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Industrial development in AFRICA

PART ONE • Progress and problems of industrialization

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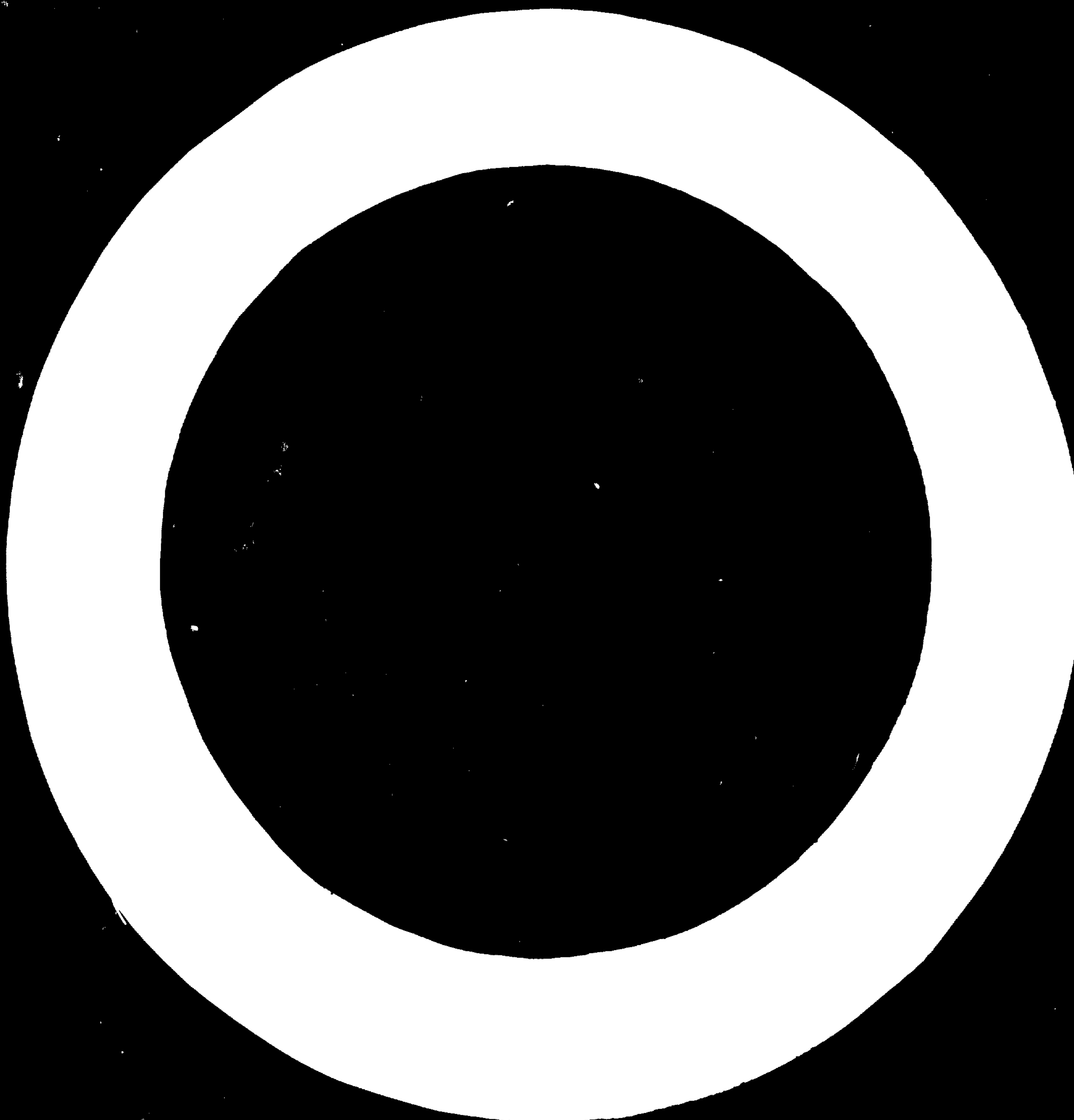
Niger • Sudan • United Arab Republic • Zambia

UNITED NATIONS

PART ONE

Progress and problems of industrialisation



1. POLICY ASPECTS OF INDUSTRIAL DEVELOPMENT IN AFRICA: PROBLEMS AND PROSPECTS

Secretariat of the United Nations Economic Commission for Africa

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I. Current status and past growth of industry in Africa

A. Current status of industrial development in Africa[1]

With the exception of South Africa and a few other countries, the structure of output in Africa and its subregions is predominantly under-developed.[2] The high share of agriculture in gross domestic product, which is more pronounced in West and East Africa than in North and Southern Africa, is a manifestation of the low level of industrial development in the western and eastern subregions, in comparison with that in the northern part of the continent and more so in comparison with that of South Africa. In recent years, manufacturing and mining have accounted for about 20 per cent of the gross domestic product of the continent as a whole, whereas their share has been 8 per cent of gross domestic in West Africa, 15 per cent in East Africa, 20 per cent in North Africa, 21 per cent in Central Africa and approximately 39 per cent in Southern Africa, as is shown in table 1.

One of the striking features made evident in table 1 is that there are only narrow differences between subregions in the level of agricultural output *per capita*, whereas the mining and manufacturing outputs *per capita* show a wider range of industrial development in the same subregions. By and large, industrial development in Southern Africa has been much more pronounced than in North Africa, which is followed by East and Central Africa, with West African industry being less developed than that of the other subregions.

Table 1. Industrial origin of gross domestic product in Africa, by subregion[a]

Sector	*Total Africa*	*West Africa*	*North Africa*	*East Africa*	*Central Africa*	*Southern Africa*[b]
	(Thousand million dollars)					
Agriculture	13.8	4.5	4.5	2.8	1.2	0.8
Mining	2.3	0.2	0.7	0.2	0.2	1.0
Manufacturing	5.4	0.5	1.8	0.7	0.4	2.0
Other sectors	15.9	2.9	5.7	2.3	1.1	3.9
TOTAL	37.4	8.1	12.7	6.0	2.9	7.7
	(Percentage of gross domestic product)					
Agriculture	37	56	35	47	41	10
Mining	6	2	6	3	7	13
Manufacturing	14	6	11	12	14	26
Other sectors	43	36	45	38	38	51
TOTAL	100	100	100	100	100	100
	(Dollars per capita)					
Agriculture	51	60	64	36	40	42
Mining	8	2	10	2	7	52
Manufacturing	20	7	25	9	14	106
Other sectors	58	38	80	30	37	206
TOTAL	137	107	179	77	98	406

SOURCES: Various United Nations publications and documents; national plans and publications.

[a] The figures in the table indicate orders of magnitude in broad terms and represent only approximations in 1963 or thereabouts.

[b] 1962 at factor cost.

[1] See also annex to this paper.

[2] In this paper, reference to South Africa indicates the Republic of South Africa. Southern Africa is taken to mean the subregion, including Basutoland, Bechuanaland, South Africa, South West Africa and Swaziland.

The fact that there are relatively small variations in the agricultural output *per capita* suggests that the differences in the over-all output *per capita* in the subregions mainly reflect the degree of development of the non-agricultural sectors.

With a population totalling about 272.8 million persons in 1963 and an industrial output of approximately $7,700 million in or about the same year (see table 2), the industrial product *per capita* for the whole of Africa has been in the neighbourhood of $28, on the average. Wide variations exist, however, in the industrial product *per capita* among the African subregions, ranging from $9 in West Africa to about $158 in Southern Africa, in comparison with $11 for East Africa, $21 for Central Africa and $35 for North Africa.

Table 2. Distribution of manufacturing mining and population in Africa, by subregion, 1963 [a]

(Percentages of totals)

Subregions	*Manufacturing* A	*Mining* B	A + B	*Population*
North Africa	33.4	30.0	32.4	25.9
West Africa	8.7	7.5	8.4	27.7
East Africa	12.5	10.2	11.8	28.4
Central Africa	7.9	7.9	7.9	10.9
Southern Africa	37.5	44.4	39.5	7.1
TOTAL	100.0	100.0	100.0	100.0
	(Thousand million dollars)			*(Millions)*
Absolute totals	5.4	2.3	7.7	272.8

SOURCES: Various United Nations publications and documents; national plans and publications.

[a] These figures refer to the year 1963 or thereabouts. They are estimates of orders of magnitude rather than accurate data.

Manufacturing development has been concentrated, thus far, in Southern Africa, which accounts for about 37.5 per cent of the total manufacturing output of the continent, followed by North Africa, which produces nearly 33.4 per cent of the total, and by East Africa, which produces about 12.5 per cent. Mining output has also been concentrated, with approximately 45 per cent of its total being in Southern Africa and about 32 per cent in North Africa. The distribution of mining and manufacturing output, in comparison with the distribution of population among the subregions, as shown above in table 2, explains the wide differences in the degree of industrial development as measured by the industrial output *per capita*. East, West and Central Africa, although producing similar percentages of the total mining and manufacturing output in or about 1963 (about 8 to 12 per cent of the total in each), portrayed wide differences in population size. In West Africa, with 27.7 per cent of the total population of the continent, the industrial output *per capita* was lower than that of East Africa, with 28.4 per cent of the population. It was lower still in comparison with Central Africa, where only 10.9 per cent of the total African population produced 32.4 per cent of the total output of industry, and with Southern Africa, the most industrialized area in the continent, where only 7.1 per cent of the total population produced about 39.5 per cent of the total output of industry in Africa during 1963.

A comparison of the main components of gross domestic product in the subregions of Africa with those of the industrially advanced countries presents striking differences. Table 3 shows the level of output per inhabitant from agriculture, industry and other sectors in the industrial countries and in the subregions of Africa.

The level of industrial development as reflected in *per capita* industrial output is very low in all African subregions (with the exception of Southern Africa), when compared with the output *per capita* in developed countries.

Table 3. Income *per capita* in African subregions and in industrially advanced countries, 1960 [a]

(Dollars)

Area	*Agriculture*	*Industry*[b]	*Other sectors*	*All sectors*
Developed countries	120	480	600	1,200
Africa — Total	41	25	51	117
North Africa	48	22	62	132
West Africa	41	8	25	71
East Africa	31	12	29	72
Central Africa	37	28	38	103
Southern Africa	52	166	271	489

SOURCE: United Nations Economic Commission for Africa, Research Division.

[a] Figures refer to the year 1960 or thereabouts.

[b] Including mining and manufacturing, construction, power and water utilities.

While the level of agricultural output *per capita* in the industrialized countries appears to be about 2.3 to four times higher than that in the subregions of Africa, the industrial output *per capita* in industrially advanced countries is nearly sixty times as much as in West Africa, forty times as much as in East Africa and twenty-two times that in North Africa, but it is only seventeen times the level attained in Central Africa and about three times that reached in Southern Africa. These figures illustrate the wide gap and the very low level of industrial output *per capita* in the various African subregions in recent years, in comparison with the industrially advanced countries and the advances these subregions must make in the years to come in order to reach, at some future time, the current level of average output in the developed countries.

A comparison of the changes in industrial output in Africa and in other areas of the world since the period prior to the Second World War is given in table 4.

B. Past rates of growth of industry in Africa

The rapid rate of industrial growth in Africa over the past two decades has, thus far, had scarcely any significant effect in bringing about a structural transformation of the African economies. Although the growth rate of industrial output in Africa averaged about 7.4 per cent annually between 1938 and 1957, compared with 4.5 per cent in the industrially advanced countries, the share of industry in the total output of Africa barely exceeded 14 per cent in the twenty-year period, 1938-1958.

Taking the manufacturing sector alone, the annual rate of growth averaged 7.9 per cent for the whole of Africa and 8.6 per cent for the continent excluding South Africa, indicating a much higher growth rate

Table 4. Changes in industrial output in Africa compared with other areas, 1938-1960 and 1948-1960

	Index (1953 = 100)				*Annual Compound Percentage Change*	
	1938	*1948*	*1957*	*1960*	*1938-1960*	*1948-1960*
World						
Mining	63	80	120	132	3.4	4.3
Manufacture	50	72	121	140	4.8	5.7
Total industry	52	73	121	138	4.6	6.5
Industrial countries						
Mining	66	85	114	112	3.3	2.3
Manufacture	47	73	116	131	4.8	5.0
Total industry	49	74	116	129	4.5	4.8
Africa						
Mining	69	73	123	150	3.6	6.2
Manufacture	30	67	127		7.9	7.4
Total industry	42	69	126		6.0[a]	6.9[a]
Africa excluding Southern Africa						
Mining	47	65	115	141	5.1	6.7
Manufacture	29	74	140		8.6	7.3
Total industry	34	71	133		7.4[a]	7.2[a]

SOURCE: United Nations, *Statistical Yearbook, 1960* (United Nations publication, Sales No.: 61.XVII.1).
[a] Up to 1957 only.

than the 4.8 per cent per annum in the industrialized countries and in the world at large during the period 1938 to 1960 (see table 4 above). It should be observed that the annual growth rates of manufacture were higher than those for mining in Africa and in the industrial countries, as well as in the world at large, throughout the period covered in table 4.

It must be acknowledged, however, that the high relative growth rates of industry in Africa, as in the majority of other developing areas, mainly reflect small absolute increments on an initial low level. The size of the industrial sector in the subregions of Africa is rather small in relation to the output of their whole economies, and the impressive high rates of growth of their industrial output have not had a substantial impact on total domestic product. The small size of the manufacturing sector is demonstrated by its contribution to the gross domestic product in the largest number of African countries. The contribution of manufacturing to gross domestic product varies a great deal from country to country (see table 5). Value added by manufacturing industries amounted to 15 per cent or more of the total output in only a few countries of Africa,[3] and in the largest number of countries for which data could be assembled, the contribution of manufacturing to total output ranged from about less than 5 per cent to approximately 10 per cent of gross domestic product.[4] In a number of countries, the size of manufactured output has been even smaller than 5 per cent of gross domestic product in recent years.[5] In industrially developed countries, however, the share contributed by the manufacturing sector has accounted for 30 to 40 per cent or even more of the total output,[6] a fact which indicates also the wise disparity between the developed countries and the African countries with regard to the size of their industrial sectors in relation to the other sectors of the economy.

Table 5. Industrial origin of gross domestic product at factor cost in countries of Africa, by commodity sector, 1960[a]

(Percentage of total gross domestic product)

Subregion and country	*Manufacturing*	*Electricity*	*Construction*	*Mining*	*Agriculture*
North Africa					
Algeria	11.0	2.0	5.0	3.0	23
Libya	10.0	2.0	.0	8.0	23
Morocco	13.4	2.2	4.0	6.6	32
Tunisia	12.0	2.0	5.0	3.0	29
Sudan	5.0	0.5	6.5	0.1	57
United Arab Republic (Egypt)	17.0	2.0	8.0	1.7	31
West Africa					
Dahomey		8.0			53
Ghana	8.2	0.4	4.0	4.4	49
Guinea					
Ivory Coast	5.4	2.3	3.8	0.6	49
Mali		15.0			48
Mauritania	1.6	1.0	28.2	2.4	52
Niger	4.3	0.9	4.0	11.9	77
Nigeria	2.7	0.6	4.4	1.3	63
Senegal	8.5	0.7	4.7	0.7	28
Sierra Leone					
Togo		19.0			52
Upper Volta		12.0			67
East Africa					
Ethiopia	5.2	0.4	2.0	0.2	76
Kenya	9.5	1.2	3.5	0.5	10
Madagascar	2.2	0.3	1.4		53
Malawi	5.1	1.0	3.5	0.6	
Mauritius	16.0	2.0	6.0	0.2	23
Southern Rhodesia	14.7	3.4	5.4	6.4	
Uganda	6.3	1.2	2.5	1.5	61
United Republic of Tanzania	7.2	0.6	5.9	3.8	59
Zambia	5.1	2.6	4.1	48.0	15
Central Africa					
Cameroon	8.1	1.9	4.0		46
Central African Republic	6.7	0.4	3.5	4.5	53
Chad	3.5	0.4	3.3	1.0	62
Congo (Brazzaville)		13.0		3.5	33
Congo (Democratic Republic of)	14.0	0.7	5.5	16.4	31
Gabon	3.0	1.9	9.0	17.0	27

SOURCES: United Nations, *Yearbook of National Accounts Statistics, 1963* (United Nations publication, 64.XVII.4); United Nations, *The Growth of World Industry, 1938-1961* (United Nations publications, Sales No. 63.XVII.5); and United Nations Economic Commission for Africa, Research Division, national publications, 1965.
[a] Data refer to 1960 or thereabouts; some data are provisional estimates.

[3] These countries include South Africa, the United Arab Republic (Egypt) and Mauritius, with the share of manufacturing accounting for 33 per cent, 17 per cent and 16 per cent, respectively.

[4] These countries include Cameroon, Central African Republic, Dahomey, Ethiopia, Ghana, Ivory Coast, Kenya, Libya, Malawi, Senegal, the Sudan, Uganda, United Republic of Tanzania and Zambia.

[5] Among these countries are Chad, Congo (Brazzaville), Gabon, Mauritania, Niger, Nigeria, Sierra Leone and Togo.

[6] In 1960, industrial output accounted for more than 30 per cent of total output in New Zealand and more than 37 per cent in Canada, Denmark, the Netherlands and the United Kingdom of Great Britain and Northern Ireland.

II. Plans for industrial development

A. Projected industrial growth in current development plans

Bearing in mind that there is some relationship between the magnitude of a sector in the economy and the pace at which it is expected to expand, and the fact that the share of manufacturing in total output is rather small in the majority of African countries, the relatively high growth rates planned by these least industrialized countries could be attributed to the fact that they need to make less of an investment effort to attain a given growth rate than would be required in a more industrialized economy.

Table 6 shows a comparison of data obtained from national development plans with those referring to periods prior to the introduction of planning. In most countries, manufacturing is anticipated to grow at a more rapid pace than before the plan periods, pointing out the importance attached to the development of manufactures. Rather large increases in the planned growth rates of manufacture can be detected in North African countries (Morocco, Sudan, Tunisia and the United Arab Republic), as well as in West African countries (Ghana, Mali, Mauritania, Nigeria, Senegal and others). Generally, the same observation applies to East African countries, including Ethiopia, Kenya, Uganda, the United Republic of Tanzania and Zambia.

Some countries stressed in their plans the development of mining, and in a number of countries which originally had a small mining base, the planned growth rates for mineral production appear to be much higher than for manufacturing. An extreme example of this will be found in Mauritania, where the bulk of projected growth would originate in the mining sector, which is expected to expand at an annual rate of more than 148 per cent. In Ethiopia, the Sudan and the United Arab Republic, the current plans in operation contemplate growth rates of mineral output much higher than that of manufacture. Mining output has been projected to expand at an annual rate of about 53 per cent in Ethiopia, 25 per cent in the Sudan and 27 per cent in the United Arab Republic. It is to be noted that the share of mining in the gross domestic product is rather small in these three, being less than 1 per cent in Ethiopia and the Sudan, and less than 2 per cent in the United Arab Republic. Table 7 shows the planned growth rates of output in manufacturing, mining and electricity, gas and water utilities in selected countries of African subregions, in comparison with planned growth rates of gross domestic product.

Table 6. Planned increase in growth rates and pre-plan growth rates in manufacturing, electricity and mining, selected African countries

(Annual percentage)

	Manufacturing		*Electricity*		*Mining*	
Subregion and country	*Pre-plan[a] growth rate*	*Planned increase rate*	*Pre-plan[a] growth rate*	*Planned increase rate*	*Pre-plan[a] growth rate*	*Planned increase rate*
North Africa						
Algeria	7.2		10.7		8.4	
Morocco	2.5	6.1	3.2	3.9	5.1	- 1.4
Sudan	6.0	15.8	10.0	13.6	—	25.0
Tunisia	4.6	3.4	5.3	- 0.9	2.4	- 0.4
United Arab Republic (Egypt)	7.8	5.5	11.4	23.0	7.7	20.0
West Africa						
Ghana		10.9[b]	19.2		6.9	
Mali		19.0[b]				
Mauritania		19.1[b]				148.0
Nigeria	7.3		13.2		5.1	
Senegal	5.7	9.8[c]		[c]		[c]
East Africa						
Ethiopia	5.5	21.8	11.3	8.1		52.0
Kenya	2.6	5.3	2.1	1.7	- 15.2	3.0
Malawi						
Southern Rhodesia	10.5		6.9		- 5.8	
Uganda	- 0.5		15.1		16.7	
United Republic of Tanzania	5.8	9.0	18.0	- 6.0	- 1.4	4.0
Zambia	8.0	23.3				3.2

SOURCES: National development plans; also United Nations, *Yearbook of National Accounts Statistics, 1965* (United Nations publication, Sales, No.: 64.XVII.4); United Nations, *The Growth of World Industry, 1938-1961: National Tables* (United Nations publication, Sales No.: 63.XVII.5).

[a] Data refer to 1954-1958.

[b] Annual growth rate totals for all industrial sectors.

[c] Planned growth rates for all industrial sectors, 12.7 per cent per annum.

In a number of countries where the mining sector is relatively more developed, the planned growth of mineral output has been much smaller than that for manufactured output. For example, in Zambia, where the share of mining accounts for almost 48 per cent of the gross domestic product, the planned growth rate of the sector is in the neighbourhood of 3 per cent per annum. In the Democratic Republic of the Congo, where mining has contributed about 16 per cent of the gross domestic product, the planned annual growth rate has been set at 3-4 per cent per annum; and in Morocco, where mining has contributed 6-7 per cent of the gross domestic product, the planned growth rate of the sector has been set at about 4.5 per cent per annum.

With the exception of a few countries, the current economic and social development plans in African countries call for an annual growth rate of industry which is substantially higher than the target growth rates of total output, i.e., the growth rates of gross domestic product (see table 7).

The projected growth of gross domestic product ranges from 4 per cent to 9 per cent per annum, while the planned growth rates for manufacturing range from 8 per cent to as high as 30 per cent per annum in the different countries.

Table 7. Planned growth rates in output of manufacturing, mining, electricity, water and gas, selected African countries

(Percentage)

		Planned Annual Growth Rates			
Subregion and country	*Plan period*	*Gross domestic product*	*Manufacturing*	*Mining*	*Electricity, gas and water*
North Africa					
Algeria	. . .	. . .	. . .	. . .	. . .
Morocco	1960-1964	7.0	8.8	4.5	7.0
Sudan	1961-1970	5.1	21.8	25.1	13.6
Tunisia	1962-1970	6.0	8.0	2.0	4.4
United Arab Republic (Egypt)	1960-1970	7.3	13.5	27.3	11.5
West Africa					
Ghana	1963-1969	5.5	8.5[a]	. . .	. . .
Mali	1961-1965	8.0	21.0[a]	. . .	. . .
Mauritania	1963-1966	9.2	30.0	148.0	10.0
Nigeria	1962-1968	4.0			
Senegal	1960-1965	8.0	15.5[a]	. .	7.2
East Africa					
Ethiopia	1963-1967	4.3	27.3	52.6	19.4
Kenya	1964-1970	5.2	5.3	3.0	8.7
Madagascar	1964-1968	5.5		. . .	. . .
Malawi	1964-1969	. . .	. . .	. . .	. . .
Uganda	1961-1965	4.5	. . .	. . .	. . .
United Republic of Tanzania	1964-1969	6.7	14.8	4.2	12.3
Zambia	1966-1970	6.5	19.4	3.0	5.6
Central Africa					
Cameroon	1961-1965	5.5		.	
Congo (Democratic Republic of)	1965-1969	7.0	14-16[b]	5-6	. . .

SOURCES: National development plans.
[a] Including mining and electricity.
[b] Including construction and electricity.

B. Planned investment and growth pattern of industry

A significant indicator of the objectives and strategy of development in the plans of various African countries is the investment for the projected growth pattern of industry in the current and perspective plans. Most of the economic and social development plans, which present some detailed allocation of investment by economic sector and give information on the distribution of investment between public and private undertakings, illustrate the differences in development strategies, if not also in objectives.

Whenever it was possible to secure information concerning the share of industry in total public investment in pre-plan periods and in total planned investment, public investment in the development of industry, as a percentage of total public investment, has been considerably lower in the pre-plan period than in the plans of those countries for which data are available. An increasing number of countries of Africa have assumed a greater role in the development of their industrial sectors through the direct investment of public funds since they attained independence than they did before. The share of industry in total planned investment has also increased in different countries during the post-independence era of planning (see table 8).

The distribution of capital expenditures among various sectors of the economy in the countries where data are available reflects the differences in the pattern of investment and in the priorities attached to the development of various economic and social sectors. Of strategic importance for the growth of the economy in the majority of African countries is the development of such basic facilities as power, transport and communication, and water-supplies for the expansion of industries. In the economic development plans of a large number of countries, considerable attention has been given and sizable investment allocations have been devoted to the improvement and expansion of transport facilities, power and water utilities, communication systems and other infrastructure required for the removal of existing bottle-necks to the growth of manufacturing, mining and other commodity-producing sectors. Alloc-

Table 8. Share of industry in total public investment in pre-plan period and in total planned investment, selected African countries

(Percentage of totals)

Subregion and country	Share in public investment		Share in total planned investment	
	Pre-plan period	Plan period	Private	Total
North Africa				
Algeria	2.5[a]	...	...	...
Morocco	2.1[b]	28	...	22.8
Sudan	9.0[c]	..	...	16.2
Tunisia	0.3[a]	...	...	...
United Arab Republic (Egypt)	2.1[a]	23	...	28.8
West Africa				
Cameroon	0.4[d]	10	...	...
Ghana	5.0	32	...	23.2
Guinea	...	18	...	...
Mali	...	14	...	14.0
Mauritania	...	50	...	41.0
Nigeria	9.0	29	...	13.0
Senegal	...	44	...	36.0
East Africa				
Ethiopia	2.0	28	28	28.0
Kenya	...	20	...	...
Madagascar	0.3[d]	5	36	16.0
Malawi	...	24	...	...
Uganda	...	19	28	21.0
United Republic of Tanzania		16	38	26.0
Zambia		7	70	51.0

SOURCES: National economic and social development plans; and United Nations, *Economic Developments in Africa, 1954-1955* (United Nations publication, Sales No.: 56.II.C.3); *Economic Developments in Africa, 1955-1956* (United Nations publication, Sales No.: 57.II.C.3).

[a] 1951-1953.

[b] 1954.

[c] 1939-1956.

[d] 1940-1955.

ations of planned investment, particularly in the public sector, for the development of these basic facilities have been large, often larger than the share of manufacturing in total planned investment. Table 9 shows the share of basic facilities, compared with the share of manufacturing and other industrial sectors, in the total planned investments in a number of countries in the subregions of Africa.

Table 9. Share in total planned investment for the development of basic facilities and of industry, selected African countries

(Percentage of totals)

Subregions and country	Plan periods	Percentage of total planned investment	
		Basic facilities[a]	Industry[b]
North Africa			
Libya	1963-1968	38.6	4.0
Morocco	1957-1965	9.7	22.8
Sudan	1961-1970	39.7	
Tunisia	1962-1971		
United Arab Republic (Egypt)	1960-1970	27.8	28.8
West Africa			
Ghana	1963-1970	23.0[c]	20.0[c]
Mali	1961-1965	48.0	14.0
Mauritania	1963-1966	50.0	30.0
Nigeria	1962-1968	45.0[c]	12.0[c]
Senegal	1961-1965		
Sierra Leone	1962-1967	37.0[c]	9.0[c]
Upper Volta	1963-1967	28.0	22.0
East Africa			
Ethiopia	1963-1967	35.0[d]	28.0
Kenya	1964-1970	23.0[c,d]	20.0[c]
Madagascar	1964-1971	50.0[d]	16.0
Malawi	1965-1969	33.0[c,d]	24.0[c]
Uganda	1961-1966	17.0[d]	21.0
United Republic of Tanzania	1967-1969	37.0[c,d]	16.0[c]
Zambia	1966-1970	40.0[c,d]	17.0[c]
Central Africa			
Cameroon	1961-1965	10.0[c]	41.0[c]

SOURCES: National development plans for the periods given.

[a] Including electricity, gas, water, transport and communication.

[b] Manufacturing and processing, and mining.

[c] Public investment only.

[d] Including also construction and housing.

C. The development of light and heavy industries

Although it is not easy to reduce the complexity and multiplicity of industrial activities and products into a few broad categories, such categorization has been attempted and followed in the United Nations study, ***Patterns of Industrial Growth, 1938-1958,***[7] as well as in other studies concerning industrial development. Industry has been classified broadly into "consumer goods" and "producer goods", the latter comprising both intermediate products and capital equipment. Industry has also been subdivided into two groups, namely, "heavy" manufacturing and "light" manufacturing, the former corresponding to the intermediate and capital goods industries and the latter to the consumer-goods industries. Although these classifications are not fully satisfactory for analytical purposes, the "light-goods industries" include food, beverages and tobacco products, textiles, clothing, apparel and footwear, leather products, rubber products, printing and publishing. The "heavy-goods industries" cover paper, chemicals, non-metallic mineral products, basic metals, metal products, and machinery and equipment, both electrical and non-electrical.

A very broad and rough distribution of major groups of manufactures, comprising both the light-goods and heavy-goods industries among the subregions of Africa in 1958, is shown in table 10. The figures show the percentage distribution of value added in each major group of industries for Africa as a whole, among its subregions. Neither the light-goods nor the heavy-goods industries are distributed evenly among the subregions. Both categories of manufacturing have been concentrated in Southern Africa, followed by North Africa, with the three other subregions contributing together about 17 per cent of the output of light industries and a similar percentage of the output of heavy-manufacturing industries of the whole region.

The distribution by country of the value added from manufacturing among major groups comprising both light and heavy industries, for 1960 or thereabouts, presents differences in the structure and development of the manufacturing sector (see table 11).

[7] United Nations publication, Sales No.: 59.XVII.6.

Table 10. The distribution of output of major groups of industries among the African subregions, 1958

(Percentage of totals of major groups)

Major groups of manufacturing	*Southern Africa*	*North Africa*	*Central Africa*	*East and West Africa*	*Total Africa*
Light industries					
Food, beverages and tobacco[a]	37	39	17	7	100
Textiles	25	65	9	1	100
Clothing, foot-wear, apparel	79	15	5	1	100
Wood products and furniture	60	16	8	16	100
Paper and paper products[b]	78	16	4	2	100
TOTAL	47	36	6	11	100
Heavy industries					
Chemicals, rubber, petroleum[c]	60	27	6	7	100
Non-metallic mineral products	49	26	20	5	100
Basic metals	54	4	36	6	100
Metal products, machinery[d]	73	19	7	1	100
TOTAL	64	19	13	4	100

SOURCE: Data derived from United Nations; *Statistical Yearbook, 1962* (United Nations publication, Sales No.: 63. XVII.1); see also International Labour Organisation, Second African Regional Conference, Addis Ababa, 1964, *Report of the Director General*, p. 127, appendix table 10.

[a] Including processing of agricultural raw materials in the subregions.

[b] Including printing and publishing in the subregions.

[c] Including petroleum and coal products.

[d] Including electric machinery and transport equipment.

In recent years, the share of value added originating in the various light-manufacturing industries has accounted for 75 per cent or more of the total value added in manufacturing in the majority of African countries—Burundi, Ethiopia, Ghana, Ivory Coast, Libya, Malawi, Mauritius, Rwanda, the Sudan etc. In some of these countries, for example, Burundi, Ethiopia and Rwanda, the share of heavy industries has been as low as 7 to 10 per cent of the total manufactured output. This is probably also the case in such countries as Niger and Somalia, where the size of the manufacturing sector as a whole is also reported to be rather small, and industry is in the initial stage of development.

In those countries where manufacturing had an early beginning and the light consumer-goods industries have been relatively more developed, the shift of emphasis in more recent years towards the development of heavy-manufacturing industries can be detected in the change of composition of investment in manufacture, as is illustrated in the economic and social development plans of several African countries, among which the United Arab Republic, Tunisia and Senegal may be mentioned.[8]

[8] The share of heavy industries in the economic development plan in the United Arab Republic accounts for about 71.6 per cent in the planned increase of manufactured output and for 77.3 per cent of total planned investment in industry. In Tunisia, the planned expansion of heavy industry would account for 55.4 per cent of the planned increase in manufactured output, for which 72.3 per cent of total investment in manufacture has been allocated. In Senegal, approximately 54.8 per cent of the planned increase in manufactured output is to come from the development of heavy industry, the share of which in the planned investment in manufacturing was about 63.5 per cent.

