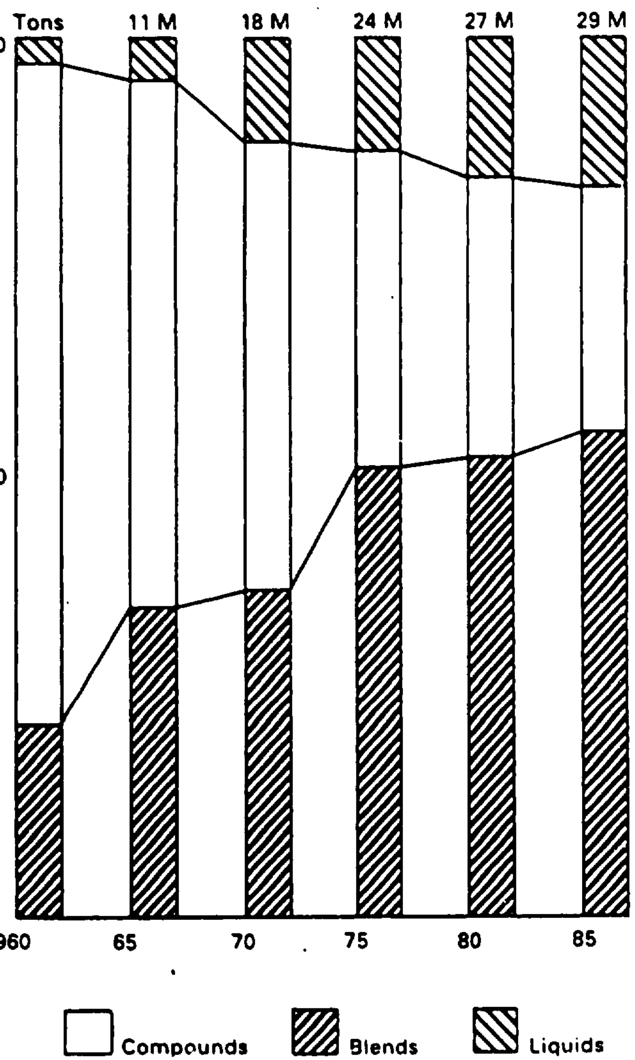


Figure 2.20

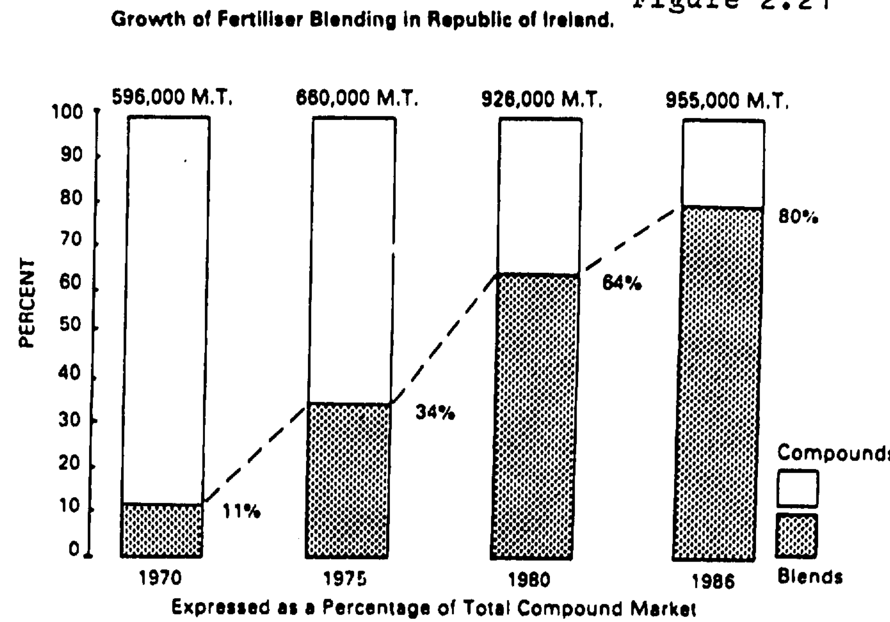


Figure 2.21

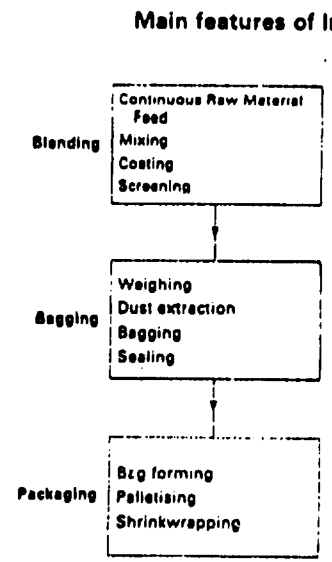


Figure 2.22

2.4.3.3 Secondary nutrients and micro nutrients

A. Secondary Nutrients

Sulphur, Calcium and Magnesium are commonly recognized as Secondary Nutrients.

The use of sulphur compounds as soil amendments to correct alkalinity or salinity in soils is commonly practiced in the world. Calcium sulphate (gypsum) is used for this purpose in areas where these conditions exist. Elemental sulphur also is used.

Application of pyrites for reclaiming alkaline soils has been reported to be successful in India. The yields of all crops grown, such as wheat, chickpea, mustard, Egyptian clover and rice, increased significantly with pyrites application.

Crop responses to sulphur depend on the supply of this element available from soil sulphur reserves, irrigation water, the atmosphere and precipitation. When these sources do not provide adequate amounts of sulphur, the use of fertilizers containing this element is essential to optimize crop yield and quality. Responses to sulphur may also be obtained in terms of improved crop quality, even when increases in dry matter yield are not obtained.

Many parts of African soils, to mention: Senegal, Ghana, Nigeria, Kenya, Uganda, Tanzania, Malawi, Zambia, are sulphur deficient, and therefore the usage of sulphur in Africa is relatively high in comparison to primary nutrients N,P, and K.
Sulphur is carried into soil with such fertilizers as: ammonium sulphate (AS), single superphosphate (SSP) and potassium sulphate (SOP). All of them are used in African agricultural practice.
Of a lesser importance are ammonium phosphate sulphate (APS) and ammonium sulphate nitrate (ASN).

Soil fertilization rate used in the world practice shows that N:S typical ratio is around 1.0 : 0.1. It is estimated that soil fertilization with sulphur-bearing materials is much higher in some regions of Africa, for instance double of that in Southern-Eastern Africa where N : S ratio can be estimated for as much as 1.0 : 0.2.