Table 11. Structure of manufacturing: percentage distribution of value added among major groups of light and heavy industries in countries under African subregions, 1960[a]

Subregion and country	*Light industries*				*Heavy industries*			
	Food, beverages and tobacco	*Textiles, clothing and leather*	*Wood and furniture*	*Paper, printing and publishing*	*Chemicals, petroleum, coal and rubber*	*Non-metallic mineral products*	*Basic metals, metal products, machinery etc.*	*Other industries*
North Africa								
Algeria	40	11	4	3	5	9	23	2
Libya	50	11	...	...	...	...	...	...
Morocco	38	23	4	3	5	6	20	1
Sudan	62	5	...	5	9	10	4	...
Tunisia	38	19	5	3	10	5	18	2
United Arab Republic (Egypt)	24	46	2	4	10	5	8	1
West Africa								
Ghana	38	1	42	3	4	2	9	1
Guinea	...	...	...	...	...	...	...	...
Ivory Coast	47	14	14	2	8	...	10	4
Mauritania	...	...	...	...	...	...	...	...
Nigeria	37	4	17	...	27	4	5	7
Senegal	53	6	2	2	1	3	7	26
Sierra Leone	...	...	...	...	...	...	...	...
East Africa								
Ethiopia	45	38	3	2	1	5	...	6
Kenya	38	8	10	3	12	11	18	1
Malawi	53	4	3	2	...	...	9	29
Southern Rhodesia	24	15	4	2	9	6	30	10
Uganda	...	...	...	...	...	...	...	...
United Republic of Tanzania	...	...	...	...	...	...	...	...
Zambia	33	3	5	...	...	14	38	7
Central Africa								
Cameroon	...	...	...	...	...	...	...	...
Central African Republic	19	27	—	—	—	54	—	—
Chad	...	...	...	...	...	...	...	...
Congo (Brazzaville)	...	...	...	...	...	...	...	...
Congo (Democratic Republic of)	...	...	...	...	...	...	...	...
Gabon	...	...	...	...	...	...	...	...

Table 11. Structure of manufacturing: percentage distribution of value added among major groups of light and heavy industries in countries under African subregions, 1960[a] (*continued*)

Subregion and country	*Light industries*				*Heavy industries*			
	Food, beverages and tobacco	*Textiles, clothing and leather*	*Wood and furniture*	*Paper, printing and publishing*	*Chemicals, petroleum, coal and rubber*	*Non-metallic mineral products*	*Basic metals, metal products, machinery etc.*	*Other industries*
Southern Africa								
Mozambique	48		—	—	—	52		
Rwanda-Burundi	80	11			4	2		3
South Africa	19	14	5	9	12	7	31	3
Africa as a region	25	25	8.6	1.2	5.2	7	21.3	6.0
Africa excluding Southern Africa	29	30	9.1	0.6	4.4	6.5	14.3	6.0

SOURCE: United Nations.
[a] Data refer to 1960 or thereabouts.

The sectoral structure of manufacturing is more or less closely related to the level of industrial development. This is as true in African countries as it has been elsewhere in the world. In the earlier stages of development, light industries, including food, beverages, tobacco products, textiles, clothing and foot-wear, are generally favoured over heavy industries, such as chemicals, basic metals, metal products and engineering industries, because of the combined impact of capital intensity, the degree of skills required and the size of market for the supply of which the industry may be established. With the exception of a few countries in which basic metal industries have been developed on a large scale for exports (e.g., Southern Rhodesia and Zambia within the copper belt) and of South Africa, where metallurgy, chemicals and rubber are relatively advanced, as well as some North African countries where chemicals and certain basic metal and metal products industries have been developed, light manufacturing is preponderant in Africa at the current time. Thus, the share of heavy manufacturing varies from less than 10 per cent in some countries to more than 50 per cent in a few others. Countries belonging to the latter group include South Africa, Southern Rhodesia and Zambia, but it is only in South Africa that the branches of heavy industry can be said to be appreciably diversified.

However, in many countries at a low level of industrialization, increasing weight has been given in recent years to the development of a number of specific branches of heavy industries, including cement, non-metallic mineral products, fertilizers and other chemical products, in addition to a number of metal products, including table and kitchen utensils, simple tools and implements, or to the assembled production of some transport equipment, refrigeration units and other electric appliances based largely on imported parts for domestic assembly.

A variety of developmental undertakings for heavy industry along the lines cited are planned or are under way in a number of African countries with various degrees of industrialization. Planned development of cement and other non-metallic mineral products exists in the plans of Ethiopia, Ghana, the Sudan, Tunisia, the United Arab Republic and various other countries. Further development of chemicals and fertilizers has been planned or is under way in Ethiopia, Nigeria, Senegal, the Sudan, Tunisia and the United Arab Republic. Plants for the assembling of agricultural and transport equipment are incorporated in the plans of Mali, the United Arab Republic and a number of East and West African countries. Iron and steel mills are planned for Liberia and Nigeria in West Africa, for the Maghreb countries of North Africa and for Uganda and Zambia in East Africa, while in Southern Rhodesia and the United Arab Republic, substantial expansions in iron and steel production are being visualized. The aluminium metal and products industry is included in the plans for Ghana, the United Arab Republic and a few other countries.

The foregoing examples show the tendency towards diversification and selectivity in the development of heavy-manufacturing industries in various African countries. In a number of these countries, the planned growth rate of heavy industry has been set at a greater pace than the planned development of light-manufacturing industries. In formulating their current plans, many countries recognized the increasing volume and values of the intermediate products and capital goods required to attain the projected high growth rates for their economies and, accordingly, placed considerable emphasis on expanding the production of certain commodities in the capital-goods and the intermediate-goods industries.

III. The influence of foreign trade on the structure and growth pattern of manufacturing development

In most African countries, the bulk of development in manufacturing which took place during the Second World War and in the post-war period was largely oriented to produce import substitutes, and in a number of them, the outstanding growth was mainly in the export-oriented industries. Most of the export-oriented industries have been based on available resources in the countries, including a relatively abundant output of minerals or farm and forest products which are processed or manufactured for exports. The industries thus established have included both resource-oriented and market-oriented ones. Vivid examples of these include the basic non-ferrous metal industries in the copper belt, as well as in East and North Africa; the wood products industry in Gabon, Ghana, Ivory Coast, Kenya, Nigeria and South Africa; the fish processing industry in Angola, Morocco and South West Africa; and the vegetable oil industry in Nigeria, Senegal and other West and North African countries. These are in addition to the simple processing of cocoa beans, coffee

beans, tea leaves, sisal into fibres and other agricultural products for exportation, which is undertaken by a number of countries, including Ghana, Kenya, Nigeria, Uganda and the United Republic of Tanzania, among others.

The development of light manufacturing, such as food, beverages, tobacco, textiles, clothing, foot-wear, furniture, soap, perfumery and other consumer goods, had been taking place in a wide range of countries in order to provide the domestic markets with substitutes for imports. More recently, in a smaller number of countries, the development of import substitutes has moved gradually into branches of manufacturing industries producing intermediate goods and a variety of capital goods, as mentioned previously.

African countries in the early stages of their industrialization rely upon enlarging the share of domestic production of consumer products, especially of light consumer goods for the domestic market, to reduce their dependence upon imports and to free foreign-exchange earnings for the importation of capital and producer goods, the production of which requires more intensive capital and relatively more advanced technologies, as well as a higher level of skills. Other countries at more advanced stages of industrialization move forward in the direction of the development of import substitutes of heavy consumer goods, producer goods and a variety of capital equipment. However, with the probable exception of South Africa, none of the African countries has reached the stage of industrial development where the expansion of industries for heavy consumer goods and the development of intermediate goods industries have not resulted in the increased growth of imports of semi-finished goods and raw materials required for the expansion of the established heavy industries.

Available data on the volume and composition of imports in several countries where import-substitute industries expanded between 1950 and 1960 indicate that the share of light consumer goods in total value of imports decreased between the 1950's and 1960's. By contrast, imports of intermediate producer goods and of capital equipment increased appreciably, resulting in a growing balance-of-trade deficit.

Table 12 shows the change in the composition of imports for the period 1950-1960 in a number of African countries at different stages of manufacturing development. Although the share of food, beverages, tobacco and some other consumer goods in the total value of imports fell between 1950 and 1960, the share of fuel, raw materials and semi-finished goods rose during the same period. In addition, the share of machinery and equipment in total value of imports has risen greatly in the majority of countries shown in table 12.

Table 12. Changes in the composition of imports by African countries, 1950-1960

(Percentage of total value of imports for the years stated)

Subregion and country	*Food, beverages and tobacco*			*Other consumer goods*			*Fuel, raw materials and semi-finished goods*			*Machinery and equipment*		
	1950	*1955*	*1960*	*1950*	*1955*	*1960*	*1950*	*1955*	*1960*	*1950*	*1955*	*1960*
North Africa												
Algeria	22	21	24	35	36	32	25	27	22	18	16	19
Morocco	25	24	21	28	33	27	26	28	38	21	15	14
Tunisia	16	21	19	39	37	30	27	29	32	18	13	19
Sudan	36	26	17	23	26	23	29	31	36	12	17	24
United Arab Republic (Egypt)	30	18	22	18	17	7	37	47	46	15	21	25
West Africa												
Ghana	...	22[a]	19	...	46[a]	42	...	15[a]	13		17[a]	26
Liberia	...	22	18	...	46	37	...	7	12	...	25	33
Nigeria	...	14[b]	14	...	54[b]	51	...	10[b]	11		22[b]	24
Sierra Leone	...	25[b]	23	...	46[b]	50	...	10[b]	10		19[b]	17
Togo	...	19	14	...	52	...	...	21			8	31
East Africa												
Kenya	...	...	8	...	...	40	...	...	34	...	...	18
Mozambique	15	14	...	42	40	...	18	17	...	25	29	...
Rhodesia and Nysaland	...	10	8	...	47	46	...	9	10		34	36
Central Africa												
Cameroon	...	17	19	...	39	36	...	19	12		25	23
Congo (Democratic Republic of)	...	12	11	...	21	22	...	32	31		35	36
Southern Africa												
South Africa[c]	7	5	5	27	34	20	33	23	28	33	38	37

SOURCES: United Nations, *Economic Survey of Africa Since 1950* (United Nations publication, Sales No.: 59.II.K.1); National publications of trade statistics; United Nations, *Yearbook of International Trade Statistics, 1960* (United Nations publication, Sales No.: 61.XVII.9); United Nations, *Economic Bulletin for Africa*, Vol. II, No. 1 (United Nations publication, Sales No.: 62.II.K.1).

[a] Data refer to 1957.

[b] Data refer to 1956.

[c] Data include South West Africa.

Excluding Southern Africa, the value of imports in the rest of the continent increased by approximately 147 per cent between 1950 and 1963, the increase being much larger in the imports of machinery and transport equipment (by about 181 per cent) and in the imports of intermediate goods, which increased by almost 159 per cent in comparison with an expansion of only 143 per cent (in value terms) in the imports of consumer goods. During the same period, the share of consumer goods declined from 42 per cent to 35 per cent of the total value of commodity imports, whereas the share of imports of intermediate goods rose slightly, from 29 per cent in 1950 to 34 per cent of the value of imports in 1963. However, the share of machinery and transport equipment rose from 29 per cent of the value of imports in 1950 to 31 per cent in 1963 (see table 13).

Table 13. Changes in the structure of imports of manufactured goods by Africa, 1950-1963 [a]

Groups of imports	Value of imports (millions of dollars) 1950	1963	Percentage change between 1950 and 1963 (1950 = 100)
Consumer goods	976	2,000	143
Intermediate goods	705	1,958	159
Machinery and transport equipment	691	1,748	181
Total imports	2,372	5,705	147

SOURCE: See annex.
[a] Excluding Southern Africa.

A. Import-substitution objectives

The target outputs in the development plans of African countries, whenever such targets have been stated, emphasize the goal of raising the manufactured output of light consumer-goods, in general, and of a number of durable consumer-goods to a lesser extent, in an attempt to reduce the share of consumer goods in total commodity imports. The projected annual growth rates of total imports and exports in the development plans of a variety of countries, in comparison with the growth rates of fixed capital formation and of consumption (both private and public), are given in table 14. The figures show that for seven countries, namely, the Congo (Brazzaville), Ghana, Mauritania, Nigeria, the Sudan, Tunisia and the United Arab Republic—total imports are expected to grow at a much slower pace than total exports. In their plans, stress has been placed on the rapid expansion of substitutes for imported consumer goods and, in a few of these countries, for a variety of producer goods.

On the other hand, in the plans of five countries—Ivory Coast, Kenya, Mali, Morocco and the United Republic of Tanzania—available data indicate that the projected rates of growth of imports are appreciably higher than those for exports, but much lower than the planned annual growth rates of capital formation. The rapid increase in the planned rates of capital formation, unaccompanied by a corresponding emphasis on the rapid growth of domestic output of heavy manufacturing of the capital goods and intermediate products required for the realization of the projected rapid growth of domestic product, necessitates a higher incremental rate of imports of these goods. Unfortunately, data are scanty on the composition of projected imports in the current plans of most African countries. Data on the

Table 14. Projected rates of growth of imports and exports in the development plans of selected African countries

(Annual compound growth rates)

Subregion and Country	Imports	Exports	Capital formation	Consumption: Private	Consumption: Public
North Africa					
Morocco	7.0	4.8	19.4	4.4	6.4
Sudan	2.0	4.7	4.9	4.3	5.6
Tunisia	2.5	7.2	10.3	−4.0	—
United Arab Republic	−1.2	11.5	11.5	4.9	4.4
West Africa					
Ghana	4.8	5.3	8.0	−5.9	...
Ivory Coast	6.9	6.3	10.3	6.2	4.9
Mali	12.2	9.0	...	...	...
Mauritania	−0.5	49.4	−8.0	5.1	3.2
Nigeria	4.0	5.5	5.6	−4.4	—
Senegal	...	...	14.0	...	...
East Africa					
Ethiopia	...	...	12.2	3.3	7.5
Kenya	11.2[a]	5.5	...	...	...
Uganda	...	...	...	...	...
United Republic of Tanzania	6.6	5.1	14.6	4.7	5.0
Zambia	...	...	8.6[b]	6.0	8.6
Central Africa					
Congo (Brazzaville)	3.3	9.5	19.2	...	...
Congo (Democratic Republic of)	12-21[a]	...	14-16	...	...

SOURCES: Data derived from national economic and social development plans of countries stated; also, United Nations Economic and Social Council, Economic Commission for Africa, "Outlines and selected indicators of African development plans (E/CN.14/336), 14 January 1965.
[a] Capital goods imports only.
[b] Government investment only, growth rates of private investment projected at 15.5 per cent per annum.

distribution of planned imports between consumer goods, producer goods and capital equipment are available, however, for a few countries—Ghana, Kenya, Mali, Nigeria, Senegal and the United Arab Republic. These data, which are given in table 15, indicate that while imports of capital goods have to expand at an annual rate of 3.8 per cent in the United Arab Republic and at about 11.2 per cent in Kenya, in the latter country, imports of producer and consumer goods would increase by 6.1 per cent and 2.1 per cent, respectively. In the United Arab Republic, where planned expansion of manufacturing and mining not only stresses the rapid development of substitutes for producer and consumer goods, but also gives high priority to the production of capital equipment, the plan anticipates a reduction of imports of consumer goods at a rate of 1.2 per

Table 15. Annual growth rate planned for imports of consumer goods, producer goods and capital equipment

Country	Total imports	Consumer goods	Producer goods	Capital goods
United Arab Republic	−1.2	−2.2	−4.0	+3.8
Ghana, Mali, Nigeria, Senegal	+4.0	+0.6	+6.2	+6.2
Kenya	+5.5	+2.1	+6.1	+11.2

SOURCES: National plans of economic and social development.

cent per annum and a reduction of imports of producer goods at an annual rate of 4.0 per cent, while imports of capital equipment would continue to expand at a rate of 3.8 per cent per annum.

Planned imports into Ghana, Mali, Nigeria and Senegal, taken together, indicate that the projected rates of growth of both producer goods and capital equipment are much higher than the rates for imports of consumer goods, which would be significantly cut down by the planned expansion of import substitutes in these countries. Table 16 shows the relative emphasis placed on the development of light and heavy manufactures as areas of import substitution in a number of African countries where available data permit such comparisons.

Table 16. The share of light consumer[a] and heavy industries[b] in total planned investment[c] in manufacturing and in total increase in manufactured output, selected African countries

(Percentage)

Country	Planned growth rates: Total manufacturing	Planned growth rates: Light consumer goods	Share of light consumer goods in total manufacturing: Increase in output	Share of light consumer goods in total manufacturing: Investment	Share of heavy manufacturing in total: Increase in output	Share of heavy manufacturing in total: Investment
Ethiopia	27.3	22.3	69.2	37.5	30.8	62.5
Ghana	8.0	11.9	72.7		27.3	
Senegal	15.5	8.0	45.2	36.5	54.8	63.5
Sudan	21.2			95.7[d]		4.3[d]
Tunisia	8.0	7.1	44.6	23.7[e]	55.4	76.3[e]
United Arab Republic	13.4	7.6	28.4	22.7	71.6	77.3

SOURCE: Based on national development plans of countries stated.
[a] Food, beverages, tobacco, textiles, clothing and foot-wear industries.
[b] Durable consumer goods, producer goods and capital-equipment industries.
[c] Gross fixed investment unless otherwise specified.
[d] Net public investment only.
[e] Net investment.

Manufactured imports still account for a very high percentage of gross manufactured output (in terms of value added) in African countries for which data are available (see table 17). In recent years, imports of manufactured goods corresponded to between one-fourth and one-third of gross value of production of the domestic manufacturing sector in only a few countries (including the United Arab Republic and South Africa, where the rate of import substitution was highest in comparison with most other African countries). In other countries, the rate of substitution of manufactured imports through the development in this direction of domestic output of manufacturing has not resulted in larger declines in manufactured imports as a percentage of domestic manufacturing output. Manufactured imports amounted to between 55 per cent and more than 75 per cent of domestically manufactured output in Algeria, Gabon, Morocco and Tunisia (to cite some examples) and were higher than 92 per cent in Chad, Ghana, Nigeria and the Sudan (to cite other examples). In many other countries, the value of manufactured imports outstrips that of domestic manufactured output and, in some cases, is more than double, as in Cameroon and the Congo (Brazzaville). These figures would indicate that greater perspective and wider scope for the substantial development of import substitutes industries exist, except in those relatively more developed countries where the manufactured imports constitute but a small percentage of domestic manufacturing output. For further manufacturing development of the latter countries, more attention should be devoted to the growth and expansion of export-oriented industries in future years. South Africa has been successful in the development of import substitutes and in the expansion of manufactured exports through

Table 17. Total demand for industrial products and share contribution of domestic industries, selected African countries, for the years noted

(Millions of dollars)

Subregion and country	Value of imports	Value added by domestic industry	Total demand	Domestic output as percentage of total demand
North Africa				
Algeria[a]	237.0	303.9	541.0	56.1
Morocco[a]	122.0	207.5	329.5	63.0
Sudan[a]	15.1	16.4	31.5	52.0
Tunisia[a]	56.3	81.4	127.7	63.7
United Arab Republic (Egypt)[a]	517.4	1,628.8	2,146.2	75.9
West Africa				
Ghana[a]	355.7	29.4	385.1	7.6
Nigeria[a]	547.0	44.0	591.0	7.5
Central Africa				
Cameroon[b]	76.5	36.5	113.0	32.3
Central African Republic[b]	20.4	21.2	41.6	51.0
Chad[b]	19.9	30.0	49.9	60.1
Congo (Brazzaville)	48.6	21.2	69.8	30.4
Congo (Democratic Republic of)	243.8	226.0	469.8	48.1
Gabon[b]	39.6	8.6	48.2	17.8
Southern Africa				
South Africa[c]	1,369.3	1,384.0	2,753.3	50.2

SOURCE: United Nations Economic Commission for Africa, Industry Division, 1965.
[a] Data refer to 1960/1961.
[b] Data refer to 1963/1964.
[c] Data refer to 1960.

the establishment of export-oriented industries. By 1960, the value of manufactured imports into South Africa amounted to about 485.5 million South African pounds, and the country exported in the same year domestically manufactured products valued at approximately £SA 179.3 million, nearly 36.9 per cent of the value of its manufactured imports. In the United Arab Republic, where substitution for imports of light and heavy consumer goods has gone a long way in reducing the share of such goods in total imports, attempts are being made to push forward manufactured exports of long-established industries like cotton and rayon textiles, leather and shoes, cement and furniture, as well as products of more recent industries, such as rubber products, chemicals, metal works and engineering industries, in an effort to secure the larger amounts of foreign exchange required to sustain higher levels of capital formation and accelerated rates of economic growth. In recent years, however, the value of manufactured goods exported by the United Arab Republic has accounted for only 10 per cent to 12 per cent of the value of imports of manufactured products. Table 18 shows the value of manufactured goods exported by a number of African countries in recent years.

Table 18. Value of manufactured exports in 1963, distributed between groups of industries, by country

Subregion and country	*Currency units*	*Food, beverages, tobacco*	*Textiles, clothing, leather*	*Timber, wood products*	*Chemicals*	*Metals, metal products*	*Oils, fats and by-products*	*Cement, glass, etc.*
North Africa								
Algeria								
Libya								
Morocco	Million dirham	241.1	13.4		23.8	18.2	0.3	1.5
Sudan	Million pounds							
Tunisia								
United Arab Republic (Egypt)	Million Egyptian pounds	25.0	29.2	0.2	0.3		1.2	2.0
West Africa								
Dahomey	Thousand million francs	0.1			0.02		0.47	
Ghana	Million pounds	3.6		13.1	1.3		0.1	
Guinea								
Ivory Coast	Thousand million francs	1.2	0.2	12.4	0.1		0.07	
Mali	Thousand million francs	0.51	0.02				0.04	
Niger	Thousand million francs	0.08			—	—	0.25	
Nigeria	Million pounds	2.9		6.8	0.2		16.1	
Senegal	Thousand million francs	2.6	0.2	...	0.09	0.32	11.52	
Sierra Leone	Million pounds						0.03	
Central Africa								
Cameroon	Thousand million francs	1.84		1.8[illegible]	0.02		0.11	
Congo (Democratic Republic of)	Thousand million francs		0.04	0.48		12.43	2.78	0.07
Gabon	Thousand million francs	—	—	9.46	0.12			
East Africa								
Ethiopia	Million Ethiopian dollars	7.02	...		0.03		1.33	
Kenya	Million pounds	4.53		0.14	2.04	0.70	0.26	0.50
Malawi, Southern Rhodesia, Zambia	Million pounds	5.33	2.11	...		129.8	0.39	...
Uganda	Million pounds	0.31	...	0.08		3.61	1.66	...
Tanganyika	Million pounds	1.20	...	0.31	0.39	...	1.50	...
Southern Africa								
South Africa	Million South African pounds	75.0	...	...	31.32		8.93	

SOURCE: United Nations, *Yearbook of International Trade Statistics, 1963* (United Nations publication, Sales No.: 64.XVII.4).

Probably the greater number of imports used in manufacturing in Africa consist of intermediate goods which have not as yet reached the stage of final production by industries on the continent. However, Africa is a producer of a variety of the raw materials which go into the making of a long list of intermediate goods, which, in turn, are used in manufacturing on the continent. Nevertheless, a great number of African countries import from outside the region an increasing volume of intermediate manufactures, the basic inputs of which may have originated in Africa. Africa, as a whole, is a net importer of leather for shoes, wood for furniture and fixtures, wood-pulp for paper, metal products from non-ferrous metals, tanning materials for leather, dyeing products for textiles etc. In the meantime, it is a net exporter of hides and skins, sawn wood, basic non-ferrous metals (including copper, tin, zinc, lead and aluminium), pigments, indigo, coal-tar dyes and other tanning and dyeing materials, all of which go into the corresponding imported intermediate goods. It seems that these input goods could be produced locally from domestic materials for use partly by the growing industries and also for exports at higher values than are obtained from their exportation in primary form. It is also evident that intraregional trade in such goods is very limited in extent, which partially explains the lack of co-ordinated development of manufacturing among African countries, in addition to the fact that production of intermediate goods needed for inputs in existing industries is quite under-developed in many African countries

B. Export-development objectives

It has been one of the stated aims of African countries to diversify their production and exports. One of the several forms that this policy has generally taken is the development of local processing of primary commodities and the expansion of industrial capacity. Progress in diversification of manufactured output has generally been felt in import substitution more than in the export trade. Steps which had been taken for the processing of primary products as an auxiliary to the export trade before independence had met, in some cases, with unfavourable reactions from the metropolitan country, resulting, for example, in import quotas and other forms of protection for the metropolitan industry. Actions of this type had been noted in Senegal in the ground-nut processing industry after the Second World War, and the rapid expansion of the same industry was discouraged in Nigeria until more recent times. Similarly, the Ghanaian attempt at diversification of exports had been confined within the extractive sector, but its current plan of development emphasizes the expansion of production for exports of cocoa products, timber, saw-mill products and aluminium, in an effort to provide the base for the development of processing industries, and they are projected to contribute significantly to the over-all industrialization programme.

The rather restricted range of exports in the majority of African countries gave rise in a number of them to the processing of primary products, as in the case of copper exports from the Democratic Republic of the Congo, Southern Rhodesia and Zambia; crude sugar and molasses from Mauritius and Mozambique, and to some extent, from Angola; fish products from Angola and South West Africa; and sawnwoods from Gabon, Ghana, Nigeria and other West and Central African countries. These woods largely pass through simple shaping and rounding before exportation.

Simple preparation of natural rubber into crude rubber for exportation has been taking place in the major producing countries of Africa, namely, Cameroon, the Democratic Republic of the Congo, Liberia and Nigeria. The hides and skins which are being salted and dried for exportation in many countries of West, East and North Africa could have been the subject of expansion of the leather and leather-goods industries, adding to the value of their exports.

The value of exports of the simply prepared products of extractive industries, as well as of a number of manufactured goods proper, increased significantly in a large number of African countries between the 1950's and 1960's, as shown in table 19. With a more advanced

Table 19. Development of manufactured exports in African countries

Subregion and country	Currency units	Value of manufactured exports (in current prices) 1950	1959	1963	Manufactured exports as percentage of total commodity exports 1950	1959	1963
North Africa							
Algeria	Million francs	67.7			68.3		
Libya	Million pounds	0.44	0.59	0.13	12.0	16.1	9.1
Morocco	Million dirham		407	389		28.2	30.3
Sudan	Million pounds	1.41	2.16	4.28	2.9	3.2	5.3
Tunisia	Thousand million dinar		28.8			48.4	
United Arab Republic (Egypt)	Million Egyptian pounds	18.9	34.2	65.3	13.2	22.1	28.7
West Africa							
Dahomey	Thousand million francs		1.02	0.71		22.4	22.3
Gambia	Million pounds		0.11	0.10		3.9	3.0
Ghana	Million pounds	7.31	22.05	22.40	7.1	21.7	
Liberia	Million dollars		4.14	7.63		6.2	11.2
Mali	Thousand million francs		1.15	0.62		33.4	23.7
Nigeria	Million pounds	20.9	22.9	36.7	24.7	14.2	19.8
Senegal	Thousand million francs		1.40	1.62		48.9	59.0
Sierra Leone	Million pounds		6.03	16.51		36.7	64.9
Togo	Million francs		316	246		8.8	5.5
East Africa							
Ethiopia	Million Ethiopian dollars		6.26	12.52		3.8	5.8
Kenya	Million pounds			11.61			26.5
Uganda	Million pounds	3.84	12.82	5.77	6.3	10.7	11.2
Tanganyika	Million pounds	4.29		10.19	12.1		16.3
Madagascar	Million francs		5,039	5,843		27.8	28.8
Malawi	Million pounds						
Southern Rhodesia	Million pounds	101.97	123.48	140.36	70.9	67.6	69.9
Zambia	Million pounds						
Mauritius	Million rupees		170	414		98.8	98.1
Mozambique	Million escudos		71.5	543.5		3.7	18.8
Southern Africa							
South Africa	Million South African pounds	89.1	180.4		29.2	45.1	

SOURCE: United Nations, *Yearbook of International Trade Statistics*, 1950, 1960, 1964 (United Nations publications, Sales Nos.: 51.XVII.2; 61.XVII.9; 65.XVII.2).

stage of industrial development, these manufactured exports tend to become more diversified, particularly in those African countries where the output of resources, including industrial resources, has attained some measure of diversification, i.e., South Africa since the early 1950's, and Algeria, Kenya, Morocco, Southern Rhodesia, and the United Arab Republic in more recent years. It is to be noted, however, that the bulk of exports of manufactured products is largely concentrated in a few commodities or a few major groups of industries. Thus, textiles, petroleum products and milled rice are by far the leading exports of manufacture in the United Arab Republic, accounting for about 82 per cent of Egyptian manufactured exports in 1963; non-ferrous basic metals, iron and steel products, meat products, clothing and foot-wear accounted for more than 96 per cent of the combined exports of manufactured products by Malawi and Southern Rhodesia in the same year. In recent years, more than two-thirds of the processed exports of Algeria and Morocco have belonged to the food, alcoholic beverages, pulp, leather, textiles and chemical industries.

Food products, oils, fats and by-products are predominant in the manufactured exports of Dahomey, Madagascar, Mali, Niger, Nigeria, Senegal and the United Republic of Tanzania. Crude metals and basic non-ferrous metals constitute the bulk of exports of industrial products from the Congo (Democratic Republic of), Southern Rhodesia, Uganda and Zambia. Wood, lumber and products make up the highest percentage of industrial exports from Gabon, Ghana and Ivory Coast, and come second to vegetable oil exports from Nigeria. The so-called "industrial exports" of a number of countries would, however, more appropriately belong to mining rather than manufacturing output, as in the case of Guinea, Sierra Leone and the United Republic of Tanzania in which unpolished and uncut diamonds account for the bulk of major industrial exports. Textile products have been substantial in the total value of manufactured exports of a few countries of Africa, including the former Federation of Rhodesia and Nyasaland, South Africa and the United Arab Republic, and, to a lesser extent, Cameroon, the Congo (Democratic Republic of), Ivory Coast, Mali, Morocco and Senegal, countries for which details of manufactured exports are more or less available.

A larger number of countries gained in exports of chemicals, but in only a few of them, e.g., Morocco and South Africa, do chemicals account for more than 10 per cent of total manufactured exports. Exports of non-metallic mineral products, such as cement, lime, ceramics and glass, appear in the foreign trade of a number of countries (the Congo (Democratic Republic of), Kenya, Morocco, Southern Rhodesia and the United Arab Republic), but most other countries endeavour to expand these branches for import substitutes more than for exportation.

Exports of domestically produced machinery, electrical machinery and transport equipment have been relatively developed in South Africa and are almost negligible in most other countries. A few countries of Africa recently attempted to produce for exportation a relatively small surplus of a variety of mechanical and electro-engineering products which belong to some branches of the three major groups of industries comprising machinery, electrical machinery and transport equipment. Cited cases in recent years can be found in Algeria, Southern Rhodesia and the United Arab Republic, for example.

One aspect of the problem of the creation and expansion of export-oriented industries is related to improvement of the conditions under which developing countries can sell such manufactured products abroad. Another aspect of the same problem relates to the choice of industries and of commodities which can succeed in developing and sustaining adequate export outlets. Industrial production for exportation in developing countries is generally successful when the producing industries have captured the domestic market and so advanced in bringing down their cost structure, and have raised the quality of output to the level of their international competitors. Co-ordination in planning of such export-oriented industries between developing countries on a regional or subregional basis, as well as the institution of some common market arrangements for the countries involved, would provide some measure of success for their promotion.

IV. The employment objectives of industrial development

Industrial development in many countries of Africa is apt to stress the employment objective of industrialization. In addition to the expansion of total output, output *per capita* and the rising *per capita* income from the development of the manufacturing sector, emphasis has been laid on the creation of employment opportunities at higher rates than the growth rates of the labour force. The large majority of the labour force in African countries, as in many other parts of the world, is mainly dependent upon the availability of employment outlets to participate in the increase of production and to earn their income from work. Data on the distribution of the economically active population in major divisions of economic activity are available for only a few countries in Africa and largely refer to a number of scattered and seldom comparable years (see table 20). They indicate, however, that the highest percentage of economically active population in individual countries are employed in the primary producing sectors, namely agriculture and mining, and small percentages of them are employed in secondary sectors, including manufacturing, construction and electricity, gas and water utilities. The available data for the year 1960 or thereabouts show that, with the exception of South Africa, the economically active population engaged in secondary production accounted for less than 10 per cent of the total engaged in most countries. Employment in secondary production in a number of countries at different stages of manufacturing development, such as Algeria, the Congo (Democratic Republic of) and the Sudan, accounted for 5 per cent or less of the total economically active population, but it was much higher in Tunisia (8.5 per cent), Morocco (9.9 per cent), the United Arab Republic (11.5 per cent) and Ghana (12.4 per cent) in or about 1955-1960 or more recent years.