Taking this higher ratio into consideration, we can estimate that with nitrogen production in Africa around 1.9 mln MTPY of N in 1987, current demand for sulphur to be introduced into African soils is about: 1.6 x 0.2 = 0.32 mln MTPY of S, say 0.3 mln MTPY of S.
The future demand for sulphur to be introduced into soil by 2000 is around: 3.5 mln MTPY of N x 0.2 = approx. 0.7 mln MTPY of S.

The question of sulphur ratio to other nutrients, and the research on sulphur deficiency in the soils throughout the whole continent of Africa should be deeply looked into, all the more that Africa has virtually no sulphur deposits and the question how much sulphur should be imported is of considerable economic importance.

It should be stressed here that S balance and S sources play the key role in economic considerations of the choice of fertilizer process routes, and as already mentioned, there are two sulphur-free processes to be used in phosphate fertilizer industry in which, instead of sulphuric acid being used, hydrochloric acid or nitric acid can be used as the phosphate rock attacking agents in order to dissolve phosphate component.

The third, highly energy consuming but possible, option of phosphoric acid manufacturing by thermal method (from phosphate rock directly to phosphorus in electric furnace and then to clean phosphoric acid) has not been analyzed in this study.

On the sulphur input side, four main S sources can be recognized: brimstone; pyrites; smelting S-bearing off-gases; and sulphur from desulphurization of hydrocarbons: crude oil, natural gas and coal.

Unfortunately, sulphur recovery ratio from smelting off-gases is only moderate in Africa (with Zambia leading here), while desulphurization of hydrocarbons practically does not exist in 43 analyzed countries (Egypt being the only exception), hence Africa, with its limited pyrites deposits, is heavily dependent on sulphur importation.

There are two outlets on the sulphur output side: sulphur applied into the soil and sulphur lost with phosphogypsum, and it is, unfortunately, that latter that dominates in the sulphur balance in Africa.
In 1987, Africa produced 3.8 mln MTPY of P205 phosphoric acid and, when appropriate consumption coefficients to sulphuric acid and sulphur are applied, one can see that as much as: 3.8 x 2.7 x 0.35 = 3.6 mln MTPY of sulphur was lost with phosphogypsum (being stockpiled or dumped into sea).
This is twelvefold higher than sulphur introduced into soil which was approximated for around 0.3 mln MTPY in 1987.
These two sulphur outlets sum up for around 3.9 mln MTPY of S and are more or less equal to sulphur imports to Africa reported for 3.9 mln MTPY in 1987.
Own sulphur production in Africa in 1987, around 1.1 mln MTPY, directed to production of fertilizers and to all non-fertilizer uses had to cover all the other losses, in particular those connected with the pollution of sulphur to the atmosphere.

Both calcium and magnesium are required in large quantities for efficient crop production. The conventional wisdom in the developed countries is that these nutrients can best be supplied as soil amendments by liming and at the same time adjusting the pH (i.e. acidity level) of the soil.

Calcium and, to a lesser extent, magnesium are present in many fertilizers,to mention only calcium ammonium nitrate (CAN) widely used in Africa, however, Ca and Mg compounds are often applied separately to counteract the acidity of soils. The application of calcium and magnesium compounds to many soils results in striking increases in plant growth beyond that expected from a simple response to the deficient nutrient element.
Application of Ca and Mg compounds benefits in improved phosphate availability, nitrogen fixation, nitrification process and micronutrients uptake by the plants.

The most commonly materials used for liming soils are:

- Ground limestone or chalk (CaCO3);

- Burnt lime also called quick lime (CaO);

- Hydrated or slaked lime [$Ca(OH)_2$];

- Waste limes from sugar-beet factories, soda ash industry and others;

- Magnesium or dolomitic limestone. This limestone consists of $MgCO_3$ and $CaCO_3$ and is commonly used as a liming material in areas where it is found. Magnesium carbonate has better utilization value than calcium carbonate. In addition, the magnesium may prevent magnesium deficiency diseases in crops.

The cost of liming is largely dependent on the transport costs from the lime works to the farm. Most widely is used ground limestone or chalk obtained by quarrying the limestone or chalk rock and grinding it to a fine powder which is subsequently spread mechanically onto the soil. The finer a liming material is ground, the more quickly it becomes effective.

When ammonium nitrate-limestone, known as calcium ammonium nitrate, is used, as much as 10-22% CaO and 0-7% MgO (depending on the limestone/dolomite quality) is applied together with 21-26% of nitrogen contained in CAN.

Potassium magnesium sulphate (langbeinite) is more and more frequently used as a carier of potassium (21% of K_2O), sulphur (22% of S) and magnesium (19% MgO).
Magnesium is essential for crop growth as it is the central ion in the chlorophyll molecule and a key component for many major biosynthetic pathways.

Magnesium demand by crops is very differentiated, therefore only some examples of the highest magnesium removal by some crops are presented below:

CROP	YIELD t/ha	MAGNESIUM REMOVAL kg MgO/ha
Sugar cane	100	83
Sugar beet	40	90
Banana	30	136
Pinapple	30	90
Tropical grasses	30	105
Oil palm	25	102

Demonstrations on the production of many plants show that the agronomic effects of potassium magnesium sulphate used as a fertilizer are superior to what might be expected on the basis of the properties of its component parts.

Fused calcium magnesium phosphate (20% P_2O_5; 32% CaO; 18% MgO) and basic slag (15-20% P_2O_5; 42-50% CaO; 2-8% MgO) can also be used as fertilizer materials containing secondary nutrients: calcium and magnesium.

B. Micronutrients

The micronutrient elements: zinc, molybdenum, iron, manganese, copper, cobalt and boron, are just as essential to plant growth as are the primary and secondary nutrients.
As crop yields are pushed upwards by more adequate fertilization with NPK fertilizers, the need for one or more of these micronutrients often becomes the limiting factor

Generelly, the micronutrients are combined with fertilizers and added to the soil. Microelements may be mixed with the fertilizer or incorporated into fertilizers during their manufacture.

The amounts of micronutrients applied depend upon soil conditions and the crop to be fertilized. Typical application rates recommended for correction of deficiencies are tabulated below:

Micronutrient	Micronutrient Applied kg/ha
Zinc	5 - 11
Molybdenum	0.01 - 0.07
Iron	3 - 11
Manganese	5 - 22
Copper	5 - 22
Boron	0.1 - 1.1

Apart from boron, African continent is well endowed with the natural resources that can be used for the production of carriers of microelements. Mining and metallurgical industries in Africa are the main sources of inorganic sources of microelements. Since the production scale involved is small, the inorganic carriers of micronutrients can (instead of being produced from pure metals) in many cases be produced from by-products and waste streams, metallic scraps and dusts collected from environment protecting facilities in the above mentioned industries.

The most important carriers of micronutrients are presented in Enclosure No. 2 at the end of this chapter.