Table 20. Distribution of economically active population, by source of employment

(Percentage of totals)

Country	Year	Agriculture	Mining	Manufacture	Electricity	Construction	Services
Algeria	1954	82.1	0.4	2.9	0.1	1.7	12.8
Morocco	1960	56.6	1.3	8.0	0.3	1.6	32.2
Tunisia	1956	68.1	1.1	6.2	0.2	2.1	31.3
Sudan	1956	86.0		2.2	0.1	2.7	13.0
United Arab Republic	1960	56.7	0.3	9.0	0.5	2.0	12.5
Ghana	1960	37.9	1.8	8.6	0.5	3.3	39.9
Central African Republic	1961	94.8	0.4	1.0		0.6	1.2
Congo (Democratic Republic of)	1955	85.2	1.4	2.8		2.1	13.5
Gabon	1963	92.5	3.2	2.2	0.1	1.8	6.2
South Africa	1960						
White		10.3	5.4	20.1	0.9	6.3	57.0
Non-white		31.7	11.9	9.9	0.6	4.5	38.1
Bantu		55.7	11.5	3.7		2.0	26.1

Of the total labour force, those who were engaged in manufacturing alone represented less than 3 per cent of the total in the Democratic Republic of the Congo and the Sudan, but accounted for 6 to 9 per cent of the total in Tunisia, Morocco, Ghana and the United Arab Republic, arranged in an ascending order. In South Africa, however, the share of employment in non-agricultural commodity producing sectors has been appreciably higher than in other countries of Africa. In 1960, about 27.3 per cent of the economically active Europeans and approximately 15 per cent of the economically active non-Europeans (except the Bantu population) were engaged in industrial employment.

Data on the distribution of wage and salary earners are available for more countries, and cover a series of years. Although such data suffer also from known deficiencies and discrepancies, they may be used for general indicators of employment development in the non-agricultural sectors, including manufacturing. The total number of wage and salaried employees increased in almost all African countries between the 1950's and the 1960's, and their employment in absolute and relative terms had also risen in the manufacturing sector (see table 21), in the majority of countries with reported data (see table 22). Employment in manufacturing in a number of countries has, however, recorded a decline in recent years. Wage employment in manufacturing declined between 1958 and 1962 or 1963 in Cameroon, Chad, Kenya, Malawi and Zambia in absolute and relative terms, in contrast with the increases which were recorded in Gabon, Ghana, Nigeria, Southern Rhodesia, Tanganyika and the United Arab Republic. It is to be noted, however, that the size of wage employment in manufacturing has been rather small in most African countries, accounting for only 3 to 4 per cent of the number of wage earners in Tanganyika and Chad, respectively, and rising to about 7 to 8 per cent of total employees in Ghana and Nigeria, but accounting for between 9 and 10 per cent of the total in Gabon, Malawi, the United Arab Republic and Zambia. Their percentages have been much higher in Uganda and Southern Rhodesia, being approximately 11.4 per cent and 13.6 per cent in these two countries, respectively, in 1961-1962.

Table 21. Persons employed in major divisions of economic activity

(Thousands)

Country	Year	Total	Agriculture, forestry, fishing (0)	Mining, quarrying (1)	Manufacturing (2-3)	Construction (4)	Electricity, gas, water (5)	Commerce (6)	Transport, storage, communication (7)	Services (8)	Others (9)
Chad	1959	1,340	1,140	1.2	5.0	6.2		4.7	2.5	29.9	105.5
	1960	1,340	1,135	1.0	4.3	7.4		5.1	2.0	20.1	165.1
	1961	1,380	1,140	1.5	4.3	7.4		5.0	0.1	20.0	198.7
Gabon	1956	37.3	14.5	4.6	2.5	1.9	0.1	2.1	1.4	6.6	3.6
	1957	41.5	12.9	6.2	2.4	3.8	0.1	3.2	1.6	6.5	3.5
	1958	38.1	12.9	4.6	2.2	3.8	0.1	3.3	1.7	6.5	2.8
	1959	41.3	13.0	5.1	3.2	2.9	0.2	4.1	2.1	6.4	4.3
	1960	42.8	14.7	6.2	4.2	3.1	0.1	4.4	3.0	6.7	0.5
	1961	42.0	13.8	6.5	3.8	2.3	0.1	5.1	2.8	6.1	1.0
	1962	42.8	13.3	6.5	3.9	3.7	0.1	5.5	2.6	6.4	0.8
	1963	44.0	13.4	6.5	4.2	3.6	0.1	5.7	2.7	7.0	0.9
Ghana	1954	244	34	37	15	50	5	24	22	58	
	1955	245	41	12	16	57	7	26	23	63	
	1956	267	42	32	18	47	8	30	23	68	
	1957	277	41	33	19	48	9	29	26	72	
	1958	292	44	33	21	51	10	29	29	76	
	1959	319	45	31	22	60	12	32	27	80	
	1960	333	58	29	24	62	14	31	31	84	
	1961	350	48	28	29	63	16	38	33	94	

Table 21. Persons employed in major divisions of economic activity (*continued*)

(Thousands)

Country	Year	Total	Agriculture, forestry, fishing 0	Mining, quarrying 1	Manufacturing 2-3	Construction 4	Electricity, gas, water 5	Commerce 6	Transport, storage, communication 7	Services 8	Other 9
Kenya	1956	596.7	235.2	9.0	55.4	39.7	2.3	35.8	52.5	166.2	0.6
	1957	614.4	253.4	7.9	57.0	36.6	2.5	36.8	54.6	165.2	0.4
	1958	593.1	249.5	6.4	55.6	34.2	2.5	36.4	48.1	160.1	0.3
	1959	596.9	251.7	5.4	53.7	31.5	2.5	37.5	45.9	168.3	0.4
	1960	622.2	271.8	5.0	52.3	33.0	2.5	39.0	46.4	171.8	0.4
	1961	589.4	252.0	3.8	42.5	28.6	2.5	43.2	44.2	172.4	0.2
	1962	581.2	245.5	3.5	45.3	12.6	2.0	42.8	46.2	182.8	0.5
	1963	535.1	219.7	3.1	40.7	18.8	2.1	42.0	45.3	162.4	0.7
Malawi	1954	135	48.8	0.4	15.8	19.4	1.2	12.2	3.9	33.3	
	1955	147	54.7	0.5	17.3	21.4	1.2	12.4	4.3	34.9	
	1956	164	63.5	0.5	18.7	25.4	1.4	12.6	5.3	37.1	
	1957	167	63.9	0.5	18.6	26.4	1.1	13.5	5.9	37.3	
	1958	167	62.3	0.6	17.8	26.4	1.4	14.5	6.4	37.2	
	1959	163	61.7	0.5	16.7	24.4	1.6	14.6	6.5	36.9	
	1960	158	60.8	0.4	16.2	22.4	1.6	14.2	6.7	35.5	
	1961	152	57.9	0.5	15.0	20.4	1.6	14.2	6.9	35.1	
Nigeria	1956	447.4	36.9	58.9	21.4	101.9	7.8	45.1	56.8	118.5	0.1
	1957	475.6	42.7	53.6	31.6	111.2	8.8	56.6	45.0	123.9	2.2
	1958	478.3	45.4	49.5	29.7	123.8	10.1	45.7	48.7	122.8	2.6
	1959	472.6	45.5	41.2	32.4	102.9	16.4	42.2	47.6	144.4	...
Southern Rhodesia	1954	625	235.9	65.3	75.6	58.5	6.4	42.7	19.9	120.6	
	1955	649	243.4	62.5	80.2	61.1	6.5	45.7	21.7	128.2	
	1956	685	246.6	64.0	89.4	66.6	6.6	50.4	22.7	139.0	
	1957	710	245.0	63.7	94.6	73.6	7.3	53.6	24.4	148.0	
	1958	724	249.4	60.0	95.4	73.0	7.8	57.3	25.0	156.3	
	1959	723	252.0	55.3	95.9	67.2	7.9	59.4	25.6	160.4	
	1960	734	260.8	55.0	96.8	64.9	8.2	59.9	26.4	162.7	
	1961	710	252.5	51.2	97.0	51.0	7.5	58.2	26.5	166.2	
Tanganyika	1954	401	218	15	18	16	1	11	7	113	...
	1955	375	201	15	17	12	2	11	6	111	...
	1956	387	207	15	17	13	2	9	7	116	...
	1957	380	211	13	18	11	2	10	8	107	...
	1958	447	216	13	22	11	2	14	9	120	41
	1959	445	222	10	21	12	2	15	10	118	36
	1960	404	201	12	19	10	2	15	7	108	30
	1961	460	189	11	20		7	19	19	...	92
Uganda	1958	243.0	58.4	4.2	26.1	38.0	2.4	13.8	11.3	88.7	...
	1959	239.5	56.8	5.5	25.4	33.0	2.3	13.7	10.5	92.2	...
	1960	244.5	61.3	5.7	25.8	30.3	2.2	14.7	11.1	93.6	...
	1961	236.1	55.7	6.1	27.0	29.3	2.0	15.0	10.6	90.3	...
United Arab Republic (Egypt)	1958	...	...	...	565	119	...	631	223	1248	49
	1959	...	...	...	545	109	...	594	261	1146	59
	1960	...	...	...	537	105	...	579	214	1130	50
	1961	...	...	...	560	112	...	578	214	1151	28
	1962	...	...	...	600	113	...	578	225	1216	16
Zambia	1954	263	42.0	45.0	23.4	59.2	3.0	15.7	9.0	66.2	...
	1955	276	39.9	47.8	24.6	62.5	3.0	17.4	9.6	71.6	...
	1956	289	38.1	43.5	27.3	68.9	3.3	18.7	10.8	78.6	...
	1957	302	38.8	46.0	27.8	70.2	3.3	21.3	12.2	82.9	...
	1958	294	39.2	40.3	27.7	66.2	3.3	20.6	12.8	84.1	...
	1959	281	40.7	41.8	26.6	48.2	3.3	22.3	13.0	85.1	...
	1960	278	40.7	44.7	26.2	38.7	3.6	22.9	13.3	87.6	...
	1961	269	41.0	44.6	25.0	32.4	3.4	21.1	13.2	88.2	...

SOURCE: International Labour Office, *Yearbook of Labour Statistics*, 1961-1964.

Table 22. Structure of employment in manufacturing in African countries in recent years

(Percentage of total)

Country	Year	Food, beverages, tobacco	Textiles, clothing, leather	Wood, furniture, fixtures	Paper, printing, publishing	Chemicals, fertilizers, rubber	Cement, glass etc.	Metals and products	Others
Algeria	1957	26.0	26.4	5.6	4.2	3.6	9.3	20.4	4.5
Libya	1958	32.9	17.9	6.9	2.8	0.9	3.9	32.1	2.6
Morocco									
Sudan									
Tunisia									
United Arab Republic	1958	22.8	49.5	2.5	4.8	6.1	4.6	8.3	1.4
Ghana	1959	12.0	1.4	55.3	9.7	3.2	3.2	13.8	1.4
Ivory Coast	1960	21.2	20.8	35.7		7.2		10.1	5.0
Nigeria									
Senegal	1959	30.0	18.2	3.4	2.9	18.5	4.8	21.5	0.7
Ethiopia	1958	47.0	26.5	12.0	1.5	5.0	4.5		5.5
Kenya	1957	24.4	8.0	19.6	4.6	7.1	6.9	28.8	0.4
Rhodesia Nyasaland	1958	29.6	14.1	9.8	4.2	3.2	10.9	26.6	1.4

The share of manufacturing in total employment is indicative of the magnitude and relative importance of the stage reached in the development of industries. It is also evident that an accelerated rate of industrial development in African countries is as much hampered by the lack of skilled labour and the scarcity of managerial personnel as by the lack of capital investment. It is now being recognized that raising productivity in the primary producing sectors in many African countries would require more and better equipment, as well as intensive application of more advanced techniques of production involving better inputs of capital and higher skills. It is necessary to introduce new techniques and new forms of organization, not necessarily involving larger inputs of labour. Thus, the further development of primary sectors in a great number of countries in Africa can scarcely bring about substantial employment outlets in agriculture or mining to accommodate the increasing labour force. Demographic pressures on land resources, which are already felt in parts of North, West and East Africa, in addition to the rising demand for higher output *per capita*, would call for shifting a sizable part of the labour force from agriculture, where its productivity is low or even negative on account of unemployment, to industry, where *per capita* output is higher.

It is true that unskilled labour is abundant in the majority of African countries, as it is in many other developing countries. It is evident also that the skilled labour required for industrial development is as scarce as capital. In many newly independent countries of Africa, "crash" programmes of education and training schemes have been visualized or even begun. Nevertheless, attention should be given to the planning of education and training in conjunction with planned development of capacities and output in the various sectors of the economy, to maximize the benefit from the utilization of resources earmarked for education in the planning and development of needed manpower. It takes a long time to "produce" skilled workers and highly trained personnel for vast developmental undertakings. However, developing countries of Africa could economize on the use of available skills and managerial abilities by the choice of industries which call for lower requirements of skilled labour in relation to the output. Examples of these industries include basic chemicals, chemical products, metal products, rubber products, pulp and paper, for which market and raw-material possibilities exist in various countries. The expanding non-agricultural activities associated with the development of such manufacturing industries as construction and building, transport and communication, as well as distribution services, can afford more intensive utilization of labour in both the investment phase and the operational phase, in comparison with a range of industries for which developed technologies put limits on the number of workers needed to produce a specified level of output without sacrificing the productivity of labour. Export industries which need to meet the cost and quality of their foreign competitors will have to be relatively more capital intensive, utilizing more advanced technologies in comparison with the traditional industries which are confined to the production of import substitutes under some measures of protection

Expansion of non-farm employment opportunities for the growing labour force and the existing surplus manpower in agriculture is a major policy goal of industrialization in several countries of Africa, including Algeria, Tunisia and the United Arab Republic, where demographic pressure and underemployment or partial unemployment have existed for some time. In West Africa, Ghana and Nigeria also emphasized the expansion of employment opportunities through the development of the industrial sectors. In East Africa, the plans of Kenya, Malawi, the United Republic of Tanzania and Zambia emphasized also the employment objective of industrialization.

The development of industries to produce substitutes for imported light consumer-goods might offer more labour-intensive possibilities when established to cater for the domestic markets than would be the case when they produce for regional or subregional markets. Noteworthy in this respect is the fact that the reports of the industrial co-ordination missions of the United Nations Economic Commission for Africa[9] to East and Central Africa, to West Africa and to the Maghreb countries in North Africa (Algeria, Libya, Morocco and Tunisia) made no reference to specific labour-intensive industries or processes in their review of the concrete possibilities of industrial development of these subregions.

More attention should be given to the possibilities of obtaining increased employment and output from existing

[9] Documents E/CN.14/INR/1, E/CN.14/247 and E/CN.14/246 for these areas of Africa, respectively.

unused capacities and through full utilization of available facilities, as a more economic alternative to the creation of additional units. In that way, available capital resources could be saved for the development of new lines of production and thus open further employment outlets for the available labour supplies. Current pla of some countries in Africa give due consideration t the degree of utilization of existing capacity, while other emphasize the creation of additional plants an equipments.

V. Problems of choice and balanced growth

As is pointed out in a document recently presented to the United Nations Committee for Industrial Development, "there is no longer any substantial controversy about the importance of industrialization as the main long-run path of economic growth for the developing countries".[10] Contemporary thinking on the industrialization of less developed economies, while recognizing the importance of international division of labour and the accrued benefits from specialization, highlights the necessity of an industrialization policy oriented towards the creation of a diversified domestic industry. As expressed in another United Nations document, the ultimate objective of developing countries should be "to construct industrial economies as diversified as those which now exist in the advanced countries."[11]

Although the present study is concerned primarily with the problems and prospects of the industrial development of Africa, such problems and the measures to resolve them could only be assessed in the larger context of economic and social development. The more rapid growth rate of industries is visualized as an instrument and an important means for accelerated development of the African economies. The difficulties of attaining advanced levels of industrialization are, however, commensurate with the importance attached to industrial development and its requirements. African economies have been largely developed along primary production lines. Wherever secondary production has been developed, it has been based largely on import substitutes, with little emphasis on export-oriented industries. This problem of choice concerning how to industrialize, like most other problems of choice, should be looked upon, from the short-run as well as the long-run point of view, as a part of the general planning problem of industrial development. Some of these problems are dealt with below.

A. Import substitutes and export-oriented industries

As previously pointed out, the bulk of manufacturing development in Africa is based on the production of import substitutes. Export-oriented industries have mainly been involved in the simple processing of primary products of agriculture or of mining. However, a wide range of commercialized production of farm and forest products, as well as the bulk of mineral output, has been almost entirely exported in raw form to the outside world. Such resource- and export-oriented output in raw-material form, if manufactured gradually in the countries of origin, would greatly generate further value added, expand employment opportunities and result in larger foreign exchange earnings, which are very muc needed for the importation of machinery, equipment an other prerequisites of further growth in the developin countries of Africa.

The African share in world trade of beverage crops an of industrial crops is substantial, and its share in worl production of minerals is relatively high. The bulk African output of cocoa, coffee, tea, oilseeds, cotto sisal, skins and hides, etc. is still exported in raw for African output of cocoa, coffee, tea, oil seeds, cotto rock-phosphate and two-thirds of the chromite an manganese output. It produces more than two-thirds the world output of cobalt and gold, about one-fifth the world output of asbestos, half of the world pro duction of antimony and the bulk of the world outp of diamonds. However, such minerals are large exported without being manufactured.

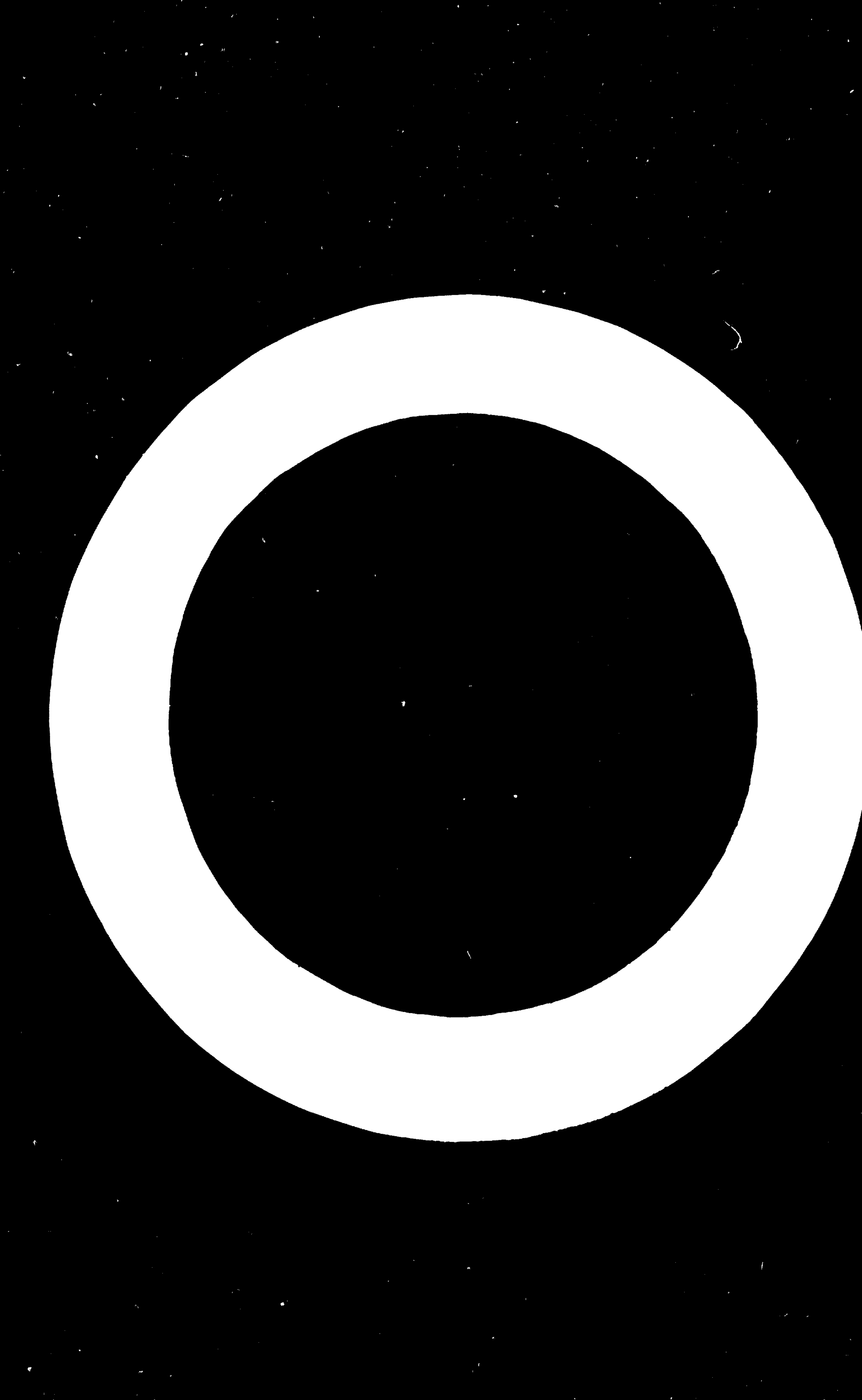
Greater diversity of economic activity throug industrialization is becoming a major aim of mo African countries. Although stress has been laid on t expansion of import-substitution industries, neve theless, it must be borne in mind that only a part of t value of imports represents value added in t manufacturing sector, and to this extent, the substitutio of domestic goods for imported ones might result in enlargement of the contribution of the domes manufacturing sector. This extent could be substantial narrowed, however, wherever import-substitutio industries are highly dependent upon imported materia labour and other requirements from abroad.

It appears that a higher degree of diversification output and significant additions to value added fr industry could be obtained through processing a manufacturing primary products before exportatio Depending in large measure upon technical a economic factors which are often beyond the control African countries, the extractive output of Africa cou provide a resource base for industrial developme oriented for relatively higher valued exports. The resource-oriented industries for export markets wou have a greater comparative advantage over a number established or contemplated industries destined produce a variety of substitutes for imports.

A balanced development of industries would requir close examination of its requirements, as well as of content. If increased consumption required the establis ment of import-substitution industries, investment such industries would necessitate larger imports machinery, equipment, raw materials and other inp which must be paid for in exports. Thus, consumpti and investment would need to be harmonized throu the establishment of some balance between impo substitution and export-oriented industries, in order effect a balance between consumption and investment a lower level of unfavourable balance of trade. It is be emphasized that the problem is not confined to choices between import-substitution or export-orien industries to be developed, but rather, it relates to

[10] United Nations Committee for Industrial Development, "Industrial development problems and issues" (E/C.5/75), Item 3(*a*) of the Provisional Agenda, Fifth Session, 19 April 1965.

[11] United Nations, *World Economic Survey, 1961* (United Nations publication, Sales No.: 62.II.C.1), p. 3.



proper combination of these two categories of industries for more balanced and sustained industrial development. Import substitution industries are largely oriented to domestic markets, but manufacturing of raw materials into semi-finished products or higher stages of output would involve the establishment of these industries mainly for exports. Needless to say, the expansion of raw material processing industries on a large scale for the production of exports would call for a co-operative arrangement between developed and developing countries and implies a new pattern in international location of industries and specialization based on a new division of labour.

B. Labour-intensive and capital-intensive industries

Another problem in industrializing is related to labour-intensive and capital-intensive industries. Here again, the problem is not concerned with the choice of one as against the other but rather the combination of the two. This combination would have to be guided by the principle of maximization of output and other benefits from the utilization of scarce given resources of capital, as well as of skilled labour, through time.

Labour at lower skills could be used where higher skills are not required, or in industries for which needed skills could be more easily acquired in a short period of time at a minimum cost. Capital-intensive industries normally require higher levels of skilled workers. Noteworthy is the fact that the combination between labour-intensive and capital-intensive industries is not merely a matter of composition of investment, but it implies also a pattern of allocation of labour skills, whether available or acquired.

Although the size of the market, and the stage of industrialization, as well the state of technology which is accessible to the country, are decisive factors in determining the technique of production to be used, the majority of current development plans in African countries favour labour-intensive processes in a number of planned industries. Other countries of the continent recognize that modern techniques over a wide range of heavy industries are capital intensive and that more mechanization is required to improve production and qualities of output. Thus, the emphasis on labour-intensive utilization is advocated less in factory operations, but more in the building trade and other construction activities, as well as in material handling, distribution and other ancillary services associated with the development of manufacturing in general and of heavy industries in particular. In addition, a number of countries have emphasized the full utilization of existing idle capacities as a possible outlet for further employment.

In contrast to traditional industries, the manufacturing industries oriented to produce for the export market would have to be relatively more capital intensive, utilizing more advanced technologies and higher levels of skill than the rest of the sector. Manufacturing lines which were originally established to produce for the domestic market, before succeeding in capturing a sizable export outlet, would have to modernize their equipment and intensify the use of capital in production processes. The spinning and weaving of cotton in the United Arab Republic, the oil extraction in a number of West African countries and some of the food and beverage preservation industries in East Africa may be mentioned as examples. It should be noted that while labour-intensive techniques will normally produce increased output and larger employment in the short run, capital-intensive techniques are apt to result in relatively higher aggregate output and a higher level of output per worker, as well as a larger surplus for reinvestment. Thus, capital-intensive techniques are to be favoured whenever the objective is to attain the greatest long-run growth of output and employment in industry. To strike a balance and provide for an optimum combination in order to attain the short-run as well as the long-run objective of industrialization is a planning problem to which attention is hereby directed.

C. Resource-oriented and market-oriented industries

Although primary production of agricultural and mineral output is predominant in African countries, stress has been laid in most countries on the development of import substitutes, largely of light consumer goods for domestic markets. Wherever these industries are based on the processing of domestically produced raw materials, they would be both resource-oriented and market-oriented. Durable consumer goods industries have been developed to a lesser extent in fewer African countries for the domestic market, but, in many cases, they are based on imported raw materials and skills, and in such cases they are market-oriented, not resource-oriented. Resource-oriented industries for export purposes are much less developed in most countries, excepting a few important industries based on the processing of the primary output of some mineral ores and a few agricultural products. In the long run, resource-oriented industries appear to have more possibilities for the accelerated growth of the industrial sector than do import substitution industries. The problem concerning choices for the development of industries is not between resource-oriented as against market-oriented ones; rather, it is related to what combination of both should be attained to sustain accelerated growth. Thus, African countries, in the formulation of their industrial development plans, should endeavour to work out these plans with a view to saving foreign exchange by developing import substitutes and increasing their earnings of foreign exchange when they establish resource-oriented industries for exports.

Past attempts to improve the foreign-exchange position through the establishment of industries which were not basically resource oriented are often found to have had adverse effects on the international balances of a variety of countries. In recent years, for example, different assembly plants have been put into operation in an increasing number of African countries and have been contemplated in the development plans of others. These industries have been intended to produce substitutes for imports of such final products as motor vehicles, bicycles, refrigerators, air-conditioners, radio sets, electric fans, sewing machines and other appliances or equipment, to save the foreign exchange previously required for the importation of these products. It is to be noted, however, that such assembly production, as it exists in a number of countries of North, West and East Africa, has not been based on established lines of manufacture, capable of producing various parts and other input goods required for sustaining its growth. In the absence of such input industries, assembly plants have to increase imports as output expands, and under these circumstances, they turn out to be import generators rather than import-substitution industries. Furthermore, assembly production in such cases would have very little backward linkage with the other home industries which do not produce the needed input. Moreover, the bulk of assembly production, based on imports of parts to be assembled into final consumer goods, has practically little forward linkage except with repair and maintenance establishments, which also depend upon imports. For lack of adequate planning to take care of the backward and forward linkage effects of such enterprises on other branches of industry, as well as on the whole economy, inaccuracies often exist in cost-benefit evaluation of projects, including the foreign exchange part. Furthermore the existence of inadequacies in other aspects of project selection in the case of assembly production in a number of African countries has often resulted in high-cost, low-capacity utilization and a mounting drain on foreign exchange.

D. Light and heavy industries

Another problem which is often raised concerning how to industrialize relates to the choice between light and heavy industries in both the short and the long run. The argument for light industries usually emphasizes the gradual approach to industrial development of countries in early stages, but it can scarcely provide the push required to break through the vicious circle of under-development and gather momentum for accelerated growth rates of the developing economies of the continent. Heavy industries which largely produce input goods for other industries and final products of capital goods provide the possibility for further development of various branches of the economy, as well as establish complementarity and closer linkage between primary and final production. Industries belonging to the group of intermediate manufacture, such as iron and steel, basic chemicals and fertilizers, rubber products and others, are among the heavy industries which have high backward and high forward linkage in the economy.

Vigorous growth of the industrial sector usually requires a combination of heavy and light industries to be established without forsaking the principles of comparative advantage, specialization and interconnexions in the development of various economic sectors. With a large portion of primary production linked with the export markets outside the national and subregional economies of Africa, its forward and backward linkages are both low with reference to the African economies, but are closely connected to the economies of developed countries which import such a production. However, turning raw-material production into intermediate and semi-finished goods would provide for a stronger industrial base at home and enlarge the possibilities for better exchange earnings from exports. These industries, however, are mostly capital intensive and require considerable "know-how" and industrial experience, in addition to some security of expectation with regard to international markets, since domestic outlets are often too small to absorb the potential output. In contrast to light industries for domestic consumption that could be developed behind tariff walls and other measures of protection or assistance on the national level, export-oriented industries would have to be competitive and would require measures of international co-operation and action.

E. National, intraregional and regional industries

With the exception of a few countries of Africa, domestic markets are small. The narrowness of national markets is manifest by the small population size, by low income *per capita*, by the sizable magnitude of the traditional and subsistence sectors and by the prevalence of large numbers of small-size establishments in the manufacturing sector. In planning for industrial development, the majority of countries in the region have based their decisions on national considerations, and few of them in more recent years have realized the importance of subregional co-operation in the establishment of large-scale, capital-intensive industries which require a larger market for more economic operations. Examples of these may be found in the case of iron and steel plants which are under way or are being contemplated in the Maghreb countries and in countries of West Africa, the assembly production of engineering industries in Southern Rhodesia and neighbouring countries of East Africa and a number of heavy and light industries in Southern Africa, as well as in Central and North Africa.

Closer co-operation between countries located in the African subregions has been fostered by the United Nations Economic Commission for Africa and is being promoted by the formation of customs unions between a number of countries in East Africa, as well as in West and Central Africa. Nevertheless, efforts in this respect have been directed towards the creation of import-substitution industries on a subregional basis, while in the field of resource-oriented industries for exports, intraregional attempts have so far been negligible. Regional and subregional action on both fronts cannot be over-emphasized. However, in planning for over-all development of industries in Africa, this important aspect cannot be overlooked.

It cannot be overstated that the establishment of subregional industries would require an adequate environment for mobility of resources and of products in order to reap the benefits accruing from specialization and diversification, and to effect a degree of integration on the national and subregional levels. Specialization and diversification on the national level coupled with integration of industrial development on a subregional or regional basis, are apt to result in minimizing socio-economic costs, on the one hand, and would serve for better distribution of benefits and of burdens, on the other hand.

Attention needs to be given to aspects of standardization in the development of national, subregional or regional industries with reference to specifications of materials, designs of plants, machinery and equipment, as well as final products. Regional and subregional co-operation is required to effect unified standards in the development of industries oriented to satisfy demand on a continental or subcontinental basis

VI. Problems of co-ordination and integration

The complex and multidimensional process of economic development through industrialization in Africa as well as in other developing areas is by necessity a long-term one requiring adequate measures of comprehensive planning and deliberate policy action in the national sphere and on the international level. It has been increasingly recognized that for these countries to achieve rapid and sustained growth rates of their economies, some determination should be made of a set of interrelated industrial targets and priorities should be assigned to resource and product allocation by a central authority to bring about harmony between objectives and action. Adequate co-ordination of efforts and reconciliation of objectives are essential elements in mobilizing available resources for industrial development in the context of over-all economic and social development. The need for adequate programming on the national level, if coupled with concerted action of the world community over periods of time, would set the pace for accelerated development and realization of mutual benefits.

Important problems of industrial programming stem from the lack of co-ordination and integration of objectives and of action on the national levels. Some of these problems originate with partial programming, which does not give due consideration to over-all development requirements. Others are related to the range of choices between complementary or alternative actions and the combination of lines of development based on such choices. It is to be stressed that the long-term view of industrialization of a national economy requires long-term planning in which proper combinations of resources and of objectives may result in vigorous development and sustained growth. What would appear to be alternative choices in the short run, as between import substitution and export-oriented industries, between capital-intensive and labour-intensive undertakings, or between light and heavy industries, would, in a longer term view of industrial development, call for the establishment of some optimum combinations of all these through time. Sets of value priorities and time priorities are required for the formulation, evaluation and selection of industrial development programmes and projects, commensurate with the short-run as well as the long-run goals to be achieved.[12]

Comprehensive planning for industrial development has been inaugurated rather recently in the majority of African countries. Although the degree of comprehensiveness and coverage varies a great deal from one country to another, most development plans have been national in scope with rudimentary or little reference to corresponding plans of neighbouring countries of the continent. Absence of co-ordination on the subregional or regional level has been a common feature. Another common feature, though it appears less pronounced, is reflected in the lack of integration between declared national policies of industrialization and national programmes and projects designed for their implementation. Proposed programmes and projects often have been based on quick surveys of industrial opportunities without detailed feasibility studies and project evaluations.