2.5.2. The Potential for Co-operation between African Countries in the Fertilizer Industry.

It is impossible for each of the African countries to produce all the fertilizers in order to cover the demand of a domestic market which, in most cases, is too small to justify the investment into fertilizer plants or complexes of full industrial capacities.

As continuous importation of ready-made fertilizers from the international markets cannot be accepted by African countries, in particular by Sub-Saharan countries, and especially land-locked ones, the only reasonable solution that emerges is co-operation in the fertilizer industry and in trade with fertilizers (and fertilizer related raw materials) in between African countries.

According to the Lagos Plan of Action for the economic development of Africa 1980-2000, African countries have decided to co-operate, among others, in the:

- preparation of sub-regional and regional plans for the creation of major industrial complexes whose cost and production capacity would exceed national financial and absorptive capacities;

- creation of multinational regional or sub-regional institutions to make an inventory of and exploit shared natural resources;

- establishment of multi-national industries in Africa, among others in such basic areas as chemicals, characterized by high investment costs.

Also, such measures at national, sub-regional and regional levels were underlined as: facilitation of fuller utilisation of excess industrial productive capacity in Africa; utilization of existing training infrastructures; exchange of information among African countries on technical and financial specifications and costs related to contracts on implementation of industrial projects with developed countries.

All these co-operation measures are directly related to the fertilizer industry in Africa.

Fertilizer industry, as an input sub-system to agricultural sector and at the same time belonging to the group of basic industries (both of them were given priority in the Lagos Plan of Action) is therefore of the strategic importance to the industrial and economic development in Africa.
The development of the fertilizer industry in Africa is also strictly connected with the development of the two other LPA priority sectors: energy and transport, which can be considered the frame on which to build the fertilizer industry, operate fertilizer industrial facilities and handle both raw materials and fertilizer products.

The potential for regional co-operation between African countries in the fertilizer industry is considerable, to put it into life, however, may not be so easy, as it would involve the planning, coordination and realization of investment in the fertilizer industry on the regional level. Financial contribution in the investment projects and the responsibility of the repayment of credits taken for the fertilizer plant or complex in question, seem to be the most important obstacles in the realization of this target. In order to obtain workable system of multilateral co-operation in the fertilizer industry between the African countries, several important and concrete decisions would have to be taken, regarding industrial, investment, transport, regional supply/demand fertilizer balances, trade, pricing and financial policies.

Some characteristic examples of the potential cooperation between African countries are given below:

a. North Africa - Egypt, Algeria and in particular Libya, producers of nitrogen fertilizers that have surplus of both hydrocarbons and ammonia, might enter into much closer co-operation with Tunisia and Morocco, trading ammonia in exchange for phosphoric acid.

   Having great export potential in crude oil, natural gas, ammonia, phosphate rock, phosphoric acid, and hence in complex NP fertilizers, all the five North African countries, with the flexibility in countertrading at the international market sulphur and potash for their raw materials, intermediaries and ready made fertilizers, could become not only totally self-sufficient in the sub-regional fertilizer demand but could even further strenghten their export potential from down-stream fertilizer units which, thanks to exchange of industrial experience, investment joint-ventures and exchange of ammonia for phosphoric acid, could be operated with even higher capacity utilization rate.

b. Sub-Saharan Africa - Nigeria, Senegal, Zimbabwe and possibly Tanzania and Zambia are probably the best suited to work-out the overall integrative programme of co-operation in the fertilizer industry in the Sub-Saharan Africa.

The issues connected with the transport and distribution of fertilizer raw materials, intermediaries and fertilizer products both in bulk and bagged, logistics and other problems related to the transportation, handling, storing, blending and granulating fertilizers are felt to be the most urgent ones.

The compatibility of the NPK demand 2000 in each of the Sub-Saharan countries, either to fertilizer synthesis (in large-scale capacity plants or minifertilizer plants) or to other operations, such as bulk-blending, compound granulation, phosphate rock grinding or phosphate rock partial acidulation plants, should be compared and analyzed at the level of Sub-Saharan region.

The existing technological options for the use of low-grade phosphate deposits, prevalent in many African countries, should be scrutinized and the findings made available to the countries concerned. The potential of the direct application of ground phosphate rock as a fertilizer to specific soil-crop systems should be examined.

Concrete steps should be undertaken, in a context of international co-operation and with active UNIDO participation, towards the encouragement of the realization of viable and appropriate minifertilizer plants, in order to optimize the use of locally available resources, both mineral and organic.

The promotion of regional trade in fertilizer raw materials, intermediaries and final products should be given special attention in sub-regional fertilizer co-operation programmes.

c. Africa - Because of almost total dependency of Africa on imports of sulphur and potash, the following seem to be the most justified programmes of co-operation at the regional basis:

- Exchange of information, and thorough survey of the techno-economic viability of the establishment of desulphurization units extracting sulphur from crude oil, natural gas, petrochemical gases, coal, smeltering S-off-gases from copper/zinc/nickel plants and others. Egypt, Algeria, Libya, Nigeria, Zambia might take the lead.

- Investigation and appraisal of the most promising and economically effective sources of potash in Africa, including the potential exploration of potash ores and brines in Ethiopia, Tunisia, Congo and Botswana, with these very countries taking the lead in the above mentioned estimations.

- Thorough survey and formulation of regional programme on secondary nutrients and micronutrients. Related raw materials, technologies best available for extraction, processing and application of secondary elements (S, Ca, Mg) and microelements (Zn, Mo, Fe, Mn, Cu, Co, B) should be analyzed.

d. Nigeria - Senegal - Closer relations in between these two countries, as far as countertrade in ammonia for phosphoric acid is concerned, seem to be reasonable.

e. Senegal - Togo - Senegal's experience in the investment in phosphate fertilizer complex, including phosphoric acid plant, might be of great use for Togo planing to develop similar facilities in the future.

f. Mozambique - Zimbabwe - There is a possibility to pipeline Mozambican high quality and sulphur free natural gas to Zimbabwe in order to establish an ammonia plant there. Ammonia and possibly finished fertilizer might be sent back from Zimbabwe to Mozambique. Zimbabwe might help in revitalization of the deteriorated Mozambican fertilizer facilities.

g. Tanzania, Malawi, Kenya, Ethiópia, Sudan (possibly with Somalia, Uganda, Rwanda, Burundi) with the NPK demand 2000 around 850,000 MTPY, should jointly look for the possibilities of investment co-operation in the development of the sub-regional fertilizer industry.

h. Tunisia, with its experience in the production of NPK fertilizers, could take a lead, possibly with Egypt and Zimbabwe, in the preparation of fertilizer training programmes for technical staff and management needed in the supervision of both investment and exploitation of fertilizer plants and complexes to be built in future in other African countries.