Many plans recognize the importance of welding the financial, the material and the administrative aspects of programming for industrial development, but details of these have been often missing. The financial plans have seldom been dovetailed with the budgeting of material resources or fitted into a comprehensive growth framework of both the capital and the labour resources required for realization of development and its objectives.

Although the plans for economic and social development in many African countries have recognized the scarcity of skills and high-level manpower, and provisions for the expansion of educational and training facilities have been incorporated in these plans in a variety of ways, nevertheless, little co-ordination actually exists between the projected expansion of education, in qualitative and quantitative terms, in relation to the requirement of planned undertakings which call for certain categories of skills, specialization and "know-how".

In the formulation of projects and programmes of development, due consideration should be given to co-ordination and integration not only within the industrial sectors, but also between these and other related sectors of the economy. The assessment of the long-term growth prospects for the economy, as well as the determination of priorities in relation to objectives, should serve as a guide not only for co-ordinated development on the national level, but also for concerted action and co-operative efforts on international levels.

In all African countries, mixed economies prevail, with varying importance of the public and private sectors. Different degrees of emphasis have been placed in the implementation of current development plans on the role of each sector, as mentioned in a previous chapter. Co-ordination between private and public spheres of action is rather important for the attainment of socio-economic goals. Conflicting policy measures could well be avoided and replaced by complementary decisions which would ensure integration and co-ordination between the objectives of policy and the various means devised to achieve them.

The economies of African countries are largely open economies which are dependent upon the world market for exports and for supplies of variety of goods and services required for development. Their current development plans depend, to a large or small extent, upon the flow of foreign resources of capital, skills and know-how for implementation. Under these conditions, more co-ordination is needed between national development efforts and related international activities and institutions. In this respect, co-ordination between technical assistance from international sources and technical problems confronting planning and implementation on the national level would be warranted.

All those aspects of co-ordination and integration, as well as a few others, require comprehensive research and elaborate studies in which both national and international agencies can assist and take an important role. It should be mentioned, however, that planners and policy-makers for industrial development on the African scene are confronted with the familiar difficulty of inadequate statistical data and the rudimentary character of available information concerning industry and other economic sectors.

[12] For theoretical analysis concerning these issues and others, see United Nations Committee for Industrial Development, "Industrial development, problems and issues" (E/C.5/75) 19 April 1965.

The need for subregional co-operation to foster economic development is being progressively emphasized by member countries of the continent and, in response, by the Economic Commission for Africa and other agencies of the United Nations family. Without closer co-operation between countries in the region, the formidable obstacles which confront many countries in Africa make it difficult to build viable economies within the strict confines of national boundaries. This derives from a variety of factors, including the narrow manpower base and the small size of national markets associated with the small populations in a large number of countries.[13] In addition, there is the fact that the natural-resource endowment is quite modest and rather undiversified in many of these countries. Closer co-operation between groups of these countries is needed to build up a strong industrial base for sustained economic and social development. An optimum situation would be for a group of neighbouring countries with a diversified, but complementary, resource combination and common interests to form among themselves a socio-economic entity for comprehensive planning. Alternatively, these countries would need to integrate, or at least to harmonize and co-ordinate, their national development plans and thus provide for the more efficient use of available resources and create an environment more conducive to sustained and accelerated industrial growth.

[13] In 1960, among the countries of West and South-west Africa, Basutoland, Bechuanaland, Gabon, Liberia, Mauritania and South West Africa each had a population of a fraction of 1 million persons; Guinea, Ivory Coast, Niger and Senegal each had a population of less than 3.2 million; in Angola, Cameroon, Mali and Upper Volta, the populations ranged from 4 million to less than 5 million. In East Africa, the populations of Burundi, Malawi, Rwanda, Southern Rhodesia, Somalia and Zambia ranged from 2 million to less than 4 million; a few countries of the subregion — Ethiopia, Kenya and Tanzania — had populations of 8 million persons or more. In Central Africa, the population of the Congo (Brazzaville) amounted to a fraction of 1 million; that of the Central African Republic, to 1.2 million; and that of Chad, about 2.7 million.

VII. Scope for international and interregional action

Solution of the intricate problems of industrialization of the under-industrialized countries in Africa, as in other areas, would require a variety of interrelated efforts, part of which should be at the national level, while others would call for international action on an intraregional or an interregional basis. Each country, in its own particular environment, would have to tackle a number of internal problems and obstacles which are national in character and participate with the world community in working out solutions for problems requiring concerted efforts and international action.

A variety of important obstacles and problems requiring national action have been reviewed in the previous chapters of this study. They are more or less related to the current state of national planning for industrial, as well as over-all socio-economic progress, and their solution is largely dependent upon progress in comprehensive planning for sustained and accelerated development. It is widely recognized that industrial growth can be accelerated in these developing countries only if they undertake deliberate action to plan the best use of their resources in the light of available markets, whether these are national, regional or world-wide. It is also important for each country to evaluate its own needs, assess its own resources, determine its own development objectives and closely assign priorities over time. There is little doubt, however, that many of these countries would need external assistance in the determination of their best industrial opportunities and in mobilizing available resources to realize these opportunities and reap their benefits.

One of the major obstacles to the promotion of industry in many of the newly emerging countries of Africa pertains to the absence of surveys of industrial development opportunities and the lack of adequately prepared programmes and projects which would attract the necessary financing from national or international sources. Over a wide area of industrial research, including the transfer or adaptation of modern technologies to the needs and circumstances of developing countries, international action and adequate assistance by the world community are also required.

It is becoming more clearly recognized that developing countries can scarcely become self-supporting at a high level of growth unless they create new capacities for export-oriented manufactures. Action directed towards the realization of this objective would involve, on the one hand, concerted efforts by developed and developing countries to bring about a "modified international division of labour, which is more rational and equitable and is accompanied by the necessary adjustments in world production and trade".[14] It involves, on the other hand, concerted efforts by countries in the subregions of Africa to promote regional specialization and exchange with a view to realizing the economies of scale not available to small developing countries acting independently of one another. In both those spheres of action, considerable assistance would be warranted on a national and on a regional and world-wide basis, in the formulation of appropriate policies needed, as well as in programming for their implementation.

There are many barriers in the individual countries of Africa formed by history, tradition, language, currency and even industrial specifications, in addition to other natural or man-made obstacles which stand in the way of closer co-operation and integration of industrial development activities. Here again, regional and subregional efforts to bring about effective co-operation through co-ordination are needed to remove the existing difficulties and to spur the tempo of vigorous industrial growth. Many efforts are being undertaken by the countries concerned, with the assistance of subregional organizations as well as with the help of the United Nations and its specialized agencies and organs, each within its own field of competence. Although programmes of research and avenues of direct assistance in various aspects of industrial development are expanding in response to the demands and needs of under-industrialized countries, collaboration and co-

[14] *Proceedings of the United Nations Conference on Trade and Development:* vol. I: *Final Act and Report* (United Nations publication, Sales No.: 64.II.B.11), Final Act, para. 5.

ordination at the current stage leaves much to be desired, at both the international and the country levels.

A great deal of effort based on concerted action at the national, regional and international levels is required in the formulation and adoption of standard specifications for various industries in Africa. The integration of markets and products requires the application of unified standards not only for industrial products and their major input content, but also in specifications concerning layout of plants, power installations, transport connexions and other services closely related to the development of industries on a subregional or regional basis.

ANNEX

Statistical data on the evolution and current structure of industries in Africa, 1950-1963: Tables 23-30

This is an attempt to produce a complete statistical picture of the evolution and current situation in the whole of Africa, with the exception of Southern Africa, comprising the following countries: Basutoland, Bechuanaland, South Africa, South West Africa and Swaziland.

There are very few countries for which series of data covering the whole period exist, and where they exist, they are far from satisfactory. Thus, the picture presented here is an attempted reconstruction of the likely pattern of movements, with many gaps being filled in by estimates of figures extracted from national development plans, the achievement of which is not known so far. Therefore, it should be understood that references to dates, e.g., 1950 or 1963, are not intended to be precise. Interpolation, extrapolation, and back and forward projections have been used when estimating the missing data for 1950 and 1963.

Data used for the tabulations and estimates were derived, for the most part, from United Nations documents and publications, and from national plans and publications. The classifications of industries and of goods used in the present exercise are given in tables 28 and 29.[a] The list of countries included in each subregion is given in table 30.

Throughout the exercise, the data refer to prices prevailing in 1957 or thereabouts, i.e., 1956-1958. The gross domestic product is given at market prices. "Medium" population estimates have been used.[b]

Although an attempt has been made, it was impossible to produce a statistical review of data concerning capital formation (within the industrial sector), as well as regarding industrial employment. In both cases, not only the scarcity of the data, but also its substantial inconsistency, made the tabulation impossible.

[a] The analysis of the available data led to these classifications, which may be regarded as not fully conforming with the theoretical point of view.

[b] Data given in *Demographic Yearbook, 1963* (United Nations publication, Sales No.: 64.XIII.1), pp.148-161, table 4, have been consistently used throughout the study.

Table 23. Africa: general statistical data, 1950-1963

	Population (millions)	Total[a]	Industrial gross domestic product (millions of dollars)							Industrial gross domestic product as percentage total	Per capita (dollars)	
			Mining and Quarrying	Manufacturing industries					Grand total		Total gross domestic product	Industrial gross domestic product
				Agro-allied	Light	Heavy	Total					
1950												
Northern subregion	51.1	7,660	135	213	187	151	551		686	9	150	13
Western subregion	50.3	4,610	79	97	43	17	157		236	5	91	5
Central subregion	22.8	1,270	108	83	33	77	193		301	23	56	13
Eastern subregion	59.3	3,270	173	153	62	124	339		512	9	55	9
AFRICA[b]	183.5	16,810	495	546	325	369	1,240		1,735	9	92	9
1963												
Northern subregion	70.8	12,680	680	597	601	600	1,798		2,478	18	179	35
Western subregion	75.6	8,130	171	287	132	52	471		642	7	107	8
Central subregion	29.9	2,920	180	171	85	171	427		607	20	98	20
Eastern subregion	77.5	5,960	231	281	151	240	672		953	16	77	12
AFRICA[b]	253.8	29,690	1,262	1,336	969	1,063	3,368		4,680	15	117	18

[a] At market prices (1956-58).

[b] Excluding South Africa.

Table 24. Evolution of the degree[a] of industrialization in Africa[b], 1950-1963

	Class I: $200 and over per capita				Class II: $100 to 199 per capita				Class III: $50 to 99 per capita				Class IV: Less than $50 per capita				Total			
	Number of countries	Class' share in gross domestic product (percentage)	Class' share in population (percentage)	Average gross domestic product, per capita (dollars)	Number of countries	Class' share in gross domestic product (percentage)	Class' share in population (percentage)	Average gross domestic product, per capita (dollars)	Number of countries	Class' share in gross domestic product (percentage)	Class' share in population (percentage)	Average gross domestic product, per capita (dollars)	Number of countries	Class' share in gross domestic product (percentage)	Class' share in population (percentage)	Average gross domestic product, per capita (dollars)	Number of countries	Subregion share in gross domestic product (percentage)	Subregion share in population (percentage)	Average gross domestic product, per capita (dollars)
1950																				
Northern subregion	1	33	18	296	5	67	82	119	—	—	—	—	—	—	—	—	6	45	28	150
Western subregion	—	—	—	—	5	39	23	148	8	57	69	76	1	4	8	45	14	27	27	91
Central subregion	—	—	—	—	—	—	—	—	6	85	82	87	1	15	18	49	7	8	12	56
Eastern subregion[c]	—	—	—	—	3	25	10	148	3	37	30	68	7	38	60	34	13	20	33	55
TOTAL	1	15	6	296	13	46	32	128	17	30	39	69	9	9	23	36	40	100	100	92
1963																				
Northern subregion	3	42	24	310	2	49	57	150	1	9	19	90	—	—	—	—	6	43	28	179
Western subregion	1	20	10	217	6	31	22	149	6	47	62	82	1	2	6	39	14	27	30	107
Central subregion	1	5	2	301	3	30	22	134	3	65	76	84	—	—	—	—	7	10	12	98
Eastern subregion	2	18	6	236	2	21	11	142	6	26	42	70	3	35	41	42	13	20	30	77
TOTAL	7	27	12	277	13	36	29	148	16	31	45	80	4	6	14	42	40	100	100	117

[a] For definition, see United Nations, *Patterns of Industrial Growth, 1938-1958"* (United Nations publication, Sales No.: 59.XVII.6).
[b] Excluding Basutoland, South Africa, South West Africa and Swaziland.
[c] Excluding Reunion.

Table 25. The growth of industry in Africa, 1950-1963

	Rates of growth (compound percentage per annum)							Growth per capita (dollars)							
	Total gross domestic product	Industrial gross domestic product						Total gross domestic product		Industrial gross domestic product		Supply of manufactured goods[a]			
		Mining and quarrying	Manufacturing Industries: Agro-allied	Light	Heavy	Total	Grand total	1950	1963	1950	1963	1950 Domestic	1950 Imported[b]	1960 Domestic	1960 Imported[b]
Northern subregion	4.0	13.2	8.2	9.4	11.2	9.5	10.4	150	178	13	35	15.4	19.6	55.8	34.2
Extremes[c]	2.1 – 14.6	2.4 – 65.4	3.5 – 12.1	0.9 – 31.0	2.9 – 19.0	3.4 – 15.8	3.1 – 29.3								
Western subregion	4.4	6.1	8.6	8.8	8.7	8.8	8.0	91	107	5	8	22.4	9.6	20.4	19.6
Extremes[d]	1.8 – 10.9														
Central subregion	6.7	4.0	5.7	7.6	6.3	6.3	5.5	56	98	13	20	9.9	13.1	18.6	19.4
Extremes[d]	5.0 – 4.4														
Eastern subregion	4.7	2.2	4.7	7.1	5.2	5.4	4.4	55	77	9	12	11.3	9.7	13.1	15.9
Extremes[c]	1.4 – 7.7	0 – 7.3	1.3 – 13.0	0.9 – 13.6	1.7 – 14.6	1.4 – 11.3	2.0 – 10.4								
TOTAL	4.5	7.4	7.1	8.7	8.4	8.0	7.8	92	117	9	18	15.1	12.9	27.5	22.5
Extremes	1.4 – 14.6	0 – 65.4	1.3 – 13.0	0.9 – 31.0	1.7 – 21.1	1.4 – 15.8	2.0 – 29.3								

[a] Excluding Southern Africa.
[b] Business gross output of c.i.f. prices

a Excluding Southern Africa.
b Business gross output of c.i.f. prices.
c Minimum and maximum rate of growth achieved by individual country.
d The former French Equatorial Africa being treated as one unit by 1950 does not allow calculation of all rates of growth.

Table 26. Africa: changes in the structure of manufactured goods supply, 1950-1963 [a]

(Percentage)

	1950					1963				
	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total
					CONSUMER GOODS					
Domestic demand	100	100	100	100	100	100	100	100	100	100
Import	39	18	42	38	31	19	28	33	44	27
Domestic supply	61	82	58	62	69	81	72	67	56	73
Export	26	—	4	21	13	8	2	3	27	9
Domestic production	87	82	62	83	82	89	74	70	83	82
Demand index[b]						372	151	256	179	234
Domestic-production index						379	138	297	178	234
Domestic-supply index						495	132	295	161	246
					CAPITAL GOODS					
Domestic demand	100	100	100	100	100	100	100	100	100	100
Import	89	100	100	100	95	79	100	100	82	86
Domestic supply	11	—	—	—	5	21	—	—	18	14
Export	1	—	—	—	—	1	—	—	4	1
Domestic production	12	—	—	—	5	22	—	—	22	15
Demand index						321	302	161	266	281
Domestic-production index						585	—	—	6990	822
Domestic-supply index						626	—	—	40790	868

	1950					1963				
	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total
					INTERMEDIATE GOODS					
Domestic demand	100	100	100	100	100	100	100	100	100	100
Import	67	64	54	37	55	52	76	62	56	59
Domestic supply	33	36	46	63	45	48	24	38	44	41
Export	5	44	86	38	32	8	24	90	65	31
Domestic production	38	80	132	101	77	56	48	128	111	72
Demand index[b]						337	377	193	149	259
Domestic-production index						498	224	188	165	242
Domestic-supply index						495	247	157	102	236
					TOTAL MANUFACTURED GOODS					
Domestic demand	100	100	100	100	100	100	100	100	100	100
Import	56	30	57	46	46	38	49	51	55	45
Domestic supply	44	70	43	54	54	62	51	49	45	55
Export	16	4	29	25	16	8	7	27	35	14
Domestic production	60	74	72	79	70	70	58	76	80	69
Demand index						354	188	218	180	247
Domestic-production index						407	147	231	182	243
Domestic-supply index						501	138	250	148	251

a Based on business gross output and c.i.f. rates.
b All indexes for 1950 = 100.

Table 27. Africa: changes in the structure of industry, 1950-1963 [a]

(Percentage)

	Structure										Output indexes[b]					Structure (comparative data)			
	1950					1963					1963								
	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total	North. sub-region	West. sub-region	Centr. sub-region	East. sub-region	Total	United Kingdom [illegible]	U.S.A. [illegible]	Italy [illegible]	France [illegible]
Mining and quarrying	20	33	36	34	29	27	27	30	26	27	502	217	166	133	255	8.4	8.8	3.8	3.2
Agro-allied industries	31	41	28	30	31	24	45	28	31	29	280	295	205	183	244	9.4	12.0	16.6	16.0
Light industries	27	18	11	12	19	24	21	14	16	21	322	302	259	244	298	30.6	29.7	29.4	46.0
Heavy industries	22	8	25	24	21	25	8	28	27	23	398	298	220	193	287	51.6	49.5	50.2	34.8
TOTAL	100	100	100	100	100	100	100	100	100	100	361	271	201	176	267	100.0	100.0	100.0	100.0

a In terms of value added.
b 1950 = 100 (in terms of value added).

Table 28. Classification of industries

Group	ISIC No.[a]	Industry or manufacture
Mining	1	Mining and quarrying
Agro-allied	20	Food
	21	Beverages
	22	Tobacco
Light	23	Textiles
	24	Foot-wear and wearing apparel
	26	Furniture and fixtures
	27	Paper and paper products
	28	Printing, publishing etc
	29	Leather etc
	30	Rubber products
Heavy	25	Wood and cork
	31	Chemicals and chemical products
	32	Products of petroleum and coal
	33	Non-metallic mineral products
	34	Basic metal industries
	35–38	Engineering industries

SOURCE: United Nations, *International Standard Industrial Classification of All Economic Activities* (United Nations publication, Sales No. 58.XVII.7).
[a] International Standard Industrial Classification.

Table 29. Classification of goods in relation to industries

Group	*SITC No.*[a]	*Industry*	*ISIC No.*[b]
Crude	27, 28, 32 (except 321.8), 331 and 667	Mining and quarrying	1
Consumer	01, 02, 03, 06, 08, 046-8, 052, 053, 055, 073	Food, beverages and tobacco	20, 21, 22
	61, 65, 84, 85	Textiles, leather, foot-wear, wearing apparel	23, 24, 29
	62, 64, 82, 892	Furniture and fixtures, paper, printing and publishing, rubber products	26, 27, 28, 30
Intermediary	63, 66 (except 667), 69, 812	Wood and cork, nonmetallic mineral products and metal products	25, 33, 35
	67, 68	Basic metals	34
	321.8, 332, 4, 5	Chemicals and chemical products (incl. petroleum etc.	31, 32
Capital	7	Engineering industries	36, 37, 38

[a] Standard International Trade Classification.
[b] International Standard Industrial Classification.

Table 30. List of African subregions and countries

Northern subregion	*Western subregion*	*Central subregion*	*Eastern subregion*
Algeria	Dahomey	Angola	Burundi
Libya	Gambia	Cameroon	Ethiopia
Morocco	Ghana	Central African Republic	Kenya
Sudan	Guinea	Chad	Madagascar
Tunisia	Ivory Coast	Congo (Brazzaville)	Malawi
United Arab Republic (Egypt)	Liberia	Congo (Democratic Republic of)	Mauritius
	Mali	Gabon	Mozambique
	Mauritania		Reunion
	Niger		Rwanda
	Nigeria		Somalia
	Senegal		Southern Rhodesia
	Sierra Leone		Uganda
	Togo		United Republic of Tanzania
	Upper Volta		Zambia

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2. DEVELOPMENT OF FOREST INDUSTRIES IN AFRICA

Forestry and Forest Products Division, Food and Agriculture Organization of the United Nations

CONTENTS

Introduction

The purpose of this paper is to go some way in assessing the potential of forest industries in Africa and the contribution that these industries may be expected to make to the over-all economic and industrial development of the region over the next decade, 1965-1975. The study is restricted to primary products. The Inter-governmental Conference on Timber Trends and Prospects (Nairobi, September 1965) and the United Nations Economic Commission for Africa (ECA) Conference on the Harmonization of Industrial Development Plans in East Africa (Lusaka, November 1965) dealt in considerably more detail than is possible in this paper with the rôle to be played by the forest resource and non-wood potential of Africa in the developing industrialization of the region, and the findings of these two conferences call for careful study.

The sources from which the present report has been compiled are indicated by asterisks in the reference list given at the end of the paper.

A. General information

Africa has a wide variety of forest conditions and an equal diversity of levels and kinds of use of wood and wood products. The resource runs all the way from the rich forests of Western Africa to those parts of Northern Africa which have little or no natural forest. Consumption of wood likewise extends from advanced applications of the more sophisticated paper, panel and other processed products to utilization in the round for fuel and mud-and-pole building, a use that still prevails over most of rural Africa. Because so much of the wood consumed in the region is used in this simple fashion, very largely outside the market economy, and because so much of the forest has not been brought into commercial use, the extent both of the forest resource and of wood production and wood use is but imperfectly known. The data which have been collected so far are often no more than tentative; nevertheless, on the basis of the information available it is possible to make a rough assessment of current forest resources and of the production, consumption and trade in wood and wood products to make tentative estimates of the needs of the region over the next ten years and to suggest in broad outline the general direction in which the wood industry should develop to meet these needs. It is hoped that it may serve as a guide to countries in harmonizing and setting up national policies and plans for the effective development of the wood and, where necessary, non-wood resources in the wider setting of the needs of the region or subregion. The study, of course, in no way approaches the detail that individual countries and groups of countries require in order to draw up and execute their policies and plans. Indeed, the paucity of the data which are currently available for some countries sharply underlines the need for investigations at national and local levels.

B. Current and future patterns of supply and consumption of wood

The current pattern of consumption of wood and wood products in each of the four subregions of Africa, as considered in this report,[1] is shown in table 1. The dominance, in terms of volume, of the largely rural, often subsistence, use of wood in the round is immediately apparent. But it is the processed forms of wood which merit attention in this paper. Sawnwood, plywood, particle board, fibreboard, paper and paperboard are vital producer and consumer goods for advanced, dynamic industrial economies. Moreover, they are products of industries which can contribute significantly to industrialization and, through it, to growth.

Table 1. Annual consumption of wood products in Africa in 1959-1961 and estimated requirements in 1975

	Sawn wood	Panel products	Round wood products	Fuel wood	Paper and paperboard (millions of tons)
	millions of cubic metres				
Current consumption					
Western Africa	1.10	0.06	4.9	80.4	0.08[a]
Eastern Africa	0.82	0.07	4.8	89.6	0.11[a]
Northern Africa	1.00[a]	0.11[a]	0.4[a]	4.1[a]	0.31[a]
Southern Africa	1.08[b]	0.13[b]	1.8[b]	2.5	0.39[a]
African Region	4.00	0.37	11.9	176.9	0.89[a]
Requirements in 1975					
Western Africa	2.39	0.15	6.6	105.2	0.26
Eastern Africa	1.62	0.20	6.6	113.6	0.28
Northern Africa	1.74	0.33	0.7	6.2	0.81
Southern Africa	1.34	0.30	1.5	3.4	0.86
African region	7.09	0.98	15.4	228.4	2.21
Index African region (current consumption 100)	177	265	129	129	246

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

[a] Consumption in 1960-1962.

[b] Consumption in 1959.

1. ESTIMATE OF GROWTH

A measure of the extent to which more processed wood will be required as the African economy grows is shown by the estimate of consumption in 1975 given in table 1. This estimate is based on an assumed growth in the population of Africa from 259 million in 1960 to [illegible] million in 1975, and an average growth in gross product *per capita* during this period of 2 per cent per annum. The regional requirements in 1975 associated with this growth in economic activity will exceed current consumption levels by some 1.3 million tons of paper and paper-board, 3 million m^3 of sawnwood and 600,000 m^3 of wood-based panel products. In fact, growth in consumption of both paper and paperboard and panel products is expected to be faster than growth in economic activity, and sawnwood consumption will rise nearly as fast as the latter. Consumption of other roundwood and fuelwood, on the other hand, is expected to grow at the same rate as population, or at a slightly slower rate.

2. PROCESSED-WOOD PRODUCTS

Processed-wood products are also important because they are, to a large extent, still imported and so must be paid for by scarce foreign exchange. Seventy per cent of the paper and paperboard, 65 per cent of the panel products and 45 per cent of the sawnwood consumed by the countries of Africa in 1959-1961 were imported (see table 2). These imports amounted to $280 million per annum, of which more than one-half was accounted for by paper and paperboard. The latter are products of an industry which is generally capital intensive and subject to significant economies of scale. The small market of most individual African countries, therefore, has not been sufficient to support domestic production—quite apart from the problems of the availability of an appropriate raw material base and of the necessary skills and capabilities to support such an industry. Outside Southern Africa and a few countries in Northern Africa, dependence upon imports for supplies of paper and paperboard has been almost total.

3. OUT-FLOW OF LOGS

The other element of the current pattern is in the exportation of wood from Africa. There is a massive outflow of logs (see table 3). These nearly all come from Western Africa, which also exports considerable quantities of sawnwood and plywood. The quantities of other forms of processed wood exported by African countries are smaller. Africa is, therefore, in the undesirable and anomalous position of having to import high-cost processed wood, but of being able to export predominantly lower value raw wood.

C. Prospects and problems

By 1975, Africa will require a considerably greater volume of wood, with much more of it in processed form than is currently the case. At current prices, the additional processed products would amount to $500 million per annum. Africa will also require wood for exportation—again preferably in high-value processed forms. What are the prospects of supplying the quantities of wood involved? Can the industries necessary to process the required production be established? What problems will be encountered, and what are the implications for the policies and plans that must be formulated in order to bring this about?

1. FOREST RESOURCE

The extent and nature of the African forest resource is summarized in table 4, and current annual removals are given in table 5. Two major types of forest can be distinguished. About 200 million hectares, most of it in the western subregion, are closed high forest of a moist type containing a great diversity of species, of which only a limited number have yet found commercial applications. Although the total wood volume in this type of forest may be quite high, commercial yields are usually low. Most of the rest of the forest area is savannah woodland and wooded steppe, mainly open formations with little material of the sizes or qualities capable of supplying sawlogs. Yields from a unit area of this type of forest are therefore very low. Also

[1] In the present paper, the following groupings of countries into subregions are used: *Western Africa:* Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Democratic Republic of), Dahomey, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Portuguese Guinea, Senegal, Sierra Leone, Spanish Equatorial Region, Togo, Upper Volta; *Eastern Africa:* Burundi, Ethiopia, French Somaliland, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Rwanda, Somalia, Southern Rhodesia, Sudan, Uganda, United Republic of Tanzania, Zambia; *Northern Africa:* Algeria, Libya, Morocco, Tunisia, United Arab Republic; *Southern Africa:* Basutoland, Bechuanaland, South Africa, South West Africa, Swaziland.

INDUSTRIAL DEVELOPMENT IN AFRICA

PART ONE Progress and problems of industrialization

PART TWO Country reports: Cameroon • Ethiopia • Kenya • Niger • Sudan • United Arab Republic • Zambia

Selected documents presented to the Symposium on Industrial Development in Africa

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Table 2. Annual production, imports, exports and consumption of processed wood products in Africa, 1959/1961

(Millions of units)

	Production	*Imports*[a]	*Exports*[a]	*Consumption*
Western Africa				
Sawnwood (cubic metres)	1.56	0.06	0.52	1.10
Plywood and veneer (cubic metres)	0.16	0.01	0.14	0.03
Fibreboard and particle board (tons)	—	0.02	—	0.02
Paper and paperboard (tons)		0.08		0.08
Total in terms of wood raw material (cubic metres)	3.52	0.43	1.39	2.56
Eastern Africa				
Sawnwood (cubic metres)	0.71	0.30	0.19	0.82
Plywood and veneer (cubic metres)	0.01	0.01	—	0.02
Fibreboard and particle board (tons)	—	(0.02)	—	0.03
Paper and paperboard (tons)	0.01	0.09	—	0.10
Total in terms of wood raw material (cubic metres)	1.47	0.94	0.38	2.05
Northern Africa				
Sawnwood (cubic metres)[b]	(0.09)	(0.91)	—	(1.00)
Plywood and veneer (cubic metres)	0.01	0.08	—	0.09
Fibreboard and particle board (tons)		0.02	—	0.02
Paper and paperboard (tons)	0.12	0.21	0.04	0.29
Total in terms of wood raw material (cubic metres)	0.56	2.70	0.12	3.14
Southern Africa				
Sawnwood (cubic metres)	0.54	0.58	0.03	(1.08)
Plywood and veneer (cubic metres)	(0.02)	0.01	—	(0.03)
Fibreboard and particle board (tons)	(0.09)	—	0.03	(0.06)
Paper and paperboard (tons)	0.18	0.20	0.02	0.36
Total in terms of wood raw material (cubic metres)	1.87	1.78	0.19	3.46
African total				
Sawnwood (cubic metres) ..	2.88	1.85	0.73	4.00
Plywood and veneer (cubic metres)	0.20	0.12	0.14	0.18
Fibreboard and particle board (tons)	0.10	0.05	0.03	0.12
Paper and paperboard (tons)	0.31	0.58	0.06	0.83
Total in terms of wood raw material (cubic metres)	7.44	5.87	2.07	11.24

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

[a] Import and export figures include the small volume of trade within the subregions and within the region.

[b] 1960-1962 averages.

Table 3. Composition of African trade in wood products, 1959-1961

	Logs[a]	*Sawnwood*[b]	*Plywood and veneers*	*Fibre-board and particle board*	*Paper and paper-board*	*Pulp and waste paper*	*All wood products (annual value in millions of dollars)*
	(Thousands of cubic metres per annum)			*(Thousands of tons per annum)*			
Imports							
Western Africa	35	62	13.3	15.7	77.08	0.3	38.27
Eastern Africa[c]	14.2	299	12.9	17.8	92.26	5.1	50.87
Northern Africa	195.3	914	84.2	15.9	209.38	52.3	121.70
Southern Africa[d]	25	578	13.6	1.9	197.64	18.1	78.42
African region	269.5	1,853	124.0	51.3	576.36	75.8	
Idem in millions of dollars	8.67	91.44	15.35	6.31	158.35	9.44	289.26
Exports							
Western Africa	4,443.6	517	141.3	—	0.67	—	166.08
Eastern Africa[c]	15.7	192	0.8	—	4.55	0.5	13.75
Northern Africa	0.3	0.8	0.8	—	37.80	14.4	11.69
Southern Africa[d]	3.3	27	0.8	35.2	14.60	71.8	20.80
African region	4,462.9	736.8	143.7	35.2	57.62	86.7	
Idem in millions of dollars	120.58	44.93	14.01	3.20	16.89	12.71	212.32

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

[a] Including roundwood products.

[b] Including sleepers.

[c] Excluding trade between the countries comprising the former Federation of Rhodesia and Nyasaland.

[d] Excluding trade within the subregion.

worthy of note are quantities of coniferous forest in the highlands of Eastern Africa. A very significant source of wood is the growing area of man-made plantations of conifers, eucalyptus and other species, notably in Southern and in Eastern Africa. In contrast to the natural forest, the rate of growth of these plantations is high. A small area of plantation can, therefore, ensure the sustained supply of the same volume of wood (though not necessarily in the same sizes or qualities) as a very much larger area of natural forest.

Table 4. Areas of forests in Africa, 1958-1963

(Millions of hectares)

	Natural forests			
	All forests	*Closed high forests*	*Other forests*	*Man-made forests*
Western Africa	406.9	173.7	233.0	0.2
Eastern Africa	250.8	18.0	232.2	0.6
Northern Africa	9.1	1.6	7.3	0.2
Southern Africa	15.8	0.3	14.5	1.0
African region	682.6	193.6	487.0	2.0

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

Table 5. Average annual removals of wood in Africa, 1959-1961

(Millions of cubic metres)

	Sawlogs, veneer logs and logs for sleepers	*Other roundwood*	*Fuelwood*	*Total*
Western Africa	7.9	4.9	80.4	93.2
Eastern Africa	1.5	4.8	89.6	95.9
Northern Africa[a]	0.1	0.3	4.4	4.8
Southern Africa	1.5	2.8	2.5	6.8
African region	11.0	12.8	176.9	200.7

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

[a] Averages for 1960-1962.

2. FUTURE PROSPECTS

From the sum total of evidence at hand, it would appear that in the years up to 1975 the great majority of the countries of Africa should be able to expand their local production of most forest products at least to an extent which should be sufficient to satisfy expected domestic requirements. In a number of countries, the wood resource can be made to contribute to a far greater degree than hitherto towards the satisfaction of internal needs. It should also be possible to maintain and probably to expand the volume of tropical hardwood exported. Even in some of the countries that are less well endowed with natural forest, production, particularly of plantation-grown wood, coupled with progressive industrialization, can almost certainly be carried to a level where exports of certain wood products, including pulp products, can be initiated or substantially expanded.

3. FOREST A DIMINISHING ASSET

Although Africa contains huge forest resources that are virtually untouched because of their location far from main consumption centres, the resources within short distances from rural and urban centres are being depleted, in some areas at a fast rate—a process owing not just to the removals of wood for use, but equally, if not more so, to burning, grazing and cultivation. The annual aggregate loss in these ways is very substantial. The measures that need to be taken to counter it are twofold: the reduction of the wasteful use of the forests both by protecting them against haphazard destruction and by putting to use a much greater proportion of the wood volume per hectare, in both the closed high forest and the dry forests; and the establishing of man-made forests.

4. FULLER USE OF THE FOREST RESOURCE

In the countries with an abundant wood resource, measures are needed to make fuller and more efficient use of the wood. Wood can often be used domestically to replace certain imported materials, and a large domestic market for, say, sawnwood or plywood can also enhance the prospects for exportation of these products. Exports should be, to a far greater extent than at the current time, in the form of processed-wood products rather than logs, both to have as great a value as possible accrue to the producing country and to allow it to use its raw material as a basis for industrialization. Domestic processing would have the further advantage of widening the range of species that can be used—a necessary step if fuller use is to be made of the forests and if costs are to be kept down. For example, secondary species can be used for core stock in plywood; and sawn, peeled or manufactured wood of lower value species can often be shipped at a competitive price, whereas logs, with the high proportion of waste they contain, cannot.

5. IMPROVEMENT OF TECHNIQUES

More efficient techniques are needed throughout the range of activities involved—harvesting, handling, transporting, processing, freighting etc. Nor does efficiency invariably mean large, modern, capital-intensive units. Small, local markets, or a scattered resource, will often favour small-scale sawing. A better use of such sawlog material as is available is particularly important in those countries where supplies are limited. Furthermore, a resource such as much of the savannah forests, which may not be capable of supporting an adequate output of sawnwood, may well suffice for the manufacture of particle board or fibreboard, products which can serve the same purpose as sawnwood in many uses.

6. PULPWOOD PLANTATIONS AND NON-WOOD RESOURCES

Plantation forests, which, as noted above, must form a source of wood of increasing importance, can also supply industrial wood raw material of types lacking in the natural forest—notably long-fibred wood for pulp. This is particularly scarce in the wood-rich countries of Western Africa, but it might be provided by plantations of coniferous species or of bamboo. Plantation programmes of the sort that would be appropriate for this rest very largely on the selection of suitable sites and species—a field of inquiry that should be pursued increasingly in many parts of Africa. Development of the use of non-wood resources for pulp production in the region generally, and in those wood-deficient subregions in particular needs to be given special and immediate attention remembering the rapidly increasing demand for paper which is to be expected over the next ten years.

7. Scale of operations

Apart from provision of a suitable and adequate raw material base, attention must be paid to the problem of the scale of operation necessary, notably in the pulp and paper industry. There is considerable scope here for development on a wider than national scale, with harmonization of individual national developments and encouragement of intra-African trade. However, even where smallness of scale inhibits domestic primary production, much can be done in the way of import saving at the secondary conversion level. In Western and in Eastern Africa, manufactured paper articles which are currently imported could probably be produced locally using imported paper and paperboard in relatively small manufacturing units calling for comparatively small capital investment.

8. External market possibilities

Development of wood-using industries in Africa should also take account of the growing external market possibilities. A joint study made by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations[2] indicates a sharp rise in demand in the future for the products made from tropical hardwoods of Western Africa. But attention should be turned also to less traditional markets—certainly North America and possibly the centrally planned economies of Eastern Europe, as well as the Union of Soviet Socialist Republics. Attention needs also to be paid to other products, in particular, pulp and paper. A growing world market for these products is expected, and external markets could provide the scale necessary to allow production while domestic markets are still small. Many parts of Africa appear to be exceptionally well endowed with sites capable of rapidly growing wood for pulping at an attractive cost. To harness this potential for such a complex industry as pulp and paper involves a whole range of further needs—capital, skills, organization etc. But a beginning has been made, notably in Southern Africa, and the possibilities it offers warrant careful and close attention.

[2] *European Timber Trends and Prospects: A New Appraisal, 1950-1975* (United Nations publication, Sales No.: 64.II.E.4).

9. Planning and training needs

Opportunities for Africa in the wood and wood products fields have been indicated briefly in this introduction. They are substantial and indicate many excellent prospects for expanding forest production, manufacturing and trade, many of which can and should be realized in the immediate future. But realization of this encouraging potential will depend in large measure upon careful planning and upon acquisition of the skills and expertise necessary to ensure the effective translation of such plans into practice. This, in turn, implies the need for much better data on the forest and wood-using sectors and for attracting into these sectors adequate and appropriately qualified personnel. As the objectives of forestry in Africa are no longer predominantly conservationist in intent and as industry changes from its initial predominantly extractive role, this will mean not just more trained people, but also more people with additional skills, i.e., not only those who are familiar with the particular disciplines of forestry and wood technology, but also those versed in planning, marketing and other specialized skills that will be needed as the sector is brought forward and integrated more fully into national and regional economies.

I. The forest resource and non-wood potential

A. General information

Basic to any appraisal of the wood-using economy in Africa must be information on the forest resources of the region. The present chapter, therefore, sets out to assemble such data as are available, in order to build up a picture of the size, nature and distribution of the forests of Africa and to establish how and to what extent they have been drawn upon to provide wood in the recent past.

The resource described here is not a simple one. The forests of Africa exhibit a wide diversity of type and concentration. They contain many hundreds of different species, often in combinations which give the forests a highly complex structure. At the same time, the category "forests" encompasses both areas endowed with wood resources of a magnitude and richness paralleled in few other places in the world and other areas where the forest is no more than a sparse open woodland. But the description of this varied and complex pattern has had to be constructed from, at best, scanty data. Very few of the African forests have as yet been surveyed to determine their magnitude, content or rate of growth. The figures in this chapter are the best estimates that can be arrived at from the information currently available. Given the limitations of this information, the over-all regional and subregional estimates have been confined to the basic measure of the forest extent, namely, the area of forest and, within it, of major forest conditions. It is simply not meaningful at this time to try to establish the volume of growing stock or the rate of growth of African forests as a whole—although this can, and has been, arrived at for certain parts of that whole.

Much, therefore, remains to be determined about the region's forest resources. Nevertheless, the principal features and general orders of magnitude are already known. While individual figures given in this chapter may require substantial amendment as new data become available, it is unlikely that the general picture set out below will prove to require serious modification.

B. Geographical and economic distribution

Table 4 (p. 32) may serve to give a broad indication of the size, distribution and nature of the forest resource of the African region.

The forests of Africa cover an estimated 683 million hectares or 23 per cent of the land area; the area of forest per inhabitant is 2.6 hectares. The great majority of this area is in Western Africa and Eastern Africa. In these vast and, for the most part, thinly populated subregions, a high proportion of the land is wooded, and the *per capita* forest area is also high. Due to climatic and other factors, natural forests are scarce in Southern Africa and even scarcer in Northern Africa; in the latter subregion, both tree growth and human settlement are limited to narrow bio-climatic areas, in which forests have been subject to centuries of intervention by man and his domestic animals.

Table 4 shows separate figures for two classes of natural forest: closed high forests, comprising types of forest that tend to have a high log content; and other natural forests. In this context, the term closed high forest is used to designate collectively: (*a*) the moist tropical forests at low and medium altitudes (which are by far the most important group of closed high forest); (*b*) the montane forests of the tropics, as also the floristically akin, lesser group of temperate and subtropical evergreen forests in the extreme south of the continent; and (*c*) the indigenous Mediterranean high forest of aleppo pine, maritime pine, cedar and deciduous oaks. The other natural forests comprise: (*a*) the many different types of dry forest that cover vast areas of land south of the Tropic of Cancer; (*b*) the mangrove forests (which represent relatively small areas); and (*c*) the indigenous Mediterranean forests other than those grouped with the closed high forests.

1. Closed high forest

The closed forests cover some 194 million hectares and represent 28 per cent of the forest area of Africa. Approximately 90 per cent of the closed forest area is within Western Africa; it is these forests that yield the renowned export woods of the African continent. Most of the remaining closed forest is in Eastern Africa, with the largest areas in Ethiopia and Madagascar. In Western Africa and in Madagascar, nearly all of this forest is situated at low and medium elevations; in continental Eastern Africa, there is a predominance of montane formations, which include several major areas of conifers. Most of the coniferous growing stock of the natural forests of Africa appears to be concentrated in the Ethiopian highlands.

In Southern Africa, the closed high forest is currently reduced to a small area, while in Northern Africa, the forests that, from an economic viewpoint, may be likened to the closed forests south of the Tropic of Cancer, are for the most part seriously degraded.

The enormous resource represented by the closed high forests of tropical Africa is shared by a limited number of countries; eleven countries in Western Africa (from Liberia in the north to Angola in the south) and five in Eastern Africa (Ethiopia, Kenya, Madagascar, Uganda and the United Republic of Tanzania) possess major areas. In these countries, the closed forest constitutes a most important, and sometimes the only, source of industrial logs, and several countries are very large exporters of timber. The majority of the countries of tropical Africa, however, are less well endowed; the log content of their natural forests is either indifferent, or poor, or virtually nil.

2. Other natural forests

In each of the four subregions, the area shown under "other natural forests" is in excess and except in Western Africa, vastly in excess of the area of closed high forest. To the south of the Tropic of Cancer, most of the former class of forests consists of dry, generally open woods of different types. Although currently rarely productive of industrial logs, the dry forests supply essential requirements in fuelwood and rural roundwood (hut poles, posts etc.), while exerting important protective functions in many areas.

Much the same holds true for the "other natural forests" of Northern Africa, although the composition of the latter is entirely different from that of the dry forests to the south.

The prevalence of dry-forest types is a characteristic feature of the African region, where the ratio of dry forest to moist forest is very much higher than that of either Latin America or the Asian-Pacific region, and a much larger proportion of the forest area is swept by fires every year. While many of the trees, particularly in the savannah woodland, are fire-tolerant to some extent, the repeated burning tends to stunt and eventually to eliminate the regrowth. Over a very large part of its huge area, the forest of Africa is fragile indeed, and its future is delicately poised.

Whereas natural forest of a high log content is of an essentially concentrated occurrence, forest of one kind or another that is capable of yielding fuelwood and rural roundwood is present in most inhabited areas of Africa. These are the most widely consumed products of the African forest. Since fuelwood and rural roundwood can rarely be transported over large distances, they are habitually short in many densely settled districts.

C. Forest ownership

In most African countries ownership of natural forest is vested in the State and other public entities, or else remains as yet to be determined. Private ownership is of little significance in Western and Northern Africa. It is of some importance in Southern Africa and in several countries of Eastern Africa, including Southern Rhodesia, where more than one-third of the forest area is owned by farmers, and Ethiopia, where the greater part of the closed high forest is reported to be in private ownership, much of it in numerous small holdings.

D. Forest reserves

Within Western and Eastern Africa, the two subregions roughly coincident with the African tropics, some 69 million hectares of forest have been reserved so far for purposes of production or protection, or both. The forest reserves represent between 10 and 11 per cent of the forest area and about 3 per cent of the land area of the two subregions; the reserved area per inhabitant is little more than one-third of a hectare. These are very low averages in view of the wide range of conditions where forest cover is needed for protective reasons and considering that the reserves are predominantly composed of savannah woodlands and other forest types of low log content and slow growth.

E. Forest plantations

Compared with the natural forests, the man-made forests of Africa are small, but they represent a very significant, and in the case of several countries of Southern and Eastern Africa, an all-important element of the forest resource. The plantations of the African region now cover approximately 2 million hectares and are being added to at a rate of more than 60,000 hectares per annum. Approximately one-third of the plantation area of Africa is coniferous and consists mainly of pines. The broadleaved area, except in Western Africa, is composed predominantly of eucalyptus or of eucalyptus and wattle (the latter species having been planted mainly with a view to tanbark production). Of the total area of man-made forest, an estimated 1.5 million to 1.6 million hectares (including 550,000 to 600,000 hectares of coniferous and 950,000 to 1 million hectares of broadleaved plantations) consist of stands of fast-growing species, particularly *Pinus patula, P. elliotti, P. radiata, Cupressus lusitanica, Acacia mollissima, Eucalyptus saligna, E. grandis, E. robusta*, cassia and grevillea. These plantations are managed on short rotations, ranging from ten years or less for eucalyptus coppice to about forty years for some of the plantations managed for sawlogs. The annual growth rate per hectare is normally from 10 m³ to 20 m³ and, infrequently, 25 m³ or more.

In Southern and Eastern Africa, which contain nearly all of the existing conifer plantations, the current tendency is to give even more emphasis than hitherto to coniferous planting, partly with a view to the building up of a resource of long-fibre material for pulp and paper-making. These subregions contain areas where conditions for plantation forestry are exceptionally favourable. Apart from the accelerated growth rate that may be attained with exotic species, the labour input is often low by almost any standard. For instance, in Swaziland, the total input in the establishment of a conifer plantation can be less than the input for land preparation alone under the conditions prevailing in many plantation areas of Northern and Western Africa.

In a number of countries, both north and south of the Sahara, an appreciable amount of row planting has been carried out in shelterbelts, in association with terracing and so on. Though valuable mainly for their protective effects, the row planting often constitutes a useful source of wood.

More than one-third of the man-made forests of Africa were created by private persons and organizations; in many cases, the local forest department provided valuable assistance by supplying seed, planting stock, technical advice etc. Practically all the plantations of Swaziland and the majority of those of Angola, South Africa and Southern Rhodesia are privately owned, as is a significant proportion of the plantations in several other countries (the Congo (Democratic Republic of), Kenya, Madagascar, the United Republic of Tanzania, etc.). Ownership units range from farm wood-lots to holdings of many thousands of hectares. In several countries, the wood-lots, though small individually, constitute a significant resource in the aggregate.

F. Forest removals

African production of wood has been rising continuously, and during the period 1959-1961, average annual removals (quantities of wood removed from the forest and also from trees outside the forest) totalled an estimated 200 million m³ (see table 5). In Africa, as throughout most of the world, fuelwood is quantitatively the most important product of forests, but African removals of fuelwood are particularly heavy in comparison with those of logs and other roundwood. Africa has about 16 per cent of the total forest area of the world, but removals of fuelwood (chiefly in Western and Eastern Africa) during the period 1959-1961 may have represented as much as one-quarter of world removals. By contrast, production of logs (which is centred in Western Africa) and of other roundwood (mostly rural roundwood harvested in Western and Eastern Africa) each accounted for an estimated 7 per cent of the corresponding world output. Of the logs produced in Africa, 1.6 million to 1.7 million were coniferous, with most of this production deriving from Southern and Eastern Africa. The total removals (200 million m³) may have represented as much as one-fifth of the wood produced in the world.

G. Non-wood fibrous raw-material resources

In addition to the wood derived from natural and planted forests in the region, there are other significant sources of fibrous raw materials. The most important of these in terms of supply and economic availability, are bagasse, bamboo, esparto, papyrus, reeds, straw and sisal. With the exception of bagasse, and perhaps rice straw, where available quantities can be estimated on the basis of sugar and rice production, little is known about the extent of these resources.[3]

1. Bagasse

More than other non-wood raw materials, bagasse has lately come into focus as a potential source for pulp and building-board raw material. The fact that bagasse is really more an industrial residue than an agricultural one (great quantities being available in one place as the residue from sugar-mills) makes it more attractive as a source of raw material than several other fibrous raw materials, where collection over a scattered area has to be arranged by the pulp or building-board mill.

In 1962/1963, the total production of bagasse, calculated on the basis of reported sugar production, was about 3.6 million bone-dry tons, which is theoretically sufficient to produce 1.3 million tons of chemical pulp. Since bagasse is the sugar-mills' prime source of fuel for power and steam, it is clear that only a part of this large tonnage would be available for making pulp.

The economic supply of bagasse for pulping depends very much upon the favourable location of the pulp mill in relation to the supplying cane-sugar mills, the cost of fuel oil to replace the bagasse in the power and steam plants and the efficiency of these heating units.

During the 1950's, the industrial production of cane-sugar in the whole of Africa increased about 6 per cent per annum. If the same annual increase continues during the 1960's the total industrial supply of bagasse by 1970 will rise to 5.6 million tons per annum and by 1975 may be expected to be 7.5 million tons per annum.

2. Bamboo

In Africa, bamboo has hitherto been used mainly by rural populations for building purposes and has had

[3] The available data are summarized in "Appraisal of the region's fibrous raw material supply, economic availability and technical suitability", *Pulp and Paper Development in Africa and the Near East*, Proceedings of the Conference held in Cairo, 8-18 March 1965 (Rome, 1966), vol. I, part II, Secretariat paper II.

very little industrial use. The industrial use of bamboo would, of course, depend upon the location and size of the growing areas. Only for a few countries are figures available on the actual area of the bamboo stands: Ethiopia has some 500,000 hectares; the Democratic Republic of the Congo, some 250,000 hectares; and Kenya, some 190,000 hectares. Bamboo pulp generally has good fibre length. Bamboo plantations could, therefore, become a valuable source of long-fibre pulp, where coniferous pulp is not available.

3. Esparto

Esparto grass is found mainly in Algeria, Libya, Morocco and Tunisia. It grows wild over large areas of the countries and is generally harvested by hand, although some attempts have been made to mechanize the harvesting. Earlier, almost all the esparto was exported to France and the United Kingdom of Great Britain and Northern Ireland, but during latter years several local pulp mills have been erected, using esparto as the raw material.

4. Other non-wood raw materials

At the current time, the other non-wood raw materials do not seem to offer the same possibilities as industrial raw materials for pulp-making as does bagasse. Papyrus and reeds are possible raw materials, but as they grow in swampy areas, harvesting presents a considerable problem.

Sisal already has an industrial use for rope-making and its development for pulping is technically feasible; its use will depend upon whether it is competitive with other raw material supplies.

With regard to straw, it must be remembered that large quantities are used for cattle fodder. Harvesting and transport difficulties between scattered farms and the pulp mill, and storage are all factors which often prevent the large-scale use of straw as an industrial source for building-board and pulp. In the United Arab Republic, rice straw is already used on an industrial scale and if transport facilities and the collecting organization can be improved also in other countries, then straw could become increasingly important as a raw-material source for pulping.

H. Summary of resources

The various parts of Africa differ widely in the extent to which they are endowed with forest resources and in the nature of those resources. Despite this diversity, there are a number of points of general application that merit a further mention in summing up.

The most important is obviously the fact that large parts of Africa do possess extensive and often rich natural forests. These represent a resource of enormous potential, the effective realization of which must be a matter of principal concern.

There are also large parts of Africa that are short—often acutely short—of productive natural forest. A second major element of concern which arises is, therefore, the need for man-made forests in the region, in order to create a forest estate, or to renew or supplement the natural resource.

The third point is common to all parts of Africa, whether rich or poor in natural forest: namely, the fact that the resource is steadily shrinking. The extent to which it is being depleted and degraded—by uncontrolled shifting cultivation, grazing and burning, and by indiscriminate cutting—must be a matter of the utmost concern. In the areas rich in forest, a valuable resource is in this way running to waste. In areas but thinly clad with tree cover, destruction of the latter often also destroys such productivity as these fragile lands possess. In Africa, the intimate interrelationships between agriculture and the forests are reinforced and underlined by the susceptibility of the soils of so much of the region to deterioration when unwisely stripped of necessary vegetative cover.

The nature of the demands that are likely to be placed upon the region's forest resources in the future and consideration of the problems and possibilities that will arise are dealt with in subsequent chapters. But before turning from specific consideration of the forests, one further point needs to be made—namely, the urgent need for more and better information about them. If solutions are to be found to the problems and if the possibilities are to be realized, the extent, nature and yield of the African forests must be adequately inventoried and recorded.

The part which can be played by non-wood sources, such as bagasse and perhaps straw, in the development of the pulp and paper industry is very important, particularly in the subregions which have limited timber resources. Esparto already has a use in high-quality paper-making, but the prospects for other non-wood sources are currently not great, as collection on a large scale presents considerable problems.

II. Current and future demand for forest products

A. Growth of requirements for wood products

From the projections given in "Timber trends and prospects in Africa",[4] requirements are expected to grow rapidly in the case of sawnwood, board products and paper and paperboard, but much less so for roundwood products and fuelwood. By 1975, regional sawnwood requirements are expected to exceed the current level by more than 70 per cent, while requirements in Western and Eastern Africa are expected to be about twice as high as they currently are. In absolute terms, the sawnwood requirements of Africa are likely to increase from the current level of about 4 million m³ to about 7 million m³ in 1975. Requirements for board products are expected to grow faster than those for any other product group—it is estimated that the increase will amount to 165 per cent for Africa as a whole and to nearly 200 per cent for Northern Africa where it is expected to be the greatest (largely as a result of the expanded use of packaging veneer). The projections for paper and paperboard suggest that regional requirements will increase almost as rapidly as in the case of board products. The Western Africa

[4] United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, joint study (1965).

requirements for paper and paperboard are expected to increase by more than 200 per cent.

On a *per capita* basis, current consumption of sawnwood, board products and paper and paperboard within the region and the corresponding medium-level projections of requirements in 1975 compare as follows:

	1960-1962 consumption per 1,000 inhabitants	*1975 requirements per 1,000 inhabitants*	*1960-1962 world consumption per 1,000 inhabitants*
Sawnwood (cubic metres)	15.4	19.1	(109.9)
Board products (cubic metres)	1.4	2.6	(9.8)
Paper and paperboard (tons)	3.4	5.9	(27.3)

While the implied growth in *per capita* requirements is great, the 1975 levels indicated remain low indeed by world standards.

1. Future requirements for sawnwood

From the projections given in "Timber trends and prospects in Africa",* compared with the current consumption of sawnwood, the 1975 requirements as indicated by the medium-level projection suggest, for Africa as a whole, an increase of some 77 per cent; for Western and Eastern Africa, requirements in 1975 are expected to be about twice as high as they currently are; for Northern Africa, the anticipated increase is about 74 per cent; and for Southern Africa, some 24 per cent. *Per capita* consumption is expected to rise in all subregions except Southern Africa. For the region as a whole, the medium-level projection implies an increase in *per capita* consumption of about 24 per cent.

The end-use distribution of consumption in 1975 is certain to differ to some extent from the current pattern. Thus, in Western Africa, furniture manufacture is likely to absorb a substantially higher proportion of sawnwood than it does at the current time. For the Maghreb countries, the use of sawnwood in packaging in 1975 is estimated to amount to 180,000 m³, which is actually somewhat less than the 1960-1962 level of consumption. In the case of Southern Africa, consumption of box-boards is likely to increase at a much slower rate than that of building timber and of sawnwood used in furniture manufacture, while the use of wooden sleepers is expected to decline.

The medium-level projections imply that by 1975, the annual requirements of sawnwood in Africa will exceed current consumption by some 3 million m³, the additional requirements being distributed as follows: Western Africa, 1,288,000 m³; Eastern Africa, 798,000 m³; Northern Africa, 738,000 m³; and Southern Africa, 260,000 m³.

In Western Africa, timber will undoubtedly be available in adequate volume to match the increased demand within the subregion; the rising demand will represent an opportunity for extending utilization to a wider range of species and will, no doubt, facilitate the expansion of sawnwood exports. But in Eastern Africa, dependence upon imports from outside the subregion is likely to increase considerably unless a much greater use is made of the available resources, including, in particular, the extensive dry forests of the subregion and the areas of closed high forest that are currently under-utilized. In the case of Northern Africa, the rise in consumption may offer trade opportunities to exporters in the surplus countries of tropical Africa, though the scope of such trade is likely to be limited by severe competition from European exporters. In Southern Africa, where the output of plantation-grown saw-timber is increasing rapidly, the current deficit in sawnwood will decrease steadily. By 1975 this deficit is likely to be overcome to a very large extent.

* See foot-note 4.

2. Future requirements for wood based panels

The projections which have been made suggest that regional requirements in 1975, as indicated by the medium-level estimate, will exceed current consumption by some 165 per cent and that both total and *per capita* consumption will increase rapidly in all four subregions, the increase in total consumption ranging from 130 per cent in the case of Southern Africa to nearly 200 per cent in Northern Africa. For Africa as a whole, the medium-level estimate implies a rise in *per capita* consumption of about 85 per cent.

In the case of Western Africa, plywood, which is manufactured on a major scale within the subregion, is likely to maintain, or even to increase, its current share in the total consumption of board products, while in the other subregions, consumption of fibreboard and particle board may be expected to rise more rapidly than the plywood consumption.

It seems likely that fibreboard manufacture will be established before long in Eastern Africa and that particle-board plants will come into being in several countries of Eastern Africa and Northern Africa. In Southern Africa, the fibreboard and particle-board industries are likely to grow considerably and to become more diversified. Consumption of packaging veneer in the Maghreb countries, which is expected to rise from the 1960-1962 level of some 45,000 m³ to more than 160,000 m³ in 1975, should provide useful outlets for the cheaper grades of West African peeler logs.

3. Future requirements of roundwood products and fuelwood

While the subject of roundwood products and fuelwood is not the concern of this paper, it should be noted that by 1975 the estimated total consumption for the region of roundwood products will be 15,390,000 m³, and of fuelwood it will be 228,390,000 m³, these basic uses of the wood resource of the region still far outweighing all other uses.

4. Future requirements for paper and paperboard

The estimated total requirements for paper and paperboard, by subregion, are given in table 6. Requirements for paper and paperboard are expected to rise steeply, on a *per capita* basis as well as in absolute terms, within each subregion and sector; the greatest rate of increase is anticipated in the case of Western Africa, where packaging requirements for bananas are expected to create a new class of demand. Regional requirements will probably increase at a similar rate for newsprint, printing and writing paper and industrial paper, and by 1975 over-all requirements for paper and paperboard products within the African region are expected to be of the order of 2.7 million tons per annum, whereby most of the consumption will be distributed between Southern Africa and Northern Africa. As indicated earlier, production in these two subregions is currently expanding at a fast rate. In Western Africa, consumption will continue to be centred in the sector which includes Ghana and Nigeria, and that of

Eastern Africa in the southern-most part of the subregion. As far as the requirements of the home market and those of neighbouring countries are concerned, it is these areas that would seem to offer the best *prima facie* prospects for an early installation of pulp and paper production on an economic scale. With the development of the industrial use of non-wood resources, such as bagasse, for large-scale pulp production, it is anticipated that these sources of raw materials will play an increasingly important role in supplying the paper and fibreboard needs of the region.

Table 6. Africa: annual consumption in 1959-1961 and estimated requirements in 1975 for processed wood products[a]

(Millions of units as indicated)

	Annual consumption 1959-1961	*Estimated requirements 1975*
Western Africa		
Sawnwood (cubic metres)	1.10	2.39
Plywood and veneer (cubic metres)	0.03	0.15[b]
Fibreboard and particle board (tons)	0.02	
Paper and paperboard (tons)	0.08	0.26
Total in terms of wood raw material (cubic metres)	2.56	5.85
Eastern Africa		
Sawnwood (cubic metres)	0.82	1.62
Plywood and veneer (cubic metres)	0.02	0.20[b]
Fibreboard and particle board (tons)	0.03	
Paper and paperboard (tons)	0.10	0.28
Total in terms of wood raw material (cubic metres)	2.05	4.42
Northern Africa		
Sawnwood (cubic metres)	(1.00)	1.74
Plywood and veneer (cubic metres)	0.09	0.33[b]
Fibreboard and particle board (tons)	0.02	
Paper and paperboard (tons)	0.29	0.81
Total in terms of wood raw material (cubic metres)	3.14	6.67
Southern Africa		
Sawnwood (cubic metres)	(1.08)	1.34
Plywood and veneer (cubic metres)	(0.03)	0.30[b]
Fibreboard and particle board (tons)	(0.06)	
Paper and paperboard (tons)	0.36	0.86
Total in terms of wood raw material (cubic metres)	3.46	5.74
African region		
Sawnwood (cubic metres)	(4.00)	7.09
Plywood and veneer (cubic metres)	1.18	0.98[b]
Fibreboard and particle board (tons)	0.12	
Paper and paperboard (tons)	0.83	2.21
Total in terms of wood raw material (cubic metres)	11.24	22.68

SOURCE: United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965).

[a] Subregional figures may not add up to regional totals due to rounding.

[b] Total board products in millions of cubic metres.

B. Summary of current and future demands

The embryonic state of most of the wood-using industries in Africa is in large part attributable to the current small size of the markets for processed wood products in the region. The nature, extent and expected growth in these markets are considered in the following chapter.

The industries development has also been affected by the supply conditions they face. Thus, the major part of the region's sawmilling and plywood and veneer activity has been built up in Western Africa, where the forest resource provides a highly suitable raw material for these products. The region's pulp and board capacity, on the other hand, has been built up in Southern and Northern Africa, where a plantation-grown raw-material base has been established.

1. Capital and technical skill

The supply of capital and of technical and managerial skills has also been important. Much of the industry, in particular, the sawmilling industry, comprises small, poorly equipped units with staff inadequately versed in the necessary skills. To say this is not to underrate the important role of simple, small-scale, labour-intensive woodworking enterprises in Africa: a scattered raw-material supply or a small, local market can often best be worked or served in this way. But the development of wood-using industries even to the modest size justified by current markets is, in general, hampered by shortages: shortages of capital—as much for infra-structure and services as for equipment; and shortages of skills—skills in marketing and organization as much as skills in processing techniques. Expansion of the industries will rest as much upon correcting these shortages as it will upon the size of markets and an adequate raw-material base.

2. Estimated future demand

If the underlying conditions assumed here of population and income growth and of wood availability are realized, African annual requirements for the various wood products will have risen by 1975 to the equivalent of nearly 23 million m³ of industrial roundwood, about 15 million m³ of rural roundwood and nearly 230 million m³ of fuelwood, the requirements being distributed between the different subregions in the manner recorded in table 6. At these levels, consumption would have risen between 1959-1961 and 1975 by the following margins: fuelwood and roundwood by 29 per cent (or nearly 55 million m³), sawnwood by 77 per cent (3 million m³), wood-based panel products by 165 per cent (0.6 million m³) and paper and paperboard by 146 per cent (1.4 million tons). The relatively slow rise in consumption of fuelwood and roundwood still will mean very large additional quantities—more than 50 million m³ a year of fuelwood and 4.5 million m³ of roundwood. But it is the rapid increase in consumption of processed wood products that will create the more significant changes in the wood economy.

3. Major expansion needed

To supply these additional quantities will require a major expansion of the region's capacity, or a heavy addition to the burden of the import bill for wood products. To produce this additional requirement of processed products within the region would call for an output of industrial roundwood in Africa amounting to 11 million m³ per annum more than that in 1959-1961, when the corresponding production amounted to about 7.5 million m³. If, on the other hand, the additional quantity of wood products consumed were all to be imported, it would cost, at 1959-1961 prices, more than $600 million per annum by 1975, on top of the $200 million worth imported in 1959-1961. Even if Africa continues to import the same proportion of its wood products requirements as it did in 1960, it would still add nearly $400 million to its annual import bill by 1975, increasing it to a sum nearly two-and-one-half times as large as the corresponding bill for imports in 1959-1961.

4. Conclusion

It is to be expected that Africa will continue to import some part, probably a considerable part, of its wood products requirements in 1975. But these figures do underline the need for meeting a higher proportion of the region's requirements from domestic production and give a rough indication of the orders of magnitude that are likely to be involved. If additional supplies are not called forth in adequate quantities or only in response to a rise in the real price of wood products, then consumption will, of course, fall short of the levels estimated. If this were to come about, the region would, in all likelihood, be the poorer for being short of the wood products required for its development and for having failed to develop and use adequately its wood resource.