Apart from the above mentioned examples of regional and sub-regional co-operation in the fertilizer industry between African countries, the necessity of strenghtening co-operation with international agencies should be underlined here, as there is a lot of other urgent issues related to the fertilizer industry that can best be solved in Africa through complex international co-operation.
There is no need to mention that UNIDO should take a lead in all those industrial and development programmes in which co-operation sought by African countries in the fertilizer industry is evident and may bring concrete results in the increase of fertilizer self-sufficiency in Africa.

2.5.3. The Role of Transnational Corporations in this Industry in Africa

There is over 500 qualified international contractors involved in the studies, appraisals, design, construction and commissioning of the fetrtilizer plants and complexes all over the world.

These contractors can deliver over 50 main fertilizer processes, not counting very many available sub-processes and alternative technological options.

As the international market for investment is tight, there is strong competition among the contractors to enter investment markets in the fertilizer industry.
Therefore, the bidding process involves sometimes participation of several qualified contractors which, in order to win the contract, organize themselves into specialized consortia, stronger and more flexible investors both in technical and financial matters. Typical consotrium incldues: Managing Contractor, Licensor, Engineering Company and Construction Company.
The strongest international concerns and corporations are able to deliver all services needed, beginning with licence and basic engineering package, through construction of a complex, up to the commisioning of the plants, and technical assistance in the first months of the operation of new fertilizer facilities. At the same time they are frequently able to offer credits and attractive financial conditions related to the newly planned investment.

The following is the indicative list of the major fertilizer processes and international contractors, being directly involved in the last yeras in investment projects or studies related to the fertilizer industry in African countries:

AMMONIA:

a. MW Kellogg/Technip/Creusot Loire - Algeria
b. ICI/Uhde/Mannesman - Egypt
c. Davy/H.Topsoe/Uhde - Libya
d. MW Kellogg/Kawasaki/Heavy Industries - Nigeria
e. CdF Chemie/Technip/Technipetrol - Egypt
f. Texaco/Topsoe/Technipetrol - Somalia
g. N-Ren/Voest Alpine - Sudan
h. Topsoe/N-Ren - Madagascar
i. Topsoe/Technipetrol - Egypt
j. Davy (management) - Libya
k. Topsoe/Agrico - Tanzania
l. Fluor (study) - Mozambique
m. Krupp Koppers/Klockner/Kobe Steel - Zambia
n. Norsk Hydro - Zimbabwe

UREA:

a. Stamicarbon/Kellogg - Nigeria
b. Stamicarbon/Uhde - Libya
c. UTI/N-Ren - Madagascar
d. UTI/Scientific Design/N-Ren - Sudan
e. Snamprogetti/Technipetrol - Somalia
f. Snamprogetti/Agrico - Tanzania
g. Kellogg/Creusot Loire - Algeria
h. Stamicarbon/Uhde/Manesmann - Egypt
i. Stamicarbon/Foster Wheeler - Libya
j. Scientific Design (study) - Nigeria

NITRIC ACID/AMMONIUM NITRATE/CALCIUM AMMONIUM NITRATE:

a. Grande Paroise/Kaltenbach/Creusot Loire - Tunisia
b. Stamicarbon/Scientific Design/Uhde - Egypt
c. Davy (study) - Libya
d. Grande Paroise/Klockner/Uhde - Zambia
e. Espindesa/Technicas Reunidas - Egypt
f. Grande Paroise/Creusot Loire - Egypt
g. British Sulphur Corp. (study) - Egypt
h. Cremer & Warner (study) - Malawi
i. Stamicarbon - Kenya

SULPHURIC ACID/AMMONIUM SULPHATE:

a. Struthers Wells/Foster Wheeler - Libya
b. CdF Chemie/Technip - Morocco
c. Polimex-Cekop - Algeria
d. Standard Messo/Klockner - Tanzania
e. Hitachi - Tunisia
f. Monsanto/Environchem/Heurtey - Tunisia
g. Monsanto/Environchem/Heurtey - Morocco
h. PCUK/Krebs - Senegal
i. Monsanto/Mitsui Eng. - Morocco
j. Lurgi/Foster Wheeler - Libya
k. Klockner/Uhde - Zambia
l. Simon Carves - Zimbabwe
m. Chemadex - Ethiopia

PHOSPHORIC ACID/TSP/MAP/DAP:

a. CdF Chemie/Technip - Morocco
b. Rhone Poulenc/Heurtey - Algeria
c. Technip/Cresout Loire - Algeria
d. Norsk Hydro/Lurgi/Babckock - Egypt
e. Bradley/GEC - Egypt
f. CdF Chemie/Krebs - Egypt
g. Rhone Poulenc - Morocco
h. AZF/Technip/Creusot Loire - Morocco
i. Jacobs/Kellogg - Nigeria
j. Jacobs/EMC - Senegal
k. Cros/Incro - Tunisia
l. Spie Batignolles - Tunisia
m. Jacobs/Zellar/Williams - Tunisia
n. Nissan/Marubeni/Hitachi - Algeria
o. Gulf Design/Badger - Morocco
p. Fisons/Norsk Hydro - Nigeria
q. Chem Systems - Togo

NPK PROCESSES AND PLANTS:

a. Norsk Hydro/Foster Wheeler/Davy - Libya
b. Jacobs/Kellogg/Kawasaki Heavy Industries - Nigeria
c. Heurtey - Senegal
d. Gardinier - Cote D'Ivoire
e. Chem Systems - Togo
f. Fisons/Norsk Hydro - Nigeria
g. Cros/Incro - Tunisia
h. Coppee Lavalin - Tunisia
i. Klockner/Uhde - Zambia

MURIATE/SULPHATE OF POTASH:

a. Entreprise Miniere et Chimique (EMC)/MPDA - Congo
b. Ethiopian/Indian Governments/EMC - Ethiopia
c. Spie Batignolles/Mines de Potasse d'Alsace (MPDA) - Tunisia
d. Unknown licensor and contractor - Botswana

It is obvious that, with hard competition on the African investment market in the fertilizer industry, there is only limited chance for the complex, mutual co-operation between African investors and the group of most active international licensors and contractors in the transfer of know-how, technology, industrial experience and knowledge in the preparation feasibility studies, pre-contracting and contracting.

It would, however, be of great importance for African countries to organize, with active UNIDO support, a general conference with the licensors, engineering offices and contractors involved in studies, development programmes, modernization, rehabilitation, intensification, revamping and new investment projects in the fertilizer industry in Africa in the last years, in order to prepare a thorough survey of past activities, point out for evident successes and difficulties encountered both in the investment process and in the exploitation, so as to derive conlusions for the future.