III. Prospects and related development needs

Any broad appraisal of the wood potential of Africa and of the prospects for utilizing this potential in the best interest of its inhabitants must perforce be tentative, since as yet most of the forest areas are very imperfectly known, while the economy of the majority of African countries has only just begun to develop.

A. Future prospects

In the preceding chapters an attempt has been made to present a summary of available data on the African wood sector and to provide an indication of future requirements for wood products. From the sum total of evidence at hand, it would appear that in the next ten years the great majority of the countries of Africa should be able to expand the output of the wood products currently derived from their forests so that domestic production will satisfy requirements for these products to the same, or a similar, extent as it now does. In a number of countries, the wood resource will permit carrying production further, making the forests contribute to a far greater extent than hitherto towards the satisfaction of internal needs. Production of wood for export may decline in one or two of the traditional exporting countries of Western Africa, while other countries with large areas of closed high forest, in Western Africa and elsewhere, should be able to supply increasingly both distant markets and deficiency areas within their respective subregions. Even in some of the countries that are less well endowed with natural forest, production, particularly of plantation-grown wood, coupled with progressive industrialization, can almost certainly be carried to a level where exports of certain wood products, including pulp products, can be initiated or substantially expanded, as the case may be. However, in order to attain desirable production goals, while safeguarding or improving, as far as is reasonably possible, the over-all potential of the forest resource, Governments will have to implement policies based on well-balanced plans that are ambitious as well as realistic.

Basic requirements

Essential prerequisites for such planning (which, in many respects, is bound to be a continuous process) include, *inter alia*: (*a*) the collection, within each country, of the basic data relevant to the forests and their products, and the gradual improvement of this data by such means as forest inventories, surveys of forest industries, surveys of wood-products consumption trends and appropriate statistical coverage of the production of, and trade in, wood products; (*b*) close liaison with planners concerned with the other sectors of the national economy; and (*c*) integration of national plans into the regional and subregional context, with due regard for any opportunities that may exist for useful agreements with neighbouring countries, particularly in matters related to the processing of, and trade in, wood products. Above all, the planning must make provision for attracting the right type of personnel to forestry and the wood-products industries and for giving them the necessary training. At the current time, one of the most serious obstacles to progress is the shortage of trained personnel at all levels. In many countries, including several that possess large areas of valuable high forest in urgent need for development, forest departments operate with severely reduced, habitually overworked staffs.

B. Satisfaction of domestic requirements

The forecasts detailed in this study point to a rapid growth in wood products requirements; in the case of paper and paperboard, sawnwood and board products, estimates corresponding to medium-level projections suggest that, by 1975, regional requirements will exceed current consumption levels by some 1.3 million tons for paper and paperboard, 3 million m^3 for sawnwood, and 0.6 million m^3 for board products. In terms of current prices, these additional requirements amount to more than $500 million, of which some $300 million is represented by paper and paperboard. It has been seen that the current consumption of paper and paperboard in the great majority of the countries of Africa rests, on the whole, upon imports, and that most countries depend heavily upon imports of sawnwood, board products or both. While it may be neither practicable nor desirable for every country to strive for maximum self-sufficiency in all wood products, it seems very necessary that countries should endeavour to keep imports within reasonable bounds and, secondly, that where possible import requirements should be satisfied in an increasing measure by means of trade within the region.

1. Sawnwood and board products

(a) *Sawnwood prospects, in high forest areas*

With regard to sawnwood and board products, the anticipated growth in domestic requirements should not present any difficult problems as far as the wood-surplus countries of Western Africa are concerned. In these countries, the additional log requirements for sawnwood and for plywood (which is likely to account for the greater part of the increase in the board-product consumption of these countries) can be met readily, provided wider use is made of the currently under-utilized species of the mixed high forest, while expanded domestic sales of the lower grades of produce are certain to be of great assistance in developing overseas trade in processed wood products (as might be also, in many cases, the growing opportunities for selling part of the cheaper grades to wood-deficient neighbouring countries). The position is likely to be similar in Ethiopia and Madagascar, as soon as the considerable high-forest resource of these two countries can be adequately developed. In the smaller areas of closed high forest found in the other countries of Western and Eastern Africa, growing domestic requirements should also make for a fuller utilization of the forest, while in several countries (notably in Eastern and Southern Africa), man-made forests are certain to provide increasing volumes of industrial logs.

(b) *Sawnwood: use of low-grade forest*

Against these favourable prospects must be set the probability that in many countries of Africa that possess neither significant areas of tropical high forest nor major areas of forest plantations, the sawnwood supply position will deteriorate in the period to 1975, unless considerable effort is directed towards a fuller use of forests that have a low log content. By far the most important of these are the dry forests that cover such vast areas of tropical Africa. In a number of countries, the whole range of technical and economic problems of sawnwood production in these forests warrants a thorough appraisal (and, in some cases, reappraisal). Often, surveys will be necessary to identify areas of promising timber content that are suitably located in relation to existing or projected transport facilities. In many areas, logging and sawmilling may not involve any heavy investment in equipment and should offer opportunities to small commercial enterprises or co-operative associations, while, under certain conditions, a combination of pit-sawing and portable sawmilling might be envisaged. Much of the sawnwood thus produced might not be of a high quality, but it would, nevertheless, be useful in satisfying essential local needs. And whereas, in a number of areas, the total cost would be relatively high for the type of material produced, the foreign-exchange ingredient of this cost may prove sufficiently low to justify the encouragement of production.

(c) *Sawnwood: recommendations*

In a report submitted to the ECA Conference on the Harmonization of Industrial Development Programmes in East Africa[5] (Lusaka, November 1965), the FAO Regional Forestry Office for East Africa made a number of recommendations for the development of the sawnwood industry, which, while applying especially to Eastern Africa, have some general application through the whole region:

"1. The need to establish additional forest reserves is once more emphasized. Reconnaissance surveys and forest inventories should be carried out in forested areas where at present the data required for planning forestry development are not available.

"2. The use of secondary and lower quality species for sawnwood should be developed. At the present time many sawmills restrict their cuttings to species which have a high degree of stability in the green state. Lumber seasoning should be further developed, not only to improve the quality of lumber but also to expand the use of less stable woods. The use of preservation methods should be developed to help to increase the use of less durable species.

"3. Where it is feasible, the building of forest roads should be expanded to enlarge the area of accessible forest which can be economically exploited. Forestry development and the development of industries related to forestry should be given proper consideration when planning major road and railway development schemes.

"4. By introducing modern equipment, and by the proper training of forest labour in its use, logging and transport costs can be reduced. The possibilities of improvement in this field have been fully demonstrated recently by a New Zealand bilateral aid scheme in Eastern Africa.

"5. The use of portable and semi-portable sawmills should be developed further so as to be able to work the smaller forest patches and more remote forest areas.

"6. Considering the forecasts for domestic demand and future export prospects the development of plantation tree growing should be expanded. When planning plantation production the following points should be considered:

"(*a*) Apart from trees for pulp production some areas should be planted with species that produce saw log timber;

"(*b*) Trees intended for sawnwood (or veneer) should be pruned;

"(*c*) Large blocks of plantations are required to sustain a large sawmill enterprise, capable of developing an export market in sawnwood and supplying a large domestic market with properly processed timber;

"(*d*) Smaller plantation blocks can be planted close to the smaller population centres, to facilitate the provision of sawnwood for local markets.

"7. To reduce unnecessary waste, the rational use of timber should be further developed. Amongst methods which might be recommended the following are given:

"(*a*) Improvement of sawing accuracy;

"(*b*) Increasing the production of small dimension stock;

"(*c*) Introduction of finger-jointing of sawnwood to utilize short varying lengths of good quality timber;

"(*d*) Increased production of glued-laminated structural timber to make use of small-size timber and low-grade material;

"(*e*) It should be noted that the useful life of timber can be increased by preservation;

"(*f*) For structures, timber waste can be reduced by using seasoned timber which has higher strength qualities than green timber;

"(*g*) High-quality timber should not be used for purposes for which a lower grade of timber is adequate.

[5] "Forest industries development in East Africa" (E/CN.14/INR/80).

NOTE

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

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"8. Many of the mills in the Region are of too small size. Steps should be taken within the industry to promote amalgamation of the too small mills into larger units and to establish co-operative operation in logging, seasoning and marketing. The allocation of new concessions could be so arranged to stimulate the merger of too small mills into units of competitive size.

"9. The full export potential of saw log resources needs to be carefully developed, particular attention being paid to high-quality timbers, especially in the form of flooring-boards and strips, parquet flooring tiles and box-boards.

"10. The study of suitable types of mill equipment for different environs should be undertaken and the results of these studies should be widely demonstrated.

"11. The training programmes for all grades working in the forest and allied industries should be expanded as a matter of urgency. Co-operation in the development of training schemes on a regional or subregional basis should be arranged. A limited number of sawmills should be set up which would be used to demonstrate new techniques. On-the-spot training in modern techniques should be considered a primary duty in all mills which are suitable for this purpose.

"12. Grading rules for broadleaved and coniferous timber should be drawn up and co-ordinated throughout the whole region, if possible, but otherwise should be developed on a subregional basis.

"13. Credit facilities should be made available to enable new units to be properly designed and to have sufficient working capital to operate efficiently. The need of working capital is particularly stressed for the proper seasoning of sawnwood.

"14. It should be noted that excess milling capacity based on eight working hours/day does exist and also that this can be increased by shift-working. The better use of present mill capacity should be more than sufficient to compensate for the expected decrease in pit-sawing and the closing down of obsolete mills."

(d) *Deficiency areas*

A natural adjunct of inquiry into ways and means of expanding sawnwood production in deficiency areas is the investigation of possibilities for using wood, either from natural forests or from the existing plantations, in the manufacture of particle board or fibreboard, or both. Once such manufacture has been set up, these products, besides being employed in the uses for which they offer special advantages, might be made to go a long way in the substitution of scarce sawnwood components in building, furniture manufacture and other uses. In some localities, plantation-grown trees (such as those of certain eucalyptus species) may provide a useful source of logs for plywood manufacture.

Looking further ahead, beyond 1975 and into the more distant future the importance of plantations is again stressed. There can be little doubt that, outside the zones of closed high forest, any production of sawnwood and board products (and, *a fortiori*, of pulp) from local wood that is to contribute significantly to the ever-growing requirements will have to depend increasingly upon man-made forests. Thus, in most African countries, the building up of the plantation estate to the limit of economic feasibility clearly constitutes a task of a very high priority.

2. Roundwood and fuelwood

The anticipated increase by 1975 in the requirements for roundwood products and fuelwood is unlikely to affect basically the over-all supply position for these products, though it will create additional local shortages and will intensify existing ones near certain towns and in areas having a dense rural population.

Plantations aimed at supplying poles or fuelwood, or both, seem very necessary indeed in many of the wood-deficient areas in order to prevent existing shortages from becoming increasingly severe with the passage of time. In addition, the setting up of facilities in the locality for the preservation of building poles and of kilns for charcoal burning will help considerably to relieve these shortages. In certain localities, planting may be necessary to provide such industrial fuels as metallurgical charcoal.

3. Wood-based panels

Plywood differs from particle board and fibreboard in that it requires high-quality logs as raw material, whereas the two other types can be manufactured from low-cost wood, wood-waste and such non-wood fibre resources as bagasse. On the other hand, all three types can, to a certain degree, substitute for each other, as far as end-use is concerned. This makes a final assessment of the development prospects confused and uncertain. In the following paragraphs, all three types are discussed collectively, on the assumption that one cubic metre corresponds to 1.6 tons.

(a) *Current position*

The current situation can be summed up as follows. Taken as a whole, the production of building-board in Africa more or less corresponds to consumption. Production is, however, very unevenly distributed, Western Africa having a huge excess of plywood and Southern Africa a small excess of fibreboard and particle-board production. Eastern Africa and Northern Africa are each producing far less than they consume.

(b) *Future needs*

In Northern Africa, the consumption is expected to rise from some 110,000 m³ in 1959-1961 to about 330,000 m³ in 1975. As this subregion produces only 10 per cent of its needs, the rest being covered by imports, a theoretical capacity increase of some 320,000 m³ would be necessary to meet the entire demand by local production, a figure that seems highly unrealistic, given the unfavourable raw-material situation in the area. Efforts should be made to utilize low-grade wood, waste and non-wood resources. At the same time, however, it should be realized that increasing quantities may have to be imported to satisfy this demand.

In the period 1959-1961, Western Africa had a total production of wood-based panels of some 160,000 m³, the local consumption being only about 60,000 m³, with the difference being exported. In 1975, local demand is expected to be in the range of current production. If total demand is to be met by local production, keeping exports at the current level, some 100,000 m³ of new capacity must be installed. Taking into account the current large production of sawn goods and plywood, it should be possible to utilize waste to provide a large share of the needed raw material.

Production in East Africa currently covers only one-seventh of demand. This demand is expected to reach 200,000 m³ by 1975. The forest resource in the subregion can provide a sufficiently large raw-material potential to anticipate good prospects for creating an important wood-based panel products industry. To meet future demand by local production would require an expansion in production of 190,000 m³ per annum. It is expected, however, that part of this future demand will continue to be met by imports.

Southern Africa differs from the other subregions in many respects. The wood-based panel industry is already well developed and the whole region consists of one sole market, eliminating many of the marketing problems that smaller countries have to face. This subregion is estimated to have a consumption of wood-based panels of 300,000 m³ by 1975, compared with some 130,000 m³ in the period 1959-1961. If the current net export of 30,000 m³ is maintained, the needed capacity increase is likely to be in the order of 170,000 m³.

(c) Development problems

The problems facing planners of the wood-based panel industry in Africa are the vastness of the country, the great distances between consumption centres, the lack of transport in many areas and the small size of the internal market in many African countries.

Much can be gained from integration of both markets and industrial enterprises (plywood particle-board, sawmill, fibreboard etc.). Improved transport facilities will cut costs and will allow larger mills to be built, with a consequent better economy of operation. Some countries with adequate raw materials will be able to gain foreign currency by developing exports of wood-based panels, particularly of plywood and veneer.

C. Development of overseas exports of wood and wood products

As discussed in a previous chapter, the outstanding feature of the African export trade in wood products has been the rapid growth of exports from Western Africa, most of which are in the form of logs. The greater proportion of these logs are used by the importing countries in the manufacture of plywood and veneer, while a smaller proportion is made into sawnwood. Projections of European requirements of wood products imply a steep rise, in the period to 1975, in the potential demand for tropical hardwoods, notably for use in plywood and veneers, and there is every indication that exports from the wood-surplus countries of Western Africa (and also from such areas as eastern Madagascar) can be greatly expanded, provided sufficient suitable produce is made available at acceptable prices. It has been seen that in the closed high forests of Western Africa, the growing stock of the currently preferred tree species is still very great. It is far from inexhaustible, however, and even if it should prove possible during a certain number of years to expand trade in these species, supplies are bound to fall off sooner or later. It is clear also that with the rapid decline in the more accessible localities of the principal species in demand, rising costs due to greater distance of transport from the more remote areas will have to be compensated in some manner if exports are to remain competitive. This being so, it is now widely recognized that, in the long run, there can be no solution to the dual problem of diminishing supplies and rising costs without a broadening of the species range of exports and, secondly, a transfer from the importing areas to the exporting areas of a large proportion of the processing currently undertaken in the former. These objectives accord well with the general economic aspirations of the exporting countries, although it is obvious that their realization will not be an easy process.

1. Manufacture of processed wood for exportation

Given suitable conditions for local processing, exports of veneer that is destined for plywood manufacture, of sawnwood, of plywood or of decorative veneer can result in substantial net savings as compared with log exports, through economy in freight, a fuller use of the lower qualities of logs or a combination of factors. It would seem that as far as veneer for plywood manufacture is concerned, many industrial enterprises in the importing countries are becoming increasingly interested in the possibility of manufacturing their veneer in Africa. Again, in the case of sawnwood, the gradual concentration of the manufacture of furniture and joinery within enterprises of a relatively large size, in several of the importing areas, is likely to favour African exports by opening up possibilities for commercial links between major consumers, on the one hand, and sawmilling enterprises in the exporting countries, on the other. Efforts to expand plywood exports would probably have to be directed mainly towards countries that already are major importers of plywood made of tropical woods; and, in this connexion, any possibilities that may arise for expanding trade with the United States of America should receive very careful attention. In the case of packaging veneer, a product which constitutes a limited, yet a significant and steadily increasing, potential outlet for African wood, a low price is all important, and manufacture will have to be almost invariably close to the source of the raw material.

(a) Freight handling

With the gradual shift of exports towards expanded trade in processed wood, there should be a growing scope for gearing production and trade to freight technology, with a view to net savings through more efficient cargo handling.

(b) Social effect of industrialization of forestry

In many cases, the industrialization of forestry may be expected to yield certain sociological side effects that appear to be associated with the lessening, through steady contact with industry, of the customary environmental isolation of forest labour in tropical areas. It has often been observed that this results in a considerable improvement of the over-all efficiency of work, while a relatively large number of the forest workers develop qualities of inventiveness and enterprise that are in pronounced contrast to their previous condition.

(c) Development of use of under-utilized species for exportation

The development of processing in wood-surplus countries is highly relevant to the problem of increasing trade in species which are currently exported in quantities that are small, or even negligible, in comparison with the availabilities in the forests.

Many currently under-utilized species of the closed high forest, including, in particular, a number of light-to medium-weight woods, offer promising possibilities for exportation on a greatly enlarged scale, provided continuity of supplies can be assured and provided prices for these woods, either in the log or after processing, are attractive in comparison with those of the more popular species.

D. Paper articles

In Western Africa and also in Eastern Africa, manufactured paper articles imported from abroad account for a high percentage of the total consumption of paper and paperboard. Many of the articles concerned could probably be produced locally, using imported paper and paperboard. Most of the production would be in relatively small manufacturing units involving a small capital investment. There are three reasons why the development of these secondary conversion industries should be encouraged: (*a*) because of the small size of the units, they would afford an opportunity for local investment or co-operative effort; (*b*) the factories would provide a useful employment outlet; and (*c*) such industries would offer immediate possibilities for savings in imports.

E. Pulp and paper

As far as pulp and paper and paperboard are concerned, considerable expansion of production has been achieved in recent years in Northern Africa and Southern Africa, the two subregions that account for the greater part of current consumption and estimated future requirements; there is every indication that production in these subregions will continue to grow at a satisfactory rate. In Southern Africa, extensive areas of man-made forest provide the base for an adequate expansion of pulp manufacture (see table 7), while in Northern Africa, domestic production of pulp will have to rely in the main on fibrous raw materials other than wood. In the Maghreb countries, however, longer term planning of production, beyond 1975, may permit a measure of choice between such raw materials as esparto grass or crop residues, on the one hand, and plantation-grown pulpwood, on the other. There certainly exist areas where it is *prima facie* possible to create major raw-material bases through afforestation, and this possibility should be taken into account.

In Eastern Africa, where the manufacture of pulp and pulp products is in its early beginnings, plans for setting up production based on plantation-grown wood are currently under consideration in several countries. To the extent that such plans may depend upon sales to other countries within the subregion, a measure of co-ordination seems desirable in order to explore possibilities for complementary manufacture and to avoid unproductive competition.

Table 7. Forest plantation areas in Africa, 1961-1964
(*Thousands of hectares*)

Subregion	*Conifers*	*Broadleaved species* *Eucalyptus*	*Others*	*Total*
Northern Africa	31	170	31	232
Western Africa	1	62	150	213
Eastern Africa	162	255	190	607
Southern Africa	461	169	373	1,003
TOTAL	655	656	744	2,055

SOURCE: "Appraisal of the region's fibrous raw material supply, economic availability and technical suitability", *Pulp and Paper Development in Africa and the Near East*, Proceedings of the Conference held in Cairo, 8-18 March 1965 (Rome, 1966), vol. I, part II, Secretariat paper II.

Within Western Africa, consumption will, in all probability, continue to be centred in the sector of the subregion which contains Ghana and Nigeria, and as far as local markets are concerned, it is this area that would seem to offer the best prospects for early installation of an economically viable plant for the manufacture of pulp and paper (such a plant is currently being built at Jebba in Nigeria). In the period to 1975, most of the long-fibre pulp needs of Western Africa will have to be imported, but it should be possible to obtain the rest of the requirements from the mixed tropical high forests and from plantations of broadleaved species. At the same time, experimental work with conifers and with bamboo should be intensified and should include the systematic seeking out of suitable sites for growing long-fibre pulpwood.

1. Cairo Conference recommendations

Particular attention is drawn to the following recommendations of the ECA/BTAO/FAO Conference on Pulp and Paper Development in Africa and the Near East, held in Cairo from 8 to 18 March 1965:

1. The region's fibre resources, wood and non-wood, though unevenly distributed, are capable of sustaining most, if not all, of the required expansion in pulp production.

2. Many African countries are favourably endowed for the rapid creation of additional reserves of coniferous fibre at a very low cost, but further investigations are needed on the introduction of species to extend the range of planting sites.

3. The use of tropical hardwoods for the production of short-fibred pulp is promising, provided any proposed scheme is built on a thoroughly sound technical and economic basis.

4. These facts, taken in conjunction with the deteriorating wood resources/requirements balance in some of the advanced regions of the world, offer the prospect of successfully establishing in Africa, not only the additional capacity needed to supply the region's expanding requirements, but also an important export-oriented industry.

5. Non-wood resources such as bamboo, esparto and reeds have a role to play, as well as agricultural residues such as bagasse and straw. It would appear that of all the non-wood resources, bagasse has the greatest potential, industrially, and the report of the Working Party on Newsprint established at the Cairo Conference in March 1965, will be of major concern and interest to those countries having little forest or lacking conventional long-fibred raw material resources.

6. Since water is scarce in many parts of the region, particular attention needs to be given to water recirculation problems and effluent disposal. In particular, further research and investigation is required into the possibility of using the effluents as a fertilizer in water irrigation systems.

7. Another prerequisite in countries that do not have an existing paper industry is the proper training

of workers and management staff for this work. The paramount importance of this aspect of a new project to ensure the ultimate success of the mill cannot be too highly stressed.

8. When reviewing the economic aspects of the production it should be stressed that in determining the feasibility of a pulp and or paper mill in the region, not only the technical aspects but also the economics of production must be very carefully evaluated.

9. Further research into the development of refiner processes semi-chemical, chemi-mechanical and mechanical is strongly recommended.

10. Recognition must be given to the great influence of the scale of operation on the economics of a project and also to the world trend towards larger manufacturing units. However, it must also be recognized that in the case of mills supplying local markets, which may be quite small, each individual development project must be very carefully evaluated on its own merits.

11. It is once more iterated that the growing need for pulp and paper in the region simply cannot be satisfied by rising imports, and, therefore, it is necessary to speed up the rate at which new pulp and paper capacity is being established in the region.

12. It is estimated that regional development of these industries should be able to cover two-thirds of local needs by 1970 and, looking forward to 1980, it is hoped that four-fifths of local needs will then be met by regional production.

2. Investment considerations

To achieve this level of production in the region, the required investment in the pulp and paper mills, alone, will run at a rate of $50 million per annum up to 1970, and at a rate of $100 million per annum after that.

It will be necessary to weigh very carefully the relative advantages and disadvantages of alternative arrangements for financing this investment. The attention of national planning agencies, of interested institutions, such as the United Nations Special Fund, the International Bank for Reconstruction and Development, the International Finance Corporation, the International Development Association and the African Development Bank, and of countries carrying out bilateral assistance programmes in the region should be drawn to the urgency of and special opportunities afforded by investments in this sector.

3. Interregional planning

Given the current small size of national markets in many of the countries of the region and the significant economies of scale in many branches of the pulp and paper industry, national self-sufficiency in paper in every country of the region will not represent optimum use of the region's resources. Governments of the region, therefore, should co-ordinate their plans for developing this industrial sector and related infra-structure. A special point is made here for the need to plan and develop transport facilities on an intraregional basis.

IV. A programme of action

On the basis of the data given above, what measures must be taken if these challenging prospects for harnessing African forest resources as an engine of growth for the region are to be realized? In the first place, there is clearly an urgent need to know more about these forests. But rough though the picture may still be, it is sufficiently well understood for the major elements of a programme of action to be quite clear—a programme of action that needs to be initiated now by the Governments of the region. These principal elements are summarized below. All are a matter of high priority.

A. Recruitment of qualified personnel

No plan or policy can hope to be effective unless there are the people qualified to put its measures into effect. Moreover, the range of expertise required must not be underestimated. The objectives of forestry in Africa are no longer primarily conservationist in intent, and industry has a much wider role than its initial predominantly extractive one. The need now is not merely for more people who are conversant with the methods of forest management and wood technology, but also for engineers, technicians, marketing specialists and those versed in the techniques of planning and the other specialized skills necessary to bring the sector forward and to integrate it more fully into national and regional economies. The first step for each Government will be to make an assessment of its personnel requirements and then to prepare and implement a programme of education and training appropriate to meeting these requirements.

The key figure will still be the professional forester. Professional-level forestry schools must be established in such numbers and locations as to serve adequately each of the different geographical and language groupings of countries in the region. Their establishment should, therefore, be co-ordinated. Schools to give sub-professional training will be needed at the country level. But for some time to come, most countries in Africa will be short of the qualified personnel they need. To overcome this temporary need, Governments, institutions and industries in the developed countries should be encouraged to second people with the necessary expertise for service in Africa. Among the more important skills that could be made available in this way would be those of a teaching and administrative nature, to help build up the schools which in due course will overcome this shortage. African countries should also utilize the highly developed training facilities available in these countries for the advanced training and the training in specialized skills that some of their personnel will require.

B. Need for production training

Particularly when considering the development of such an expensive, highly complex and sophisticated industrial establishment as a modern pulp and paper mill, it cannot be too strongly emphasized that academic and institutional training is simply not enough. Special plans are needed to enable all grades of staff both to gain the theoretical background and to acquire the necessary practical experience in their own particular skill within the fabric of a smoothly running production organization.

While this aspect of training is particularly true in the pulp industry, it applies generally in all the other branches of the timber industry. The prime importance of on-the-job training cannot be over-emphasized. There cannot be hard and fast rules about the best ways of developing this kind of training. Sponsoring of the management and training of a new industrial project by a consortium from one of the advanced timber industry countries is certainly one method. More discussions at a high level between developing and developed countries on this matter would appear to be desirable.

C. Securing an adequate forest estate

At the current time, the degree of abundance or scarcity of forests in African countries is still much more a reflection of their original resource endowment than of their actual need of and capacity for producing wood. There is an urgent need for establishing the size and pattern of the forest estate appropriate to:

(*a*) Current and prospective demand—domestic and export—for wood and other products of the forest (wildlife, tourism etc.);

(*b*) The availability of land which could be best employed by using it for growing trees;

(*c*) The balance between forest and agriculture needed to protect and sustain permanent agricultural production.

This must be established within the framework of an integrated land-use plan which takes account of the parallel needs and potentials of agriculture and the other competing uses of land.

To secure the forest estate required, it will be necessary to:

(*a*) Establish as forest reserves the land set aside for forestry and bring them under the desired management;

(*b*) Enact forest legislation designed effectively to secure the forest reserves and to protect them against unauthorized incursions and abuse;

(*c*) Establish an administrative service strong enough in numbers and training to enforce the legislation and to ensure the management desired;

(*d*) Bring under control the designation and transfer of those other parts of the forest which are destined for agriculture or other uses. It is vitally important that the current large-scale, indiscriminate destruction of the forest should be curbed, i.e., that it should proceed only as far and as fast as is called for by the planned extension of agriculture, settlement, etc., and that the merchantable timber from this land should not be destroyed, but harvested for use;

(*e*) Establish such areas of plantation forests as are required to supplement or to replace natural forest. Man-made forests have a particularly vital part to play in Africa, and this item—with its accompanying need for more investigation into species and methods of plantation—should figure prominently in the action programmes of most African countries.

D. Improvement of data collection

The process of compiling this study has pointed out the critical need underlying all else for a major effort to acquire a better knowledge of the African forest and forest products sector. Five types of information and data-gathering activity are called for:

(a) *Forest inventory.* An inventory must be made of the productive and potentially productive parts of the forest resources, with the level of inventory activity being always geared to the particular potential of the part of the resource under survey;

(b) *Statistical reporting.* A system of accurately recording and reporting production and trade in forest products must be instituted and kept up;

(c) *Market surveys.* A periodic survey must be made of the nature, location and evolution of markets—domestic and export—for wood products. Plans for producing wood and its products must take account of what they are to be produced for;

(d) *Cost data.* It is necessary to undertake inquiries to establish how much it will cost to grow wood in plantations, to grow wood by treatment of the natural forest, to extract and transport the wood, to produce a given processed wood product in a certain location etc. Cost data are as integral a part of planning the development of the wood resource as the quantitative data. They are basic requirements for establishing the feasibility of producing wood and wood products in a country and for determining the desirability of doing so.

(e) *Resources.* Availability and extent of non-wood fibrous resources for pulp-making with the region.

The effort devoted to improving the level of data collection must be a continuing one. The initiation of the process of developing the forest resource cannot await the acquisition of a complete data base. Enough is known to make a beginning. But if major, possibly irreversible, errors are to be avoided, plans and programmes must be limited to what can be firmly based on what is known. A major part of such early development programmes should, therefore, be devoted to improving knowledge about the sector.

These measures are clearly not exhaustive, but they represent the fundamental framework for a successful beginning. Nor does this effort have to begin from scratch. Some countries are well advanced in putting into practice at least some of the measures advocated above; but many others have as yet gone little further than making a beginning. For all countries in Africa, it is true to say that the challenge and the opportunity are great; the response must be swift, decisive and imaginative.

E. Research

Too little is known about the forestry and wood-using problems peculiar to Africa, and too little effort is devoted to seeking their solution. Africa is still heavily dependent upon methods developed to meet quite different conditions. In an era of economic growth in which the momentum of that growth rests upon the continuous emergence of new technology, this limitation could become critical. A more extensive research effort is required to adapt existing technology and to develop new techniques appropriate to African conditions. In this effort, the developed countries can and should make a major contribution. The Governments and great forest industries of these countries should seek to make available a greater part of their vast research facilities and resources to assist the expansion of the research peculiar to African needs. Such an effort could begin now with particular industries and institutions taking up particular problems. Subjects that require investigation include the following:

(*a*) Widening the range of species used for sawnwood, plywood and veneer;

(*b*) The economics and techniques of pulping hardwoods, both natural forest and plantation growths;

(*c*) Techniques to use wood products more widely, in particular, in low-cost housing construction;

(*d*) Investigation into the organization and training required for small-scale industrial plants capable of producing wood products competitively for the markets of the restricted size found in some countries of Africa;

(*e*) Research into methods of work and equipment to improve efficiency in harvesting and in sorting the out-turn from mixed tropical forests.

(*f*) Investigation into species and cultivation methods to permit plantations to be established in wood-poor areas, particularly the savannah zone;

(*g*) Investigation into the best species and cultivation methods, and the economics of plantations to provide wood for industry, paying particular attention to the need for low-cost wood in the coastal regions of Africa to assist the development of export-oriented industries;

(*h*) Investigation into the economics and management methods required to raise the yield from natural forests;

(*i*) Investigation into methods to improve the out-turn of wood from the savannah and other open woodlands, paying particular attention to the problems of maintaining the ecological balance in these areas;

(*j*) Investigation into the more extensive use of non-wood resources for pulp and paper manufacture;

(*k*) Investigation into the related problem of effluent disposal in pulp manufacture.

F. Expansion

Provision of wood to meet the traditional demands of wood for fuel and for pole building material must continue to figure prominently in development considerations. However, the demand for wood in Africa, as everywhere else in the world, will be increasing as the raw material for the whole range of the wood-using industries. The expansion of these industries will rest upon:

(*a*) The growth of domestic demand for wood products currently used and increased domestic production of those wood products currently imported;

(*b*) Expanding the range of domestic uses of wood—substituting locally produced wood products for non-wood products currently imported;

(*c*) Expanding exports of wood products through growth in existing markets, penetrating new markets and, above all, by upgrading the current trade from exports of roundwood to exports of processed-wood products;

(*d*) By developing on a considerable scale a pulp-making industry, using both wood and non-wood raw materials, to provide for the considerable increase in paper products expected to be required in the region and also to develop where possible an export to meet the ever-increasing world demand for pulp products.

G. Investment effort

Throughout the following sections, the estimates that are given cannot and should not be taken as precise budgeting figures. They are intended solely to provide an idea of the order of magnitude of the investment required, if expanded requirements of wood products throughout the region between now and 1975 are to be met by increased production within the region.

The investment that will be called for, in terms of both capital and industrial skills, to achieve this four-fold expansion will be enormous. It seems reasonable to expect that for the first three items a large part of this investment could be met from local sources. The fourth item, however, involves, in many cases, such vast sums in capital investment that external financing and international loans may be needed if these schemes are to come to fruition.

1. Sawnwood

During 1961/1962, some 3 million m³ of sawnwood were produced in Africa. At the same time, the region consumed slightly more than 4 million m³, the difference being met by a net import of about 1 million m³. By 1975, local consumption is expected to reach around 7 million m³. If this demand is to be satisfied by local production alone then the region as a whole would have to produce 4 million m³ more than in 1961/1962. When trying to estimate what new sawmilling capacity may reasonably be expected to be put into service by 1975, two facts have to be borne in mind:

(*a*) Whereas Western and Southern Africa will have no difficulties in finding the raw-material resources for the necessary expansion, Eastern Africa, probably, and Northern Africa, certainly, will have to rely to some extent upon imports of sawnwood because of the lack of saw-logs;

(*b*) The current sawmilling industry comprises small, poorly equipped units and often operates considerably under full capacity. With a better supply of logs, improved technical and managerial skills and improved marketing, the output could be much higher than it is at the current time. If existing mills operated on two shifts instead of one, then in all probability they could produce a considerable part of the increased requirements foreseen.

The two points mentioned above make it clear that estimates of the investment requirements in the African sawmilling industry, with regard to 1975, should not be based on an additional capacity of 4 million m³. A rough estimate would be between 1.5 million and 3 million m³. The investment in the sawmilling industry varies greatly with size of operation, location etc. Very approximately, the average might be between $25 and $40 per annum per m³ of output. In order to provide some idea of the order of magnitude of the investment required, it may be calculated that an increase in capacity of 2 million m³ from 1961/1962 to 1975, at an average investment of $30 per annum per m³ of output would correspond to a total investment of $60 million, spread over thirteen to fourteen years.

2. Wood-based panels

In 1961/1962, the total consumption of wood-based panel products in Africa amounted to some 370,000 m³, and local production was estimated as being around 280,000 m³. By 1975, it is anticipated that consumption will have increased to 980,000 m³, which means that production at that time should be some 700,000 m³ greater than in 1961/1962 if local demand is to be met, but without any allowance for exportation. Projections are not available showing the proportion of this increase separately for plywood, fibreboard and particle board. Investment figures for the different types of mills differ considerably, making it difficult to give even a rough estimation of the amount of investment required. Some countries may develop a considerable export of plywood and veneer, possibly also fibreboard. Others, where there is a raw-material deficit, may have to rely heavily upon imports, except perhaps for particle board. If one calculates with an investment of between $100 and $250 per annum per m³ of output, then the total investment required between 1961/1962 and 1975 would probably be between $70 million and $170 million, over a period of some fifteen years.

3. Pulp and paper

A paper prepared for the Cairo Pulp and Paper Conference shows that the average annual consumption (1960-1962) of paper and paperboard in Africa was nearly 90,000 tons and that annual production in the region during the same period was 35,000 tons.[6] A tentative estimate of total expected requirements by 1975 of paper and paperboard is 2,420,000 tons[7]. Another paper presented at the Conference suggests that by 1975 Africa alone should be able to produce nearly 80 per cent of its domestic requirements of paper and paperboard. This would imply a capacity increase of some 1.5 million tons, which, together with capacity existing in 1960-1962, would bring the total capacity to some 1.9 million tons.[8] The investment necessary to carry out this expansion programme (paper and paperboard capacity only, excluding pulp manufacture) has been estimated at $350 million, spread over the period from 1961 to 1975. It has furthermore been estimated, taking into account available raw-material resources, markets and infra-structure, that the production of pulp could be increased by some 1.4 million tons by 1975, which (together with capacity existing in 1960-1962, 0.2 million tons) would bring the total to 1.6 million tons. The above-mentioned expansion of the pulp industry would thus call for an investment of about $440 million. The total investment, therefore, in pulp and paper mills alone, would thus amount to around $800 million, spread over fourteen years, or, roughly, $60 million per annum. The total investment foreseen for the development of forest industries in Africa between 1960-1962 and 1975 are outlined in the table given below. It must be emphasized, however, that the estimates shown relate only to capacity aimed at satisfying the domestic demand for forest products. Additional investment which, at the current stage, cannot even be roughly estimated will be required for the development of export-oriented forest industry undertakings.

Estimated investment requirements in forest industries to meet increased consumption in the African region, 1961-1975

Industrial sector	*Estimated increase in capacity by 1975*	*Estimated total investment required, 1965-1975 (millions of dollars)*
Sawnwood	2 to 3 million cubic metres	60
Wood-based panels	600,000 cubic metres	70 to 170
Pulp and paper	1.5 million tons	800

4. Basic development

On top of this considerable expenditure, further substantial investments will be required to expand conservation work, development of forest inventories, development of new plantations and development of forest roads and adequate connexions to the main arterial routes of the country or subregion.

H. Conclusions

The onus of promoting and guiding this development will remain with the Governments of the region. Governments will need to:

(*a*) Co-ordinate interregional plans to secure a rational development of industries so that they serve markets of a size permitting economic scales of operation;

(*b*) Provide, where appropriate, the social overhead capital works, such as roads, which are the framework within which industry operates;

(*c*) Determine forest fees, export levies, taxes etc. to encourage domestic processing and use of wood products to the desired degree;

(*d*) Ensure the quality of wood products, e.g., by establishing grading rules and ensuring adherence to these rules;

(*e*) Encourage and, where necessary, participate in the setting up of bodies which can effectively promote new market outlets and organize the process of marketing. Particular attention should be paid to the widening of the range of species marketed;

(*f*) Negotiate to remove tariff and other trade barriers in importing countries which create difficulties for the expansion of exports of processed-wood products from Africa;

(*g*) Create conditions which will encourage all sources of capital and skills to participate in the development of the different sectors of the forest industry to the fullest extent.

Above all, the principal task of Governments must be to ensure that the complex of wood-using industries is of a size and structure which conforms to and is fully integrated with the plans for over-all economic development.

[6] "Review of past developments and future demand estimates", *Pulp and Paper Development in Africa and the Near East*, Proceedings of the Conference held in Cairo, 8-18 March 1965 (Rome, 1966), vol. I, part II, Secretariat paper I.

[7] This forecast corresponds to the higher estimate of 2,490,000 tons given in "Timber and trends and prospects in Africa" rather than the medium estimate of 2,210,000 tons.

[8] "Development prospects and investment needs", *Pulp and Paper Development in Africa and the Near East*, Proceedings of the Conference held in Cairo, 8-18 March 1965 (Rome, 1966), vol. I, part II, Secretariat paper V.

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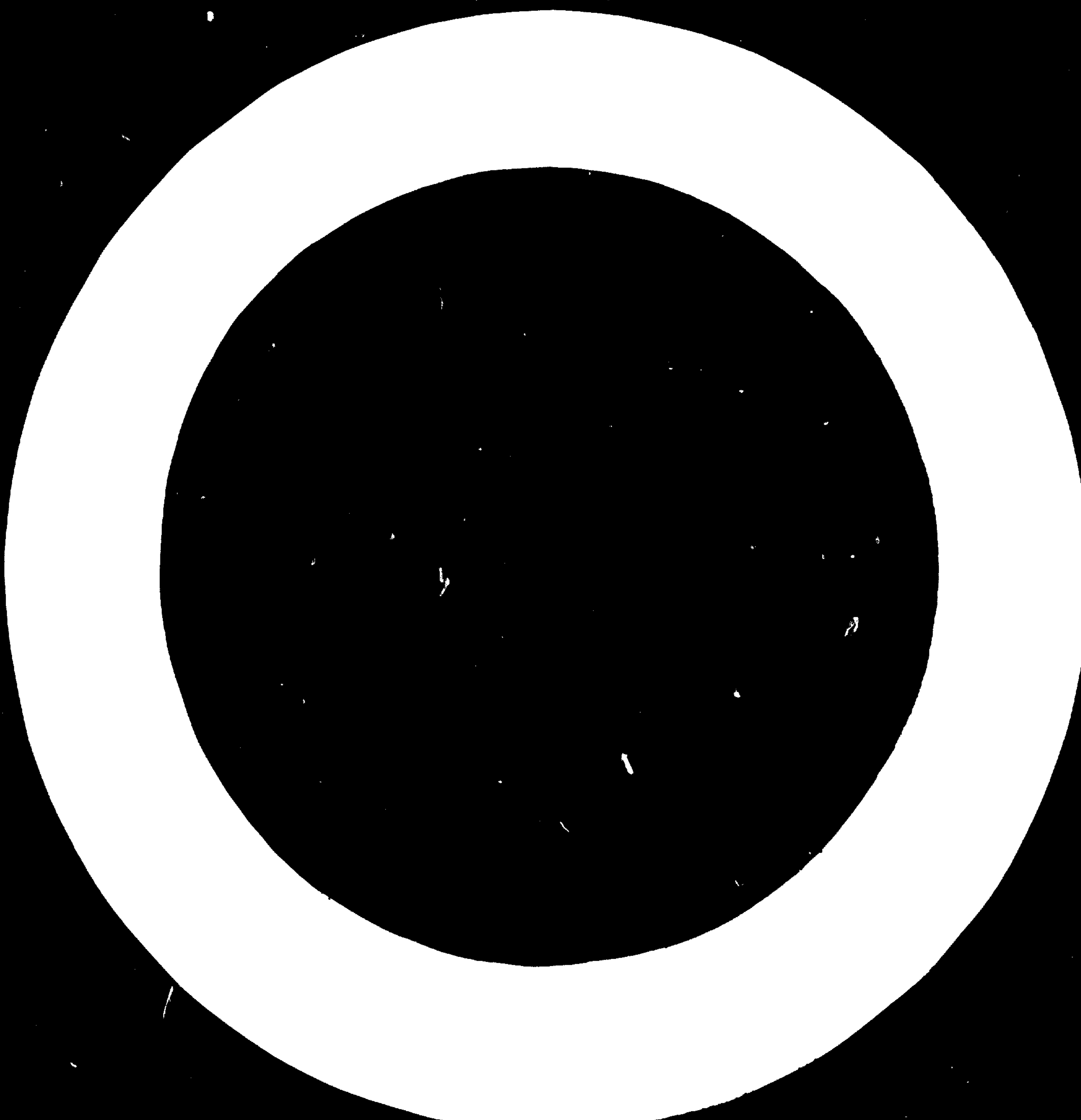

PREFACE

The United Nations General Assembly, at its eighteenth session in 1963, adopted resolution 1940 (XVIII) calling for the convening of an International Symposium on Industrial Development, to be preceded as appropriate by regional and subregional symposia which would prepare the ground for the international symposium.

In accordance with this resolution, regional symposia were held in Asia and the Far East (December 1965), Africa (January 1966) and Latin America (March 1966) under the auspices of the United Nations economic commissions of the respective regions in co-operation with the United Nations Centre for Industrial Development. A Symposium on Industrial Development in the Arab Countries was held from 1 to 10 March 1966 at the invitation of the Government of Kuwait, with the technical co-operation of the United Nations and, in particular, of the United Nations Economic and Social Office in Beirut.

Of the countries participating in the Symposium on Industrial Development in Africa, the following countries also participated in the Symposium on the Industrial Development of the Arab Countries (ID/CONF.1/R.R./4): Algeria, Libya, Morocco, Sudan, Tunisia, United Arab Republic.

The purpose of the regional meetings was to study the existing situation and future prospects for industrial development in each region and to consider possible action which could be taken on the national, regional and international levels to accelerate industrial development.

The present volume contains extracts of selected documents presented to the Symposium on Industrial Development in Africa. The material is divided into two parts. Part One contains papers dealing with various aspects of progress and problems of industrialization, while Part Two consists of country reports.

In general, the studies and reports are printed in the form in which they were submitted. However, corrections have been incorporated, and some minor editorial changes have been made. The usage and style of the original texts usually have been retained. Bibliographical and other references have, wherever possible, been verified. Some references have been printed as foot-notes.

The views and opinions expressed in papers other than those prepared by the United Nations are those of the individual authors and do not imply the expression of any opinion on the part of the Secretariat of the United Nations.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

EXPLANATORY NOTES

The following symbols have been used throughout the report:

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

A slash (/) indicates a crop year or financial year, e.g., 1965/1966.

Use of a hyphen (-) between years, e.g., 1963-1966, signifies the full period involved, including the beginning and end years.

References to "tons" indicate metric tons, unless otherwise stated.

References to "dollars" indicate United States dollars, unless otherwise stated.

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

The country names used throughout the report are, for the most part, the names current at the time of the Symposium on Industrial Development in Africa. They do not reflect earlier or subsequent changes.

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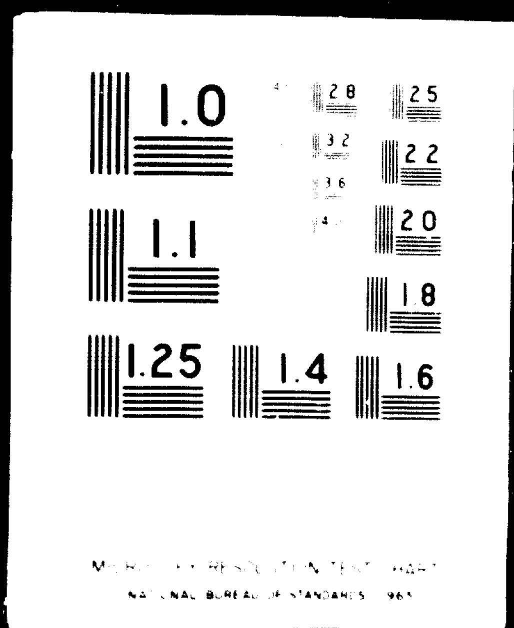


Figure IV shows trends in domestic production and imports. For most of the basic materials, both supply sources have increased fairly steadily. In the case of cement, however, domestic production has, by and large, kept close to trends in consumption. In contrast, import trends have decreased visibly. The relative importance of domestic production and imports in total consumption are shown in figure V for the two years chosen, i.e., 1953 and 1963. For most of the basic materials and in the majority of subregions, the relative importance and quantities of imports have not decreased appreciably.

In terms of *per capita* consumption, the growth trend has been modest, and *per capita* consumption levels for Africa continue to represent a small fraction of world *per capita* consumption levels. In the early 1960's, the ratios of African *per capita* consumption levels to those of world *per capita* consumption were one-third for cement, one-eighth for crude steel, one-ninth for sawnwood and one-tenth for plywood. These orders of magnitude, furthermore, show no improvement on the situation in the early 1950's. Since the late 1950's, the African share of world *per capita* consumption has tended to decrease. Nevertheless, for the continent to have increased its *per capita* consumption levels by 31 per cent for cement and crude steel, by 33 per cent for sawnwood and by 100 per cent for plywood underlines the potentials of the African market for building materials (see fig. I, graph 3).

Table 5 summarizes the past trends and current levels of *per capita* consumption, by subregion. Two series of rates of growth are shown: one is an average compounded rate for the whole period and the other, the best rate of growth sustained over a period of not less than five years within the period 1953-1963.

Table 5. Africa: *per capita* consumption levels of basic building materials in the early 1960's and assessment of past growth rates, by subregion

	Average per capita consumption					*Rates of growth (compounded)*[a] *(percentage)*				
	Cement	*Crude steel*	*Sawnwood*	*Plywood*	*Board products (kilogrammes)*	*Cement*	*Crude steel*	*Sawnwood*	*Plywood*	*Board products*
	(kilogrammes)		*(cubic metres per 1,000 inhabitants)*							
North Africa	68	16	18	1.2	0.40	4.1(4.1)	3.9(6.9)	1.2(5.6)	10.0(11.2)	14.8(20.1)
West Africa	23	6	7	0.3	0.13	6.7(7.5)	7.2(8.0)	13.1(14.9)	11.6(18.9)	12.5(15.9)
Central Africa	19	5	10	0.4	0.02	(1.1)	( )	(2.9)	(7.2)	(28.3)
East Africa	17	6	6	0.3	0.10	0.6(7.5)	(1.5)	(5.9)	7.2(25.9)	(7.4)
Southern Africa	146	135	42	0.6	2.37	4.2(3.6)	2.2(4.1)	2.5(11.0)	11.6(14.9)	12.2(13.4)
Africa	39	17	12	0.6	0.30	2.8(3.3)	2.7(5.7)	2.9(5.4)	7.2(17.7)	0.5(16.5)
World	110	116	110	5.6	2.3	5.6(6.1)	3.2(3.9)	2.7(3.8)	7.2(7.2)	9.6(9.6)

SOURCE: Computation of the Secretariat of the United Nations Economic Commission for Africa.

[a] Figures in brackets are the best compounded annual rates of growth attained over a period of not less than five years during the period 1953-1963.

The first point that emerges from table 5 is the considerable disparity between subregions in *per capita* consumption levels. While North and Southern Africa have attained levels of *per capita* consumption of two to five times the averages for the continent, *per capita* consumption in the remaining three subregions is at less than half of these averages. It would also appear that where the over-all trend is one of growth, those areas with the lower levels of *per capita* consumption seem to show the highest rates of growth. This observation is especially noticeable in the case of the West African subregion. By contrast, in the Southern African subregion, where high *per capita* levels have been attained, the rates of growth were among the lowest for the continent. Finally, as far as the rates of growth of the materials themselves are concerned, these show an interesting aspect, in that it appears that relatively higher rates of growth are indicated for those materials whose use in Africa was introduced or encouraged in recent years. Thus, the rates of growth of plywood and board products are considerably higher than those for cement and crude steel.

These observations of past trends will be useful in the elaboration of a methodology for assessing future trends and quantifying the future demand for building materials, which is the subject matter of the section which follows.

B. Future prospects

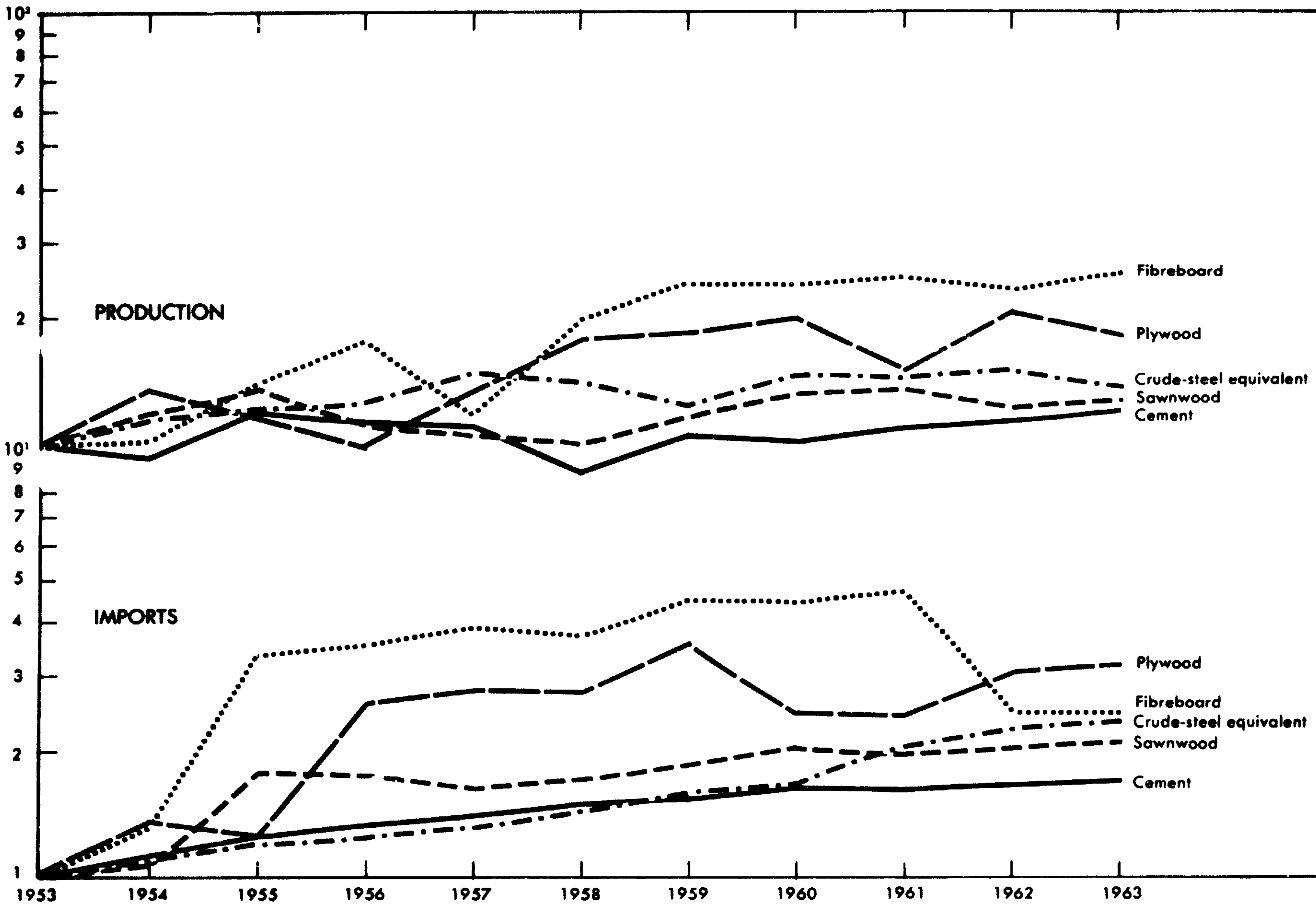
The justification for the methodologies which are used for assessing the future demand for the major building materials in this section are adequately explained in other documents.[4] It would, however, be appropriate to indicate here the broad concepts and aims underlying the methods used.

The methodologies used are based, directly or indirectly, on assumed, planned or assessed growth rates of the economy as measured by the gross domestic product. The linking of future demand to the pace of economic development is an inevitable step in order to be able to take the implications of accelerated economic development into account.

It will be appreciated that quantifying future growth rates for the economy is a difficult proposition. Any hypothesis could provoke argument. It could be argued that the concepts of *per capita* gross domestic product and *per capita* consumption on which projection methods are often based might lead to unreliable results. Censuses of population have not been undertaken in

[4] See United Nations Economic Commission for Africa/Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (1965); Economic Commission for Africa, "Development of the iron and steel industry in Africa" (E/CN.14/INR/27).

Figure IV. African production and imports of selected building materials, volume index trends, 1953-1963



the majority of African countries; therefore, the reliability of *per capita* figures is doubtful.

Although such objections pose limitations on the use of a methodology based on the above mentioned concepts, nevertheless, these and similar objections do not invalidate it. This is especially true within the context of this report, where the aim is to evaluate broad orders of magnitude of future demand arising from a given growth rate of the economy. In other words, the projection exercise aims at demonstrating the broad magnitude of the supply problem that will face Africa when the current desire and hope of African countries for accelerated economic development begin to materialize.

At the same time, however, a practical note is injected into the assumptions, in that the growth rates of the economy assumed for the exercise are of modest orders of magnitude. In fact, they could be considered the minimum growth rates within the grasp and possibility of the countries of Africa. The rates of growth of *per capita* gross domestic product assumed for the period ending in 1980 are as follows: North Africa, 4.0 per cent; West Africa, 3.5 per cent; Central Africa, 3.0 per cent; and East Africa, 3.0 per cent. These rates are, on the whole, below the minimum set by the United Nations Development Decade; moreover, several countries have set rates of growth higher than those given above. Consequently, it is not beyond the bounds of possibility that the projections in this report would be exceeded by a significant margin.

Table 6 summarizes the demand for basic building materials, by subregion. (The table excludes the Southern Africa subregion, which already enjoys self-sufficiency in its domestic supply of building materials and would experience little difficulty in expanding current sources to keep up with demand.) The various steps in the calculations are not indicated in the table. For a detailed explanation of the methods of forecasting used, reference should be made to the papers listed above in foot-note 4. At the same time, it is convenient to summarize briefly the major co-efficients used.

Table 6. Estimates of demand for selected building materials and components in Africa, 1970 [a]

Materials	*Units*	*North Africa*	*West Africa*	*Central Africa*	*East Africa*	*Total Africa*
Basic materials						
Cement	Millions of tons	8.5	4.5	1.5	2.5	17
Sawnwood	Millions of cubic metres	2.2	1.0	0.5	0.8	4.5
Iron and steel products	Millions of tons	1.9	1.0	0.3	0.9	4.1
Sheet glass	Thousands of tons	41	14	5	14	74
Secondary materials and others						
Asbestos cement products	Thousands of tons	170	80	45	70	365
Clay products[b] (excluding ceramic sanitary wares)	Thousands of tons	105	30	10	15	160
Paints and varnishes[b]	Thousands of tons	20	25	10	10	65
Plywood	Thousands of cubic metres	210	65	30	45	350
Board products	Thousands of tons	55	35	5	20	115

SOURCE: Computation of Secretariat of the United Nations Economic Commission for Africa.
[a] Excluding Southern Africa.
[b] Only shortfall in domestic supply estimated.

First, for forecasting the demand for cement and timber, the concept of elasticity of demand was used; the elasticity of *per capita* cement consumption with respect to *per capita* gross domestic product was computed to fall in the range of 1.8-2.6, depending upon the subregion; for sawnwood, in the range of 1-1.5; and for plywood and board products, in the range of 2-2.5. In order to forecast the demand for iron and steel products, the capital formation content of the gross domestic product was assumed to reach 20 per cent of gross domestic product in 1980 for Africa, excluding Southern Africa. Again following the hypothesis of a growing share of capital formation in gross domestic product, expenditure on constructions and, in particular, expenditure estimates for housing and building formed the basis for forecasting sheet glass consumption. With regard to other materials, past rates of increase in consumption were assumed to take place in the future as well. In these cases, therefore, the implication of accelerated development has not been taken into account. This is not considered serious in that (*a*) they are secondary products based on the use of the above-mentioned basic materials; (*b*) they are, in general, substitute materials, in which instance, forecasting is, at any rate, a delicate and nearly impossible matter; and (*c*) the interest of this report in these cases is to indicate import-substitution possibilities.

Table 7 shows the shortfall in supply that would result in 1970, based on the full utilization of current installed capacity.

The magnitude of the supply problem that would face African countries, excluding Southern Africa, becomes evident from the table. All items required for building and construction are not included. Conspicuous among these are electrical installation materials, sanitary, lighting and heating fittings and fixtures, and materials and components in non-ferrous metals, for the totality of which supply the continent today depends upon imports. Moreover, the results of the tabulation tend to be underestimates, since the computation assumes the full utilization by deficient countries of surplus production elsewhere within a given subregion—an aim that may not, in practice, be attained for some time. This is especially true of the surplus production of timber products in West and Central Africa, where over 80 per cent of the exports are currently directed to countries outside Africa.

Therefore, the shortage in supply that would face Africa in 1970 is very likely to exceed by a considerable

Figure V. Africa: relative magnitudes of apparent consumption, by subregion, and structure of supply

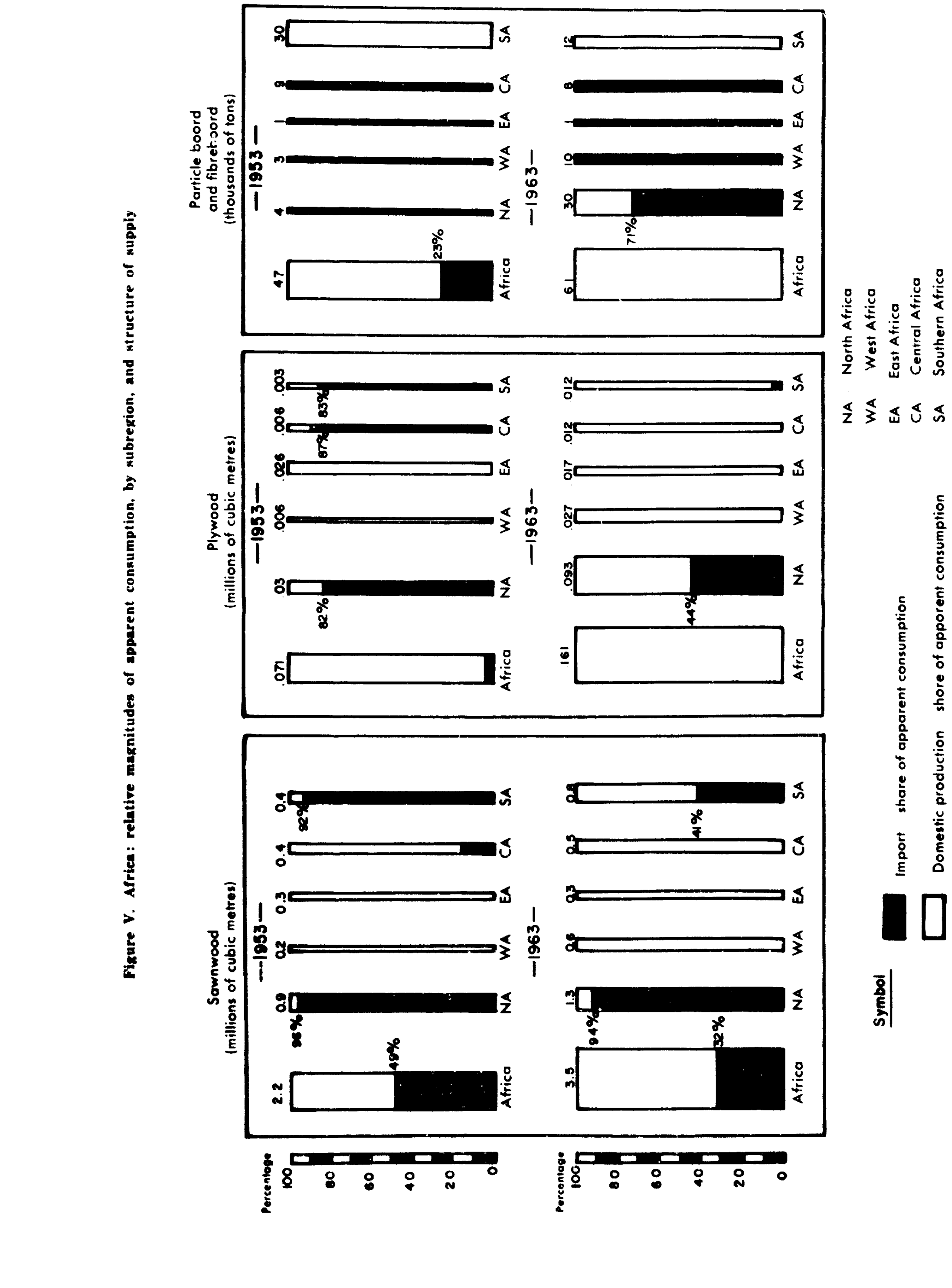


Figure V. Africa: relative magnitudes of apparent consumption, by subregion, and structure of supply (*continued*)

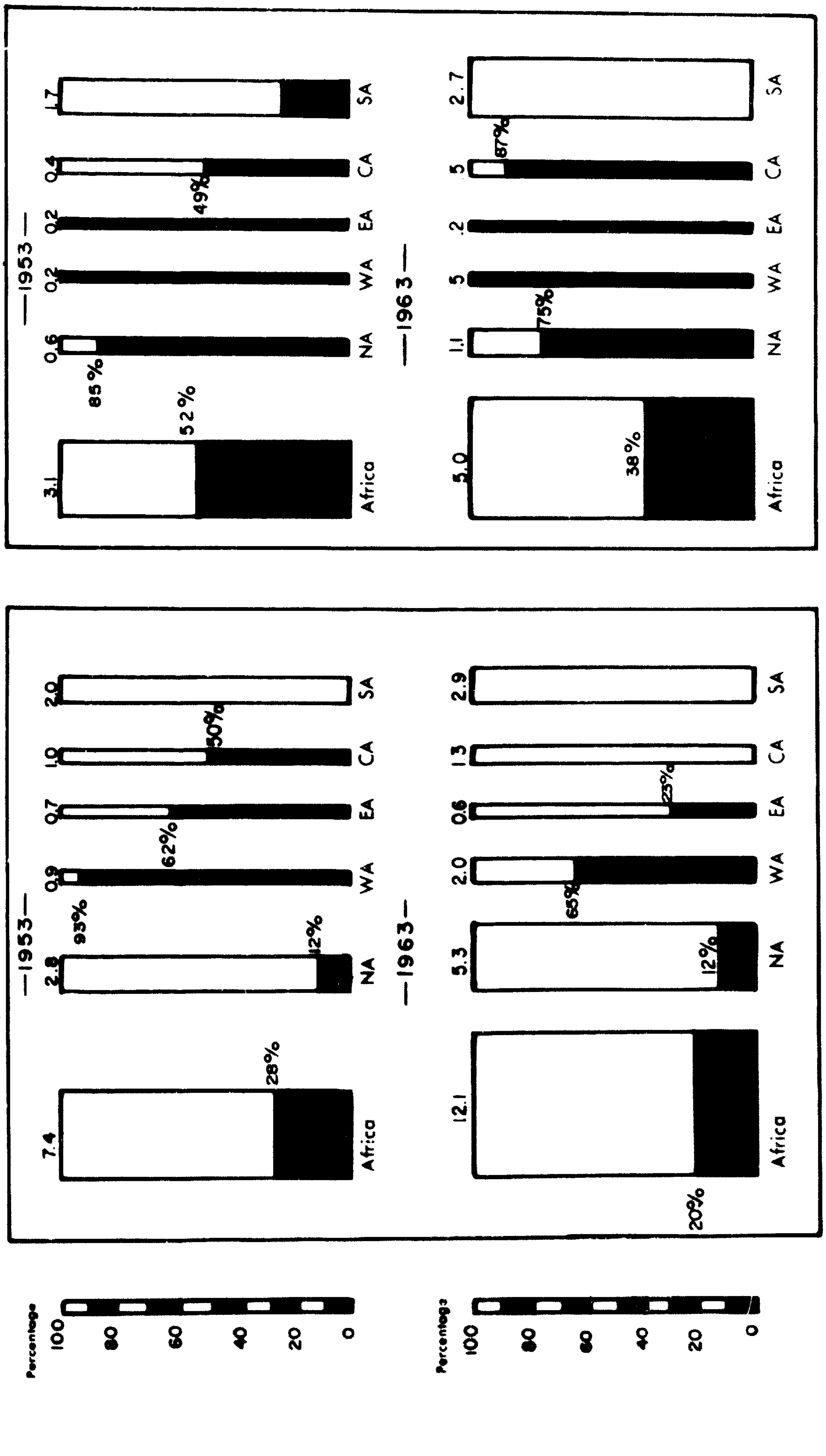


Table 7. Shortfall in supply of selected building materials and components in Africa, 1970[a]

Materials	*Units*	*Total Africa*	*North Africa*	*West Africa*	*Central Africa*	*East Africa*
Basic materials						
Cement	Millions of tons	7.4	3.3	3.5	0.2	0.4
Sawnwood	Millions of cubic metres	2.3	2.0		—	0.3
Iron and steel products[b]	Millions of tons	3.5	1.4	1.0	0.3	0.8
Sheet glass	Thousands of tons	60	27	14	5	14
Secondary materials and others						
Asbestos-cement	Thousands of tons	140	50	50	20	20
Clay products (excluding ceramic sanitary ware)	Thousands of tons	160	105	30	10	15
Paints and varnishes	Thousands of tons	65	20	25	10	10
Plywood	Thousands of tons	230	130	5	—	35
Board products	Thousands of tons	115	45	35	5	20

[a] Excluding Southern Africa.
[b] Expressed in crude-steel equivalents.

margin that indicated in table 7. What is striking is that even under such a moderate estimate of demand, a considerable expansion of the building materials industry would be required. The cement industry would need to be expanded by 80 per cent, the iron and steel products industry by 600 per cent, the sheet glass industry by 430 per cent and so on.