Such a survey, illustrated with exemplary case studies, would for sure indicate the most critical issues regarding the co-operation between African countries and international contractors, and, on the other hand, would constitute a frame on which international contractors could build their future follow-up investment programmes in the fertilizer industry in Africa.

The continuous contact between licensor/contractor and African investor in the fertilizer industry (beginning with the planning stage and ending with the achievement of full economic revenues from the project), is one of the principal conditions for fertilizer plants to operate smoothly and efficiently.

A relatively high degree of deterioration of the already built fertilizer plants and complexes in Africa, very many of them being irreversibly shut-down, low degree of utilization of nominal capacities, poor on-stream coefficients, evident failures in start-ups in some new plants and fertilizer complexes, obsolete processes used in many fertilizer plants, are the evidence of too weak a contact in between African investors and international licensors/contractors.

Two more issues related to the role of transnational corporations in the fertilizer industry in Africa need to be underlined:

- the responsibility of the international contractor for the complex planning of the investment in the fertilizer industry in Africa should be considerably increased. In majority of cases, contractor is responsible only for "battery limits" investment, sometimes with technological off-sites, while the overall responsibility for the whole infrastructure, continuous deliveries of raw materials, energy and other supplies is located on the investor's shoulders. In many cases, such a model does not function at all, since - even for modern fertilizer plants - major inputs may not be available from outside "battery limits" of the plant and in the process the whole project cannot function. Therefore only those contracts should be negotiated in which the availability of all the necessary inputs is confirmed also by the contractor.

- there are many cases in which the contractor should give a guarantee to the investor regarding the sale of the final fertilizer product on the international market, so that the new installed facilities were not idle after successful start-up. Long-term agreement on product buyback or compensation agreement signed between African investor and international contractor gives much better prospects for future high capacity utilization, in particular in the export oriented fertilizer plant/complex.

2.5 Prospects for Growth of the Fertilizer Industry in Africa by the year 2000.

As described in section 2.2.7 above, the NPK gap 2000 in fertilizers, illustrating the difference between NPK demand 2000 and NPK production 1986 in 43 analyzed countries, is equal to around: 6.2 - 2.7 = 3.5 mln MTPY of NPK.

To answer the question, what are the possibilities of covering this gap through fertilizer production increase in Africa, the above mentioned gap should be examined in more detail. In particular, five North-African countries should be isolated, in order to expose the real NPK gaps 2000 for North Africa and Sub-Saharan Africa.

As there was surplus in NPK production 1986 over NPK demand 2000 in Tunisia and Libya, amounting to: 658,000 + 66,000 = 724,000 MTPY of NPK, therefore two alternative cases of the NPK gap 2000 should be analyzed for North Africa: Case A - without surplus, Case B - with surplus, this being of significant importance for the overall NPK gap analysis, as follows:

	NPK GAP 2000 CASE A	NPK GAP 2000 CASE B
NORTH AFRICA	1,368 000 MTPY	644 000 MTPY
SUB-SAHARAN AFRICA	2,831 000 MTPY	2,831 000 MTPY
43 AFRICAN COUNTRIES	4,199 000 MTPY	3,475 000 MTPY

When analyzing the NPK gap 2000 (approximated in case A to 4.2 mln MTPY and in case B to 3.5 mln MTPY of NPK) in terms of a new fertilizer capacity increase, realistic ratio of capacity utilization should be assumed. For the majority of African countries the capacity utilization ratio over 70% is an ambitious target.
Applying this ratio, we can estimate the approximate NPK CAPACITY GAP by the year 2000, as follows:

	NPK CAPACITY GAP (A)	NPK CAPACITY GAP (B)
NORTH AFRICA	2 mln MTPY	1 mln MTPY
SUB-SAHARAN AFRICA	4 mln MTPY	4 mln MTPY
43 AFRICAN COUNTRIES	6 mln MTPY	5 mln MTPY

When active sub-regional co-operation in ammonia and phosphoric acid trade between North African countries is assumed, Case B is more adequate for the future growth of fertilizer production, and therefore this more optimistic case has been adopted in this study.

Staying with the Case B, in which the calculated overall capacity gap 2000 is 3.5/0.7 = 5 mln MTPY of NPK, we must notice that 80% of this gap (i.e. 4 mln MTPY of NPK) is located in Sub-Saharan Africa.

In Sub-Saharan Africa, the NPK gap 2000, hence capacity gap, is concentrated almost in 92% in the following 15 countries: Nigeria, Zimbabwe, Sudan, Kenya, Zambia, Tanzania, Cameroon, Ethiopia, Malawi, Cote D'Ivoire, Senegal, Ghana, Mozambique, Mauritius and Madagascar (see Table 6 for reference).

In North Africa, the NPK gap 2000, hence capacity gap, is connected practically with two countries: Egypt and Algeria, the remaining three countries: Libya, Tunisia and Morocco being self-sufficient, and dependent only on imports of potash.

Therefore, the prospects for growth of the fertilizer industry in Africa by 2000 should be analyzed in three groups of countries:

I. Three North African countries giving prospects for attaining or even increasing NPK surplus by 2000 and strenghten their position as fertilizer exportes: Libya, Tunisia, Morocco.

II. Two North African countries: Egypt and Algeria that must fight for their self-sufficiency in fertilizers to eliminate substantial NPK gap estimated for over 1.2 mln MTPY of NPK.

III. The Sub-Saharan countries that will have to realize import substitution strategy in order to decrease the NPK gap 2000 estimated for around 2.8 mln MTPY of NPK.

Country Group I.

Tunisia, Libya, Morocco in North Africa the best prospects for the export oriented fertilizer industry in Africa.

Libya is already strong producer and exporter of ammonia and urea and, with its potential in natural gas deposits and industrial experience gained at the operation of nitrogen fertilizer complex at Marsa-el-Brega, even with the explosion at the ammonia plant that damaged some equipment, Libya has generally good prospects for further development of the production of nitrogen fertilizers for export.
Uhde of West Germany will rebuilt the damaged ammonia plant and at the same time will revamp one of the two urea units.
The reconstruction was expected to be completed in the middle of 1989.
The most important capacity increase is, however, expected from the new nitrogen fertilizer complex at Sirte that includes two ammonia plants of the total capacity 750,000 MTPY of N, together with the down-stream urea plant, sulphuric acid plant, ammonium sulphate plant and two NPK units.
Davy Mc Kee, the managing contractor, co-operating with four other contractors and Libyan Government, is examining ideas to revive this project, abandoned some years ago due to lack of finance.

Morocco and Tunisia are already strong producers and exporters of phosphate rock. Expected positive supply-demand balance in phosphate rock, estimated for Africa in 1992/1993 at around 14 mln MTPY of P205, ought to be connected with these countries, mostly with Morocco.

Morocco and Tunisia are major exporters of phosphoric acid in Africa and, thanks to these countries, in particular Morocco, supply-demand balance in Africa in 1992/1993 is estimated at plus 3.6 mln MTPY of P205.

Tunisia and Morocco are also important exporters of phosphate (TSP, MAP/DAP) fertilizers.

Tunisia, with already developed NP fertilizer industry, is looking for further production diversification into potash. Foreign investment is being sought to finance the construction of a plant to extract potassium sulphate from brine deposits near Zarzis in the south of the country. The project can provide a valuable means to diversify and increase export earnings.
The future development of the phosphate and potassium industries will be necessary to enable the country to make up for falling oil exports.
Tunisia's long experience in phosphate production has given it expertise in plant and process design, which it has been able to sell to other developing countries in joint-venture projects. Joint-ventures (already established or planned with China, Algeria, Turkey and Kuwait) may provide the key to ensure Tunisia's future development of the phosphate industry and provide the country with markets abroad.

Morocco, which has the advantage of larger scale production and a higher quality raw material base, competes with Tunisia in international phosphate markets.
Morocco has announced that the production facilities in a huge

fertilizer complex at Jorf Lasfar will be duplicated and brought on stream alongside the existing plants by the early 1990s. A site has been put aside for this purpose and the infrastructure at Jorf Lasfar has been installed in such a way that a doubling of production capacity can be accommodated with relatively little additional investment. In view of the experience gained in building the first phase of Jorf Lasfar, the new project may be brought on stream in three to four years.

Country Group II.

In Egypt, 380,000 MTPY of N ammonia capacity increase is planned for 1990 in Abu Quir and in Suez. Additionally another ammonia plant in Abu Quir is revamped up to the capacity 272,000 MTPY of N. Again another ammonia plant at Suez of the capacity 100,000 MTPY of N is planned for replacement. The majority of this ammonia capacity increase will be directed towards down-stream ammonium nitrate (AN) plants.
Abu Zaabal phosphate fertilizer complex with sulphuric acid (SA), phosphoric acid (PA) plant and two TSP units added more capacity since 1986, around 200.000 MTPY of P2O5.

Thus, Egypt with its NPK gap 2000, estimated for around 0.8 mln MTPY of NPK, will have covered around 75% of this gap at the beginning of 1990s.
With its great fertilizer industrial potential, Egypt will have to spent, however, a lot of capital not only to fill the NPK gap 2000, but first of all in order to modernize, revamp and replace some of its already obsolete processes and over-exploited fertilizer plants.

Algeria, with its NPK gap 2000, estimated for 470,000 MTPY for the conditions of 1986, has already made a substantial move since that time as it put on stream new ammonia plant in Annaba of the capacity 272,000 MTPY of N.
Plans for the phosphoric acid and TSP capacity increase in Tebessa aim at additional capacity of 130,000 MTPY of P2O5. Having realized this project, Algeria would achieve additional NP capacity around 400.000 MTPY which may substantially cover the estimated NPK gap 2000.

Thus, both Egypt and Algeria are considered to have good prospects for growth of their fertilizer industry by the year 2000 and for substantial decrease of the NPK gap 2000. It is estimated, however, that it will be difficult for these countries to cover totally their fertilizer demand 2000 by their own production, all the more that they are dependent on imports of potash.

Country Group III.

Apart from some exceptions, the situation development in fertilizer self-sufficiency in Sub-Saharan Africa looks very gloomy.

Figure 2. 23, enclosed below for reference, illustrates plainly the gap between total fertilizer consumption and production in Sub-Saharan Africa in the past 17 years.
As can be seen from this graph, only in the middle of 1970s Sub-Saharan countries were able to keep pace in production with growing fertilizer consumption level. In 1980s the NPK gap widened substantially to as much as 1 mln MTPY of NPK in 1986.

Thus, without substantial increase in production of fertilizers in Sub-Saharan Africa, the NPK gap 2000 between fertilizer demand and fertilizer production as of 1986 would widen to as much as 2.8 mln MTPY of NPK, equivalent of around 4 mln MTPY of additional NPK capacity.

Nigeria, with the NPK gap 2000 estimated for 840,000 MTPY of NPK as of 1986, has already made a substantial progress towards fertilizer self-sufficiency putting on stream its new fertilizer complex at Onne of the nominal ammonia capacity of 272,000 MTPY of N.
Having built down-stream urea, DAP and NPK plants, Nigeria is, however, still dependent on imports of phosphoric acid and potash. Phosphate and potash components are not derived from own units and therefore they cannot be fully included in the capacity increase.

Nigeria studies the possibility of constructing an another ammonia/urea complex of the capacity 272,000 MTPY of N.
It is estimated, that with already gained experience in investment and exploitation at Onne, Nigeria (having foreign exchange revenues from exports of oil) will manage to built this complex by 2000.

Other large-scale export oriented ammonia/urea complexes, studied in Tanzania, Mozambique and Angola are estimated to have very little prospects to get-off the ground soon, as they cannot be competitive with urea cost at the international markets, even with very cheap, locally available natural gas. Investment location factor around 1.5 in comparison to locations in Arab Gulf or in Europe and the risk of the low capacity utilization will probably not attract foreign capital, this being principal condition to invest into export-oriented projects.

Much more realistic scenario in the development of nitrogen fertilizer industry in the Sub-Saharan Africa is connected with fertilizer import substitution. This strategy involves, however, on the one hand much higher diversification of ammonia processing into down-stream products suitable for local soils and crops (not only urea, but AS, AN, CAN, MAP/DAP, NP, NPK as well), and on the other hand the necessity of the sub-regional co-operation among Sub-Saharan countries, in which the planning of optimum size and locations for the new nitrogen fertilizer facilities should be one of the most important issues.

In this strategy, there might be a room for at least one nitrogen fertilizer complex in West Africa (Cote D'Ivoire), East Africa (Tanzania) and South Africa (Zimbabwe).

These nitrogen complexes, together with already discussed Nigerian potential in nitrogen fertilizer industry, and with small-scale ammonia-urea complexes in Sudan, Somalia and Madagascar that still are not operational and probably must be rehabilitated, would only create a frame for Sub-Saharan Africa to get out from almost total dependency in fertilizer importation and to get closer to self-sufficiency in fertilizers by 2000.

The possibility of investing into small scale ammonia plants based on very cheap electricity cannot then be excluded, as it still might be the source of the cheapest ammonia in some locations in Africa.
Pipelining of natural gas to land-locked countries may aslo prove to be a better option than coal gasification to ammonia planned in Zimbabwe. This process is being used in Zambia at Kafue where nitrogen fertilizer complex is being currently revamped.

As ammonia and nitrogen fertilizer plants are characterized by relatively higher specific investment cost than phosphate and potash fertilizer plants, being at the same time more sophisticated, hence more difficult to operate at high capacity utilization rate, therefore the gap in nitrogen fertilizers by the year 2000 is the most critical issue for Sub-Saharan Africa.

Senegal, with its relatively new phosphate fertilizer complex at Taiba-M'Bao, based on own phosphate rock and imported ammonia and sulphur, has still good prospects for achieving self-sufficiency in fertilizer balance, provided that the phosphoric acid plant will utilize its nominal capacity 264,000 MTPY of P205. Senegal is an exporter of phosphoric acid at a moderate scale but, since the international markets are limited, there are no foreign exchange revenues to supply sulphur, ammonia and spare parts for the complex equipped with down-stream units: TSP and DAP that might deliver much more fertilizers for the domestic and export markets.

Togo is important exporter of high quality phosphate rock. Togolese phosphate has very favourable characteristics, and its use for the production of phosphoric acid in a phosphate fertilizer complex with down-stream units would have considerable advantages. The modern phosphate complex, planned at Kpeme with the capacities (PA - 165,000 MTPY of P205 with down-stream plants TSP, DAP/NPK) far exceeding the demand of such a small country as Togo, can, therefore, be only built on the basis of sub-regional co-operation.

Although the future prospects for Togolese project to get-off the ground are promising, yet not so good Senegal's experience that had to fight to sale its phosphoric acid at international markets, though there are markets close-by in West Africa, will for sure not be ecouraging the Togolese Government to invest into this complex at the present time. It is estimated that this project will be much more realistic in the middle of 1990s.

Small increases in phosphate production balance may also be expected from:

- the modernization of phosphate fertilizer complex at Tanga, Tanzania;

- the development of small-scale capacities in Uganda and Burundi, processing local phosphate rock into SSP;

- the intensification of phosphate rock processing in Niger, Mali and Burkina Faso through partial acidulation process (PAPR);

- the usage of ground phosphate rock elswhere in Sub-Saharan Africa.

Congo, has potentially very good prospects for the revitalization of once flooded potash mine. However, detailed techno-economic analysis of the project viability must precede the final decisions. Export markets for potash in Africa is substantial, to mention Nigeria, Cameroon, Cote D'Ivoire, Senegal, however the economic analysis and marketing study is needed in order to compare landed cost of Congolese potash in West Africa and elswhere with potash delivered from Europe, Canada and Jordan.
Congo had produced some 280,000 MTPY of K20 before the mine was flooded in 1977. This is equal to 40% of the total potash demand in Africa, estimated for 700.000 MTPY of K20, therefore the project should be promoted on the regional, or at least sub-regional basis.

Ethiopia and Botswana are also studying posibilities of potash extraction and processing to potash fertilizers, these two projects, however, seem to be less advanced than those in Congo and Tunisia.

One of the most interesting trends, that can be observed also in Africa is diversification to those products that to the fullest extent cover shortage of nutrients in the soil. Probably the best example here would be the family of potash fertilizers. Muriate of potash (KCl) is the cheapest source of potassium, it contains, however, chloride ion that is harmful for some crops and soils. Therefore sulphate of potash is more and more frequenly used, as it carries also valuable sulphate ion. This trend confirms not only the value of SOP as a fertilizer itself. It also indicates the way for Africa to escape from the total dependency in imports of potash and sulphur.
This trend once again underlines the necessity of undertaking investment programmes in sulphur recovery in Africa in order to lessen dpendence of this continent from sulphur imports.

Slow trend in the production of nitrophosphates (manufactured according to a sulphur free route, using nitric acid or hydrochloric acid as an agent dissolving phosphate component) can be observed in Africa, as Algerian example shows.

Application of KMgS fertilizers, i.e. langbeinite indicates again for the growing importance of secondary nutrients.
In this case, potash, which is limiting primary nutrient, is combined together with two secondary nutrients: sulphur and magnesium.

Introduction of different organic fertilizers in some African countries (Madagascar, Burundi) or PAPR process (Niger, Mali, Burkina Faso) indicates for the efforts in Africa to escape from the high dependency on imported fertilizers, using locally available raw materials and by-products.

Therefore, even with very many serious constraints in the development of the fertilizer industry in Africa, in particular in Sub-Saharan Africa which will find it impossible to fill NPK gap 2000, there is still a room for improvement of the situation in order not to widen this gap.

One of the most recommended in this study directions is connected with the extraction of potash and with the maximum recovery of sulphur in Africa, this continent being heavily dependent on importation of these components.

Issues related to the development of the fertilizer industry in Africa and constraints it faces in substantial increase of consumption of fertilizers are broadly discussed in the further chapters of this study.

M I C R O N U T R I E N T S

CARRIERS OF ZINC

Common/trade name	Chemical Formula	Zn Content Percent
	Inorganic Sources	
Zinc sulphate	$ZnSO_4.7H_2O$	23
Zinc sulphate	$ZnSO_4.H_2O$	36
Zinc oxide	ZnO	60-80
Zinc chloride	$Zncl_2$	45-52
Zinc carbonate	$ZnCO_3$	56
Zinc oxide-sulphate	$ZnO - ZnSO_4$	55
Zinc ammonium phosphate	$Zn (NH_4) PO_4$	37
Sphelarite	ZnS	60
Zinc dust	-	99.8
Zinc frits	-	4 (variable)
	Chelated Sources	
Synthetic	Na_2-Zn EDTA	14
	Na-Zn HEDTA	8
	Na-Zn NTA	13
Natural	Zn-lignin sulphonate	5
	Zn-polyflavonoid	10

COMMONLY USED Mo CARRIERS

Source	Chemical Formula	Mo (approx. percent)
Sodium molybdate	$NaMoO_4.2H_2O$	39
Ammonium molybdate	$(NH_4)_6Mo_7O_{24}.4H_2O$	54
Molybdenum trioxide	MoO_3	66
Molybdenite	MoS_2	60
Molybdenum frits	-	2-3

CARRIERS OF Fe FOR AGRICULTURAL USE

Source	Chemical Formula	Iron (Percent)
Inorganic		
Ferrous sulphate	$FeSO_4.7H_2O$	20.5
Ferric sulphate	$Fe_2\ (SO_4)_3$ $4H_2O$	20.0
Ferrous carbonate	$FeCO_3$	42.0
Ferrous ammonium sulphate	$(NH_4)_2\ SO_4$ $FeSO_4\ 6H_2O$	14.0
Organic Complexes		
Iron frits	-	40.0 (variable)
Lignin sulphonate	-	6.0
Methoxy phenylpropane complex	-	5.0
Polyflavonoid	-	6.0-9.6
Chelates		
Fe-DTPA	-	10.0
Fe-EDTA	-	9.0-12.0
Fe-EDDHA	-	6.0
Fe-HEDTA	-	5.0-9.0

COMMONLY USED Mn FERTILIZERS

Source	Chemical Formula	Percent Mn
Manganese sulphate	$MnSO_4.3H_2O$	26-28
Manganous oxide	MnO	41-68
Manganese methoxyphenylpropane	MnMPP	10-12
Manganese chelate	MnEDTA	12
Manganese carbonate	$MnCo_3$	31
Manganese chloride	$MnCl_2$	17
Manganese oxide	MnO_2	63
Manganese frits	-	10-25

SOME CARRIERS OF COPPER AND SUGGESTED RATES OF APPLICATION

Source	Chemical Formula	Cu (approximate percent)	Suggested Rate of Soil Application (kg/ha Cu)	
			Broadcast	Band
Copper sulphate	$CuSO_4.5H_2O$	25	3.0 - 6.0	1.4 - 4.5
	$CuSO_4.H_2O$	35	3.0 - 6.0	1.4 - 4.5
Cuperous oxide	Cu_2O	89	3.0 - 6.0	1.1 - 4.5
Cuperic oxide	CuO	75	3.0 - 6.0	1.1 - 4.5
Copper chelates	Na_2-CuEDTA	13	0.8 - 2.4	0.2 - 0.8
	Na-CuEDTA	9	0.8 - 2.4	0.2 - 0.8

FERTILIZATION WITH Co

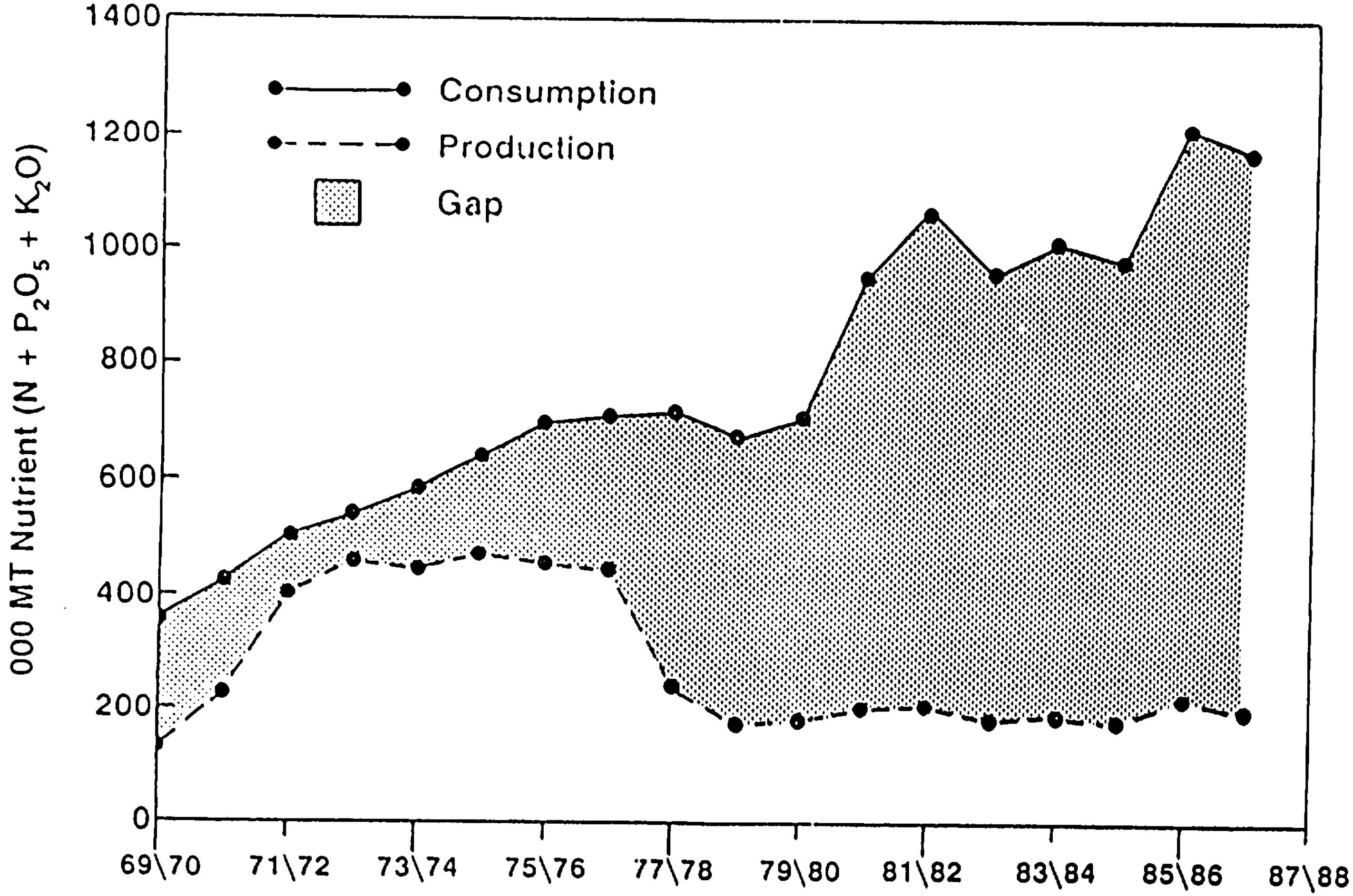
Cobalt deficiency in grazing animals may be eliminated by applying Co salts to the pastures. Cobalt sulphate ($CoSO_4.7H_2O$, 21% Co) is the widely used source of Co. It is applied by broadcast. The application rates correspond to 0.06-0.24 kg/ha Co. One application may last for 1-5 years, depending upon amount of Co applied, soil characteristics and rainfall.

SOURCES OF BORON

Source	Chemical Formula	Boron (approx. percent)
Borax	$Na_2B_4O_7.10H_2O$	11
Sodium tetraborate		
Fertilizer borate 46	$Na_2B_4O_7.5H_2O$	14
Fertilizer borate 65	$Na_2B_4O_7$	20
Solubor	$Na_2B_4O_7.5H_2O$ + $Na_2B_{10}O_{16}.10H_2O$	20
Boric acid	H_3BO_3	17
Colemanite	$Ca_2B_6O_{11}.5H_2O$	10
Boron frits	-	2-6

Figure No. 2.23

Sub-Saharan Africa: Gap Between Total Fertilizer Consumption and Production



Source: FAO

Note: Does not include ground phosphate rock for direct application.