The market for building materials, at least on the subregional level, does not evidently constitute a hindrance to development, as was once thought. On the contrary, it poses a serious problem of shortage and inadequacy for which urgent solutions will have to be sought.

IV. Problems and possibilities for development

A. The factor of raw-material resources

The continent of Africa is not lacking in the major raw material resources which are essential for the building materials industry. In many instances, Africa is a major producer of basic resources, as is evident from table 8.

The table demonstrates the relative importance and distribution of some major resources. In addition to those shown in table 8, Africa has extensive resources of other minerals, notably limestone, clay and silicates.

It may be seen from table 8, however, that there is an over-all imbalance in the distribution of resources by subregion and by country. In many cases, only a handful of countries account for the major share of a given resource. For example, the Democratic Republic of the Congo and Zambia account for over 90 per cent of African production of copper; Algeria, Liberia and Sierra Leone for 60 per cent of iron-ore production; and so on. Some subregions also lack adequate amounts of those resources which are basic to resource-oriented industries, such as limestone, roundwoods, clays etc. For example, resources of roundwoods in North Africa are negligible, and limestone deposits in West Africa are notably inadequate.

At the same time, the exploitation of resources in Africa is undertaken primarily to satisfy the export demand outside Africa. For many countries, a single or a few basic commodities are the main or sole sources of foreign-exchange earnings. In the early 1960's, over $900 million were earned annually from the exportation of raw-material resources or their primary-transformation equivalents, while the annual expenditure on imports of finished building materials was about $800 million.

The two figures are obviously not comparable, but

Table 8. African production of basic resources related to the building materials industry, 1963

Resource	*Unit*	*African production*		*Subregional distribution of total production (percentage)*				
		Quantity	*Share of world production*	*North Africa*	*West Africa*	*Central Africa*	*East Africa*	*Southern Africa*
Asbestos	Thousands of tons	347	15	—	—	—	37	63
Bauxite	Thousands of tons	2,100	8	—	99	—	1	—
Copper-ore	Thousands of tons	986	24	1	—	27	63	9
Iron-ore	Thousands of tons	11,020	5	21	49	—	4	26
Lead-ore	Thousands of tons	191	9	50	—	—	11	39
Roundwoods[a]	Thousands of cubic metres	19,218	2	8	32	19	17	24
Tin-ore	Thousands of tons	20	12	—	44	36	11	9
Zinc-ore	Thousands of tons	242	8	29	—	41	16	24

SOURCE: Mainly United Nations, *Statistical Yearbook, 1964* (United Nations publication, Sales No.: 65.XVII.1).
[a] Industrial woods only.

the unfavourable aspect of such a trade arrangement, purely from the point of view of balance of payments, may be demonstrated by considering one product, say, iron and steel. In 1960, Africa imported about 1.3 million tons of finished iron and steel products and exported about 6.5 million tons of iron-ore, equivalent to 4 million tons of finished steel.[5] Thus, while the continent exported the equivalent of 4 million tons of finished steel in ore form in excess of its domestic requirements and earned just over $200 million, it spent, nevertheless, nearly $320 million on imports of the finished product.

Although the geographical imbalance of the distribution of basic raw-material resources, on the one hand, and the export alignment of resources, on the other, tend to discourage the development of the domestic industry, they also indicate the vast potential of the continent for import-substitution industries and for the expansion of inter-African trade.

B. Problem of scale of operations

It has been seen that at the subregional level, the current demand, let alone future demand, would be adequate to justify modern production units.

But the production of building materials and components from centralized units is not always practicable. Several building materials need to be produced near centres of end-uses to avoid transportation problems, which could attain enormous proportions, especially in the case of such bulky and heavy products as building materials. In addition, transport facilities in Africa are still at inadequate levels of development, and, consequently, transport costs are, in general, prohibitive. This poses serious limitations on the establishment of units to serve subregional requirements for a wide range of basic building materials.

The complex problem that is raised by the desire to benefit from the economies of large-scale operations, on one hand, and the practical limitations imposed by high marketing costs, on the other, require detailed analysis. A summary report like the present paper would not be the right place for such an exercise. At best, the report can only indicate the broad divisions between those industries of subregional and national interest, respectively

By and large, the development of a wide range of building materials to serve national needs is a choice that would be favoured by Governments. For countries where prevailing prices are high—and this usually happens in hinterland countries—such a course would, in general, be justified, especially for bulky and heavy materials, such as cement, clay and cement products etc. But the problem here is that modern technologies of production have advanced so fast that those small units which would have served the needs of many countries in Africa are considered obsolete by capital-equipment manufacturers. In consequence, although the industrialists of the advanced countries could fabricate small productive units, their research efforts in this direction are not intensive enough. The efficiency and adaptability of small units under current African conditions of inputs etc. is, therefore, open to question.

While the purely national development of the production of building materials has to overcome a complex series of technico-economic problems, the development of the building materials industry to serve several countries could, on the other hand, count on unimpeded progress. This might even prove to be the only sensible course to follow under certain conditions. Thus, in view of the lack of basic resources in some countries, there is considerable scope for the interchange of products; the wood-surplus countries could supply the wood-deficit countries with a range of wood products; clinker could be exported to those countries which are unable to set up their own cement plants because of lack or inadequacy of limestone resources etc. With regard to the factor of market size, the minimum requirement to justify domestic production, calls for integrated industries in many cases, e.g., iron and steel works and sheet glass and ceramic-ware manufacture. The need and desire to economize on scarce resources, (funds, manpower, fuel etc.) might justify specialization and the sharing out of industries within a framework of subregional co-operation.

C. Cost of production and prices

The most significant role played by the factor of scale of operations is, of course, in attaining low production costs. In so far as operations in African countries are concerned, there are, however, too many adverse factors for the achievement of levels of costs of production which would be comparable with those in the advanced countries, even when the scales of operations are equivalent.

The capital cost of setting up a production unit in Africa is much higher. The ratio could be as high as 1 : 3, and even more. This comes about for several reasons, some of which are: maritime transport; expensive port and handling charges; high rail and road freight rates; inflated insurance premiums and commission charges; high cost of feasibility studies; erection and construction costs, which have to take account of the high fees of short-term expatriate salaries and allowances; and the requirement of ancillary works under typical African conditions, whereby new access roads, housing and community facilities and even new electric-power generating plants might be required.

There is also the prevailing situation of high prices of inputs, whether imported or supplied locally; high electric-power tariffs; still higher delivery prices of fuels; the need of employing expatriate staff with all the expensive items that this requires (high salaries, allowances etc.); low productivity; the need for stocking large quantities of supplies and spare parts to avoid stoppages due to long and unreliable delivery periods, etc.

However imposing the extent of the problem might appear, there is nevertheless, considerable scope to lower significantly the prevailing high levels of costs of production through a concerted attack on the cost-sensitive elements of operations. Standardization of productive units appropriate to the size of the African market might induce machinery and equipment manufacturers to reduce both their f.o.b. prices and their erection costs, as this would guarantee a larger market for their goods. It would not be beyond the bounds of possibility, at the same time, for Africa to initiate the fabrication of machinery and equipment on a limited scale. The production units for certain

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[5] United Nations, *Long-term Trends and Problems of the European Steel Industry* (United Nations publication, Sales No.: 60.II.E.3).

materials, such as bricks, blocks, sawnwood and wood products, have characteristics which would not make their domestic fabrication in Africa unrealistic.

In many cases, units that were designed for maximum efficiency under the specific input conditions of the advanced countries are also used in Africa without the essential modifications. Studies and research to adapt production units to specific African operation conditions would, no doubt, bring about substantial economies of operation.

These and similar measures would contribute substantially to the attainment of reasonable prices for goods produced in Africa. At the same time, it would be appreciated that in several instances even the high costs of production levels could not, by themselves, constitute sufficient grounds for African Governments to postpone the realization of a building materials industry, which otherwise has considerable merit. Many countries in Africa experience very high prices for imported building materials. The price differential between the exporting countries and the majority of countries in Africa could be as high as one to four. Hinterland countries are particularly subjected to prohibitive prices.

African countries can, by and large, rely upon a high margin of profitability in developing their domestic industries and in competing with imported materials. High as their costs of production might be, they have the potential, through the elimination of the transport and related costs on the voluminous and heavy products involved, of producing at prices substantially below those of imported products.

V. Evaluation of a possible pattern of development

The increased demand for building materials and components in the years to come and the need to expand the current capacity of the building materials industry in the continent are beyond question. The order of magnitude of the current and future gaps between demand and supply is such that even relatively important errors in the assumptions on which the estimates were based would not affect the general picture.

It would not be within the scope and purpose of this report to attempt to define in precise terms the most desirable form of development, much less to put forward detailed recommendations on individual plants for each building material. But a general idea of a possible over-all pattern of development would be appropriate in order to assess the implications of expansions on resources (especially finance) and to evaluate in broad terms the economic impact of the development of the industry.

Table 9 constitutes a proposal for a possible pattern of development to cover the estimated shortfall by 1970 of a few key materials. The size and distribution of units has been arrived at taking into account the major economic and technical factors discussed in earlier chapters. The table is not inclusive of the total building materials and components effort of the continent. Notable omissions are, for example, steel re-rolling mills, finished metal building-component industries, wood joinery works, paints and varnishes, electrical installation materials, building fittings and fixtures, etc.

Table 9. Estimate of manufacturing units to balance the demand of selected building materials in Africa, 1970 [a]

Material	*Remarks*	*Subregional locations*				*Total number of units*
		North Africa	*West Africa*	*Central Africa*	*East Africa*	
Cement	Plant sizes	100-400,000 tons p.a.	30-200,000 tons p.a.	40-100,000 tons p.a.	60-200,000 tons p.a.	—
	Number of units	14	38	3	5	60
Iron and steel integrated works	Plant sizes	600-1,000,000 tons p.a.	600-1,000,000 tons p.a.	400-600,000 tons p.a.	200-600,000 tons p.a.	—
	Number of units	2	1	1	2	6
Sawnwood	Plant sizes	10,000 cubic metres p.a.	10-20,000 cubic metres p.a.	10-20,000 cubic metres p.a.	5-10,000 cubic metres p.a.	—
	Number of units	50	50	50	40	190
Plywood	Plant sizes	10-20,000 cubic metres p.a.	10-20,000 cubic metres p.a.	5-10,000 cubic metres p.a.	5-10,000 cubic metres p.a.	—
	Number of units	8	3	2	4	17
Board products	Plant sizes	5-10,000 tons p.a.	5-10,000 tons p.a.	5-10,000 tons p.a.	5,000 tons p.a.	—
	Number of units	30	30	30	20	110
Sheet glass	Plant sizes	10,000 tons p.a.	6-10,000 tons p.a.	7,000 tons p.a.	10,000 tons p.a.	—
	Number of units	3	2	1	2	8
Asbestos cement	Plant sizes	15-25,000 tons p.a.	5-10,000 tons p.a.	5-8,000 tons p.a.	5-10,000 tons p.a.	—
	Number of units	2	5	3	3	16
Clay products	Plant sizes	25-40,000 tons p.a.	5-10,000 tons p.a.	5,000 tons p.a.	5,000 tons p.a.	—
	Number of units	4	3	2	2	16

SOURCE: Secretariat of the United Nations Economic Commission for Africa.
[a] Excluding Southern Africa.

Although of modest coverage, the table demonstrates the extent of the development requirements of the continent within the next few years.

Table 10, which summarizes the costs involved in such a development pattern, further defines the extent of the problem. The total investment requirement comes to nearly $1,640 million for those materials selected for the purpose of the exercise. In addition, further investments would be required to expand the production of such building materials as concrete products, building fittings and fixtures, paints and varnishes, wood and metal joinery works etc. The above mentioned estimate could, therefore, be raised to about $2,000 million to represent the over all investment required by 1970.

Table 10. Estimate of development cost for selected building materials and components for Africa [a]

(Millions of dollars)

Subregion	*Cement*	*Other non-metallic mineral products* [b]	*Iron and steel works*	*Timber products*	*Total*
North Africa	140	6	310	47	503
West Africa	250	9	300	47	606
Central Africa	20	4	200	37	261
East Africa	25	6	220	16	267
TOTAL	435	19	1,030	147	1,637

SOURCE: Secretariat of the United Nations Economic Commission for Africa.

[a] Excluding Southern Africa.

[b] Including clay products, asbestos cement products and sheet glass only.

An investment of this magnitude must be viewed against the perspectives of the economic benefits that will accrue from it. Recalling the broad assumptions that were made concerning future trends in development, it was noted that if the current installed capacity of the industry remained unchanged over the period 1965-1970 and the additional demand were met by imports, then the share of imports in total expenditure would grow from 60 per cent (1965) to nearly 75 per cent (1970) for Africa, including Southern Africa. This is one hypothesis, which demonstrates the magnitude of the supply problem under the most unfavourable prospects of development.

An alternative hypothesis assumes that the building materials industry will be developed along the lines set forth in the present report and that the gradual substitution of imports will bring about a relative reduction in building material prices which, coupled with a moderate increase in building productivity, could result in an over all reduction in building costs. Over a period of ten years, a reduction in costs of about 10 per cent is not considered overly optimistic, judging from the experience of a number of developing countries.

Table 11 summarizes the two hypotheses and demonstrates the possible economic benefits.

Table 11. Estimates of gains resulting from an expansion of the building materials industry in Africa, 1960-1970 [a]

(Thousand million dollars at 1960 prices)

Breakdown of expenditure	*1960*	*1970*	*Total cumulated over the period*
Hypothesis A continuation of the current situation			
Investment in total construction	1.6	3.6	26.0
Expenditure on building materials	0.9	2.2	16.0
of which imported materials	0.5	1.8	11.0
Imported materials as a percentage of total materials expenditure	54.0	82.0	
Hypothesis B possible development			
Investment in total construction with decreasing costs	1.6	3.2	24.0
Expenditure on building materials	0.9	1.9	14.0
of which imported materials	0.5	0.5	5.0
Imported materials as a percentage of total materials expenditure	54.0	26.0	

SOURCE: Secretariat of the United Nations Economic Commission for Africa.

[a] Excluding Southern Africa.

Regarding hypothesis A, the estimate of the investment in building materials in 1970, $2,200 million, would represent little more than one eighth of the total expenditure on building materials cumulated over the period and only one fifth of the savings in foreign currency which would be obtained if locally produced materials were substituted for imported ones. By the end of the period, the annual expenditure on imported materials, if the current situation were allowed to continue (hypothesis A), would be of the same order of magnitude as the total investment required to make Africa practically self-sufficient in 1960.

These figures speak for themselves. The development of the building materials industry is not only necessary, but also possible within the framework of the economic development of the continent.

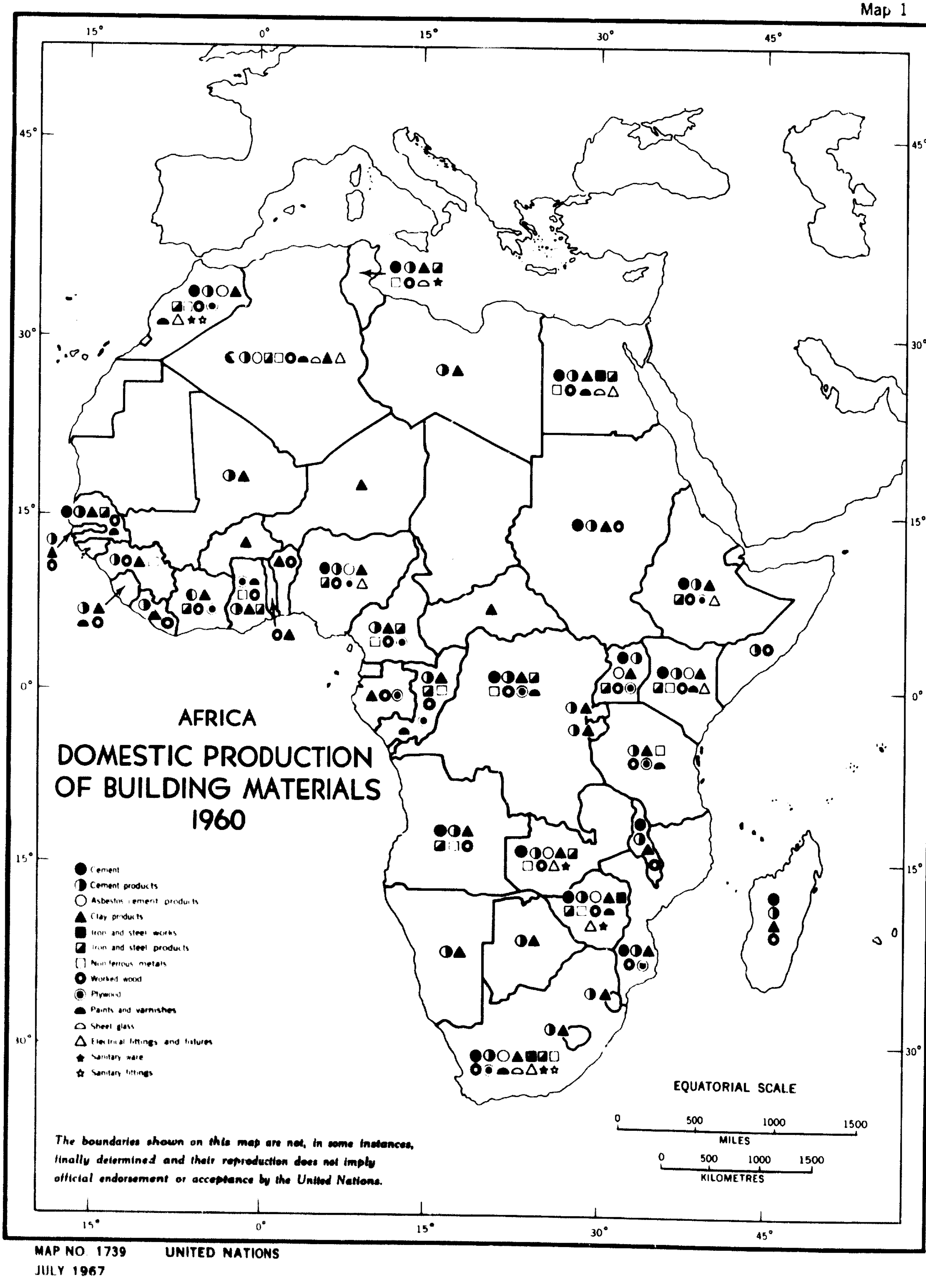
ANNEX

Africa: production, consumption and imports of building materials — Maps 1-9

[See pages 66 to 74]

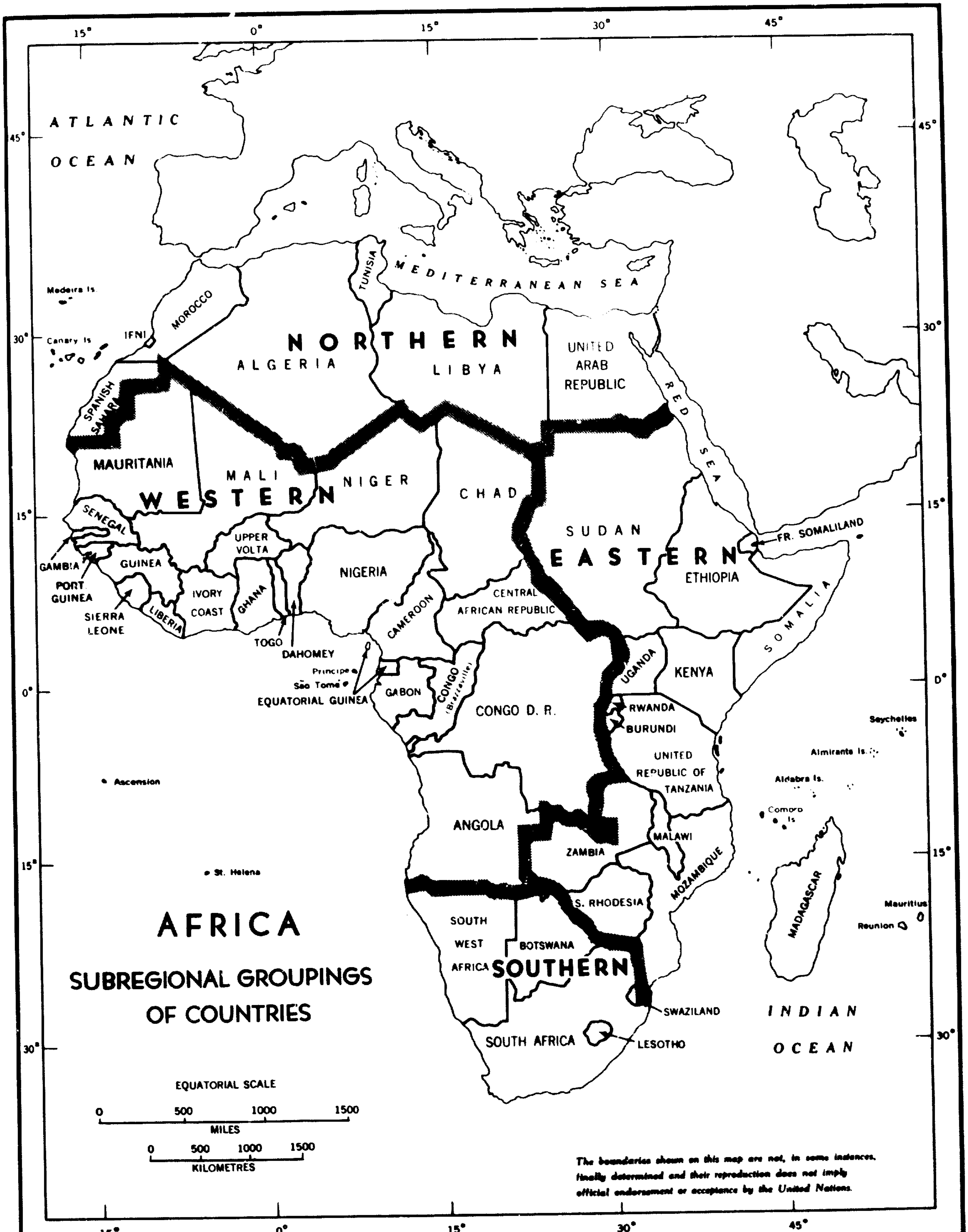
Map 1. Africa: domestic production of building materials, 1960

Map 1



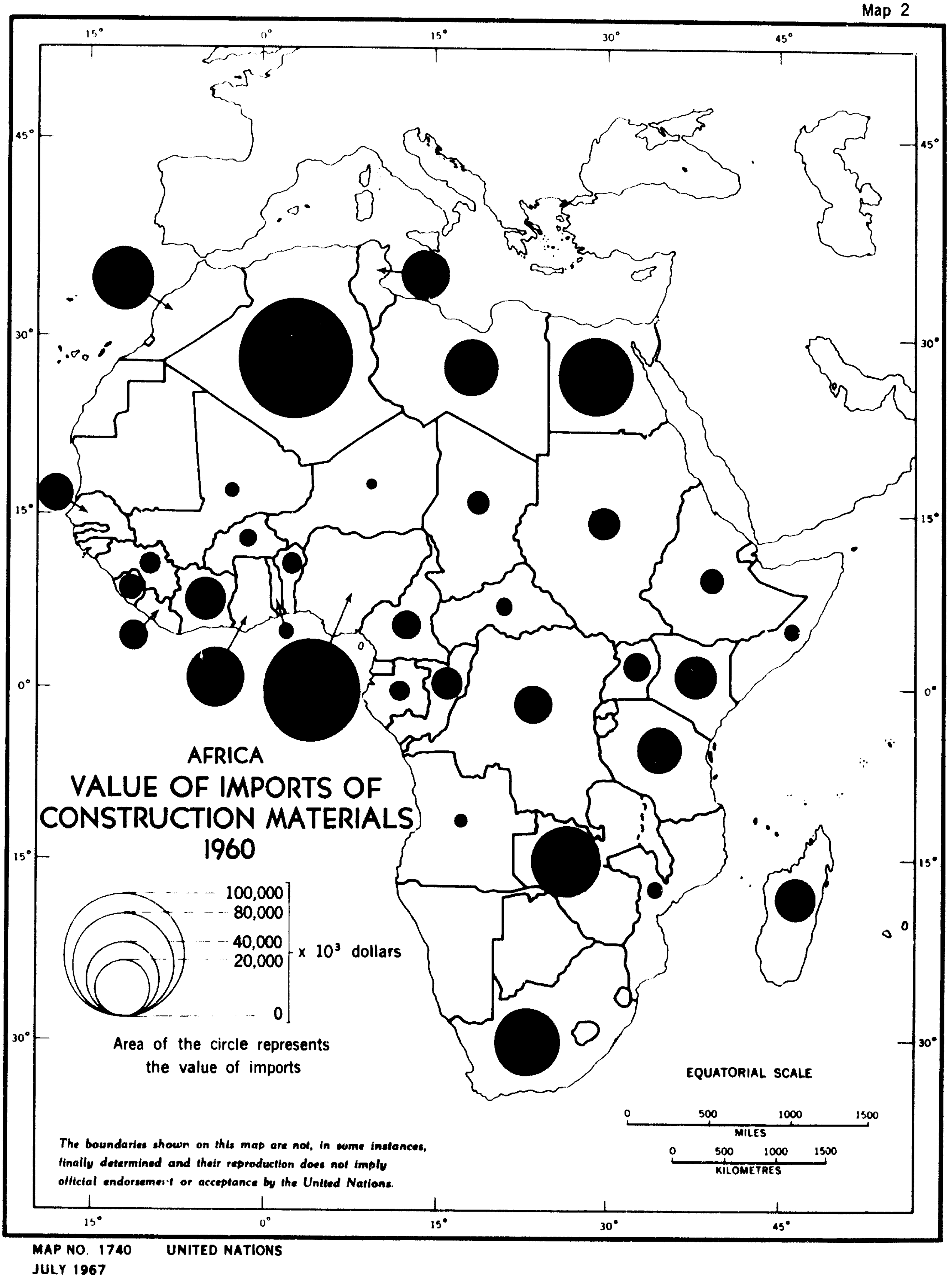
ANNEX

Africa: subregional groupings of countries

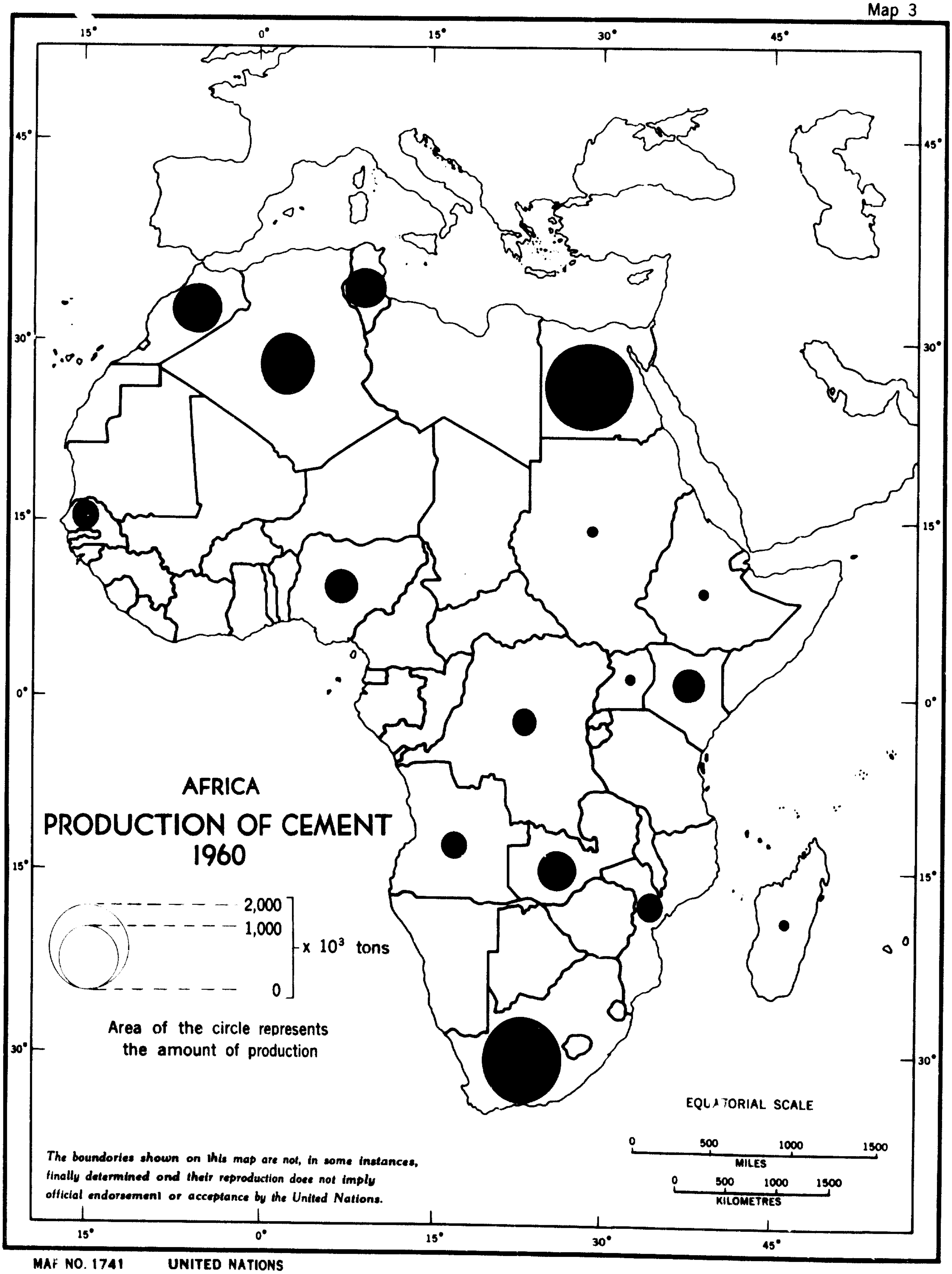


MAP NO. 1738 UNITED NATIONS
JULY 1967

Map 2. Africa: value of imports of construction materials, 1960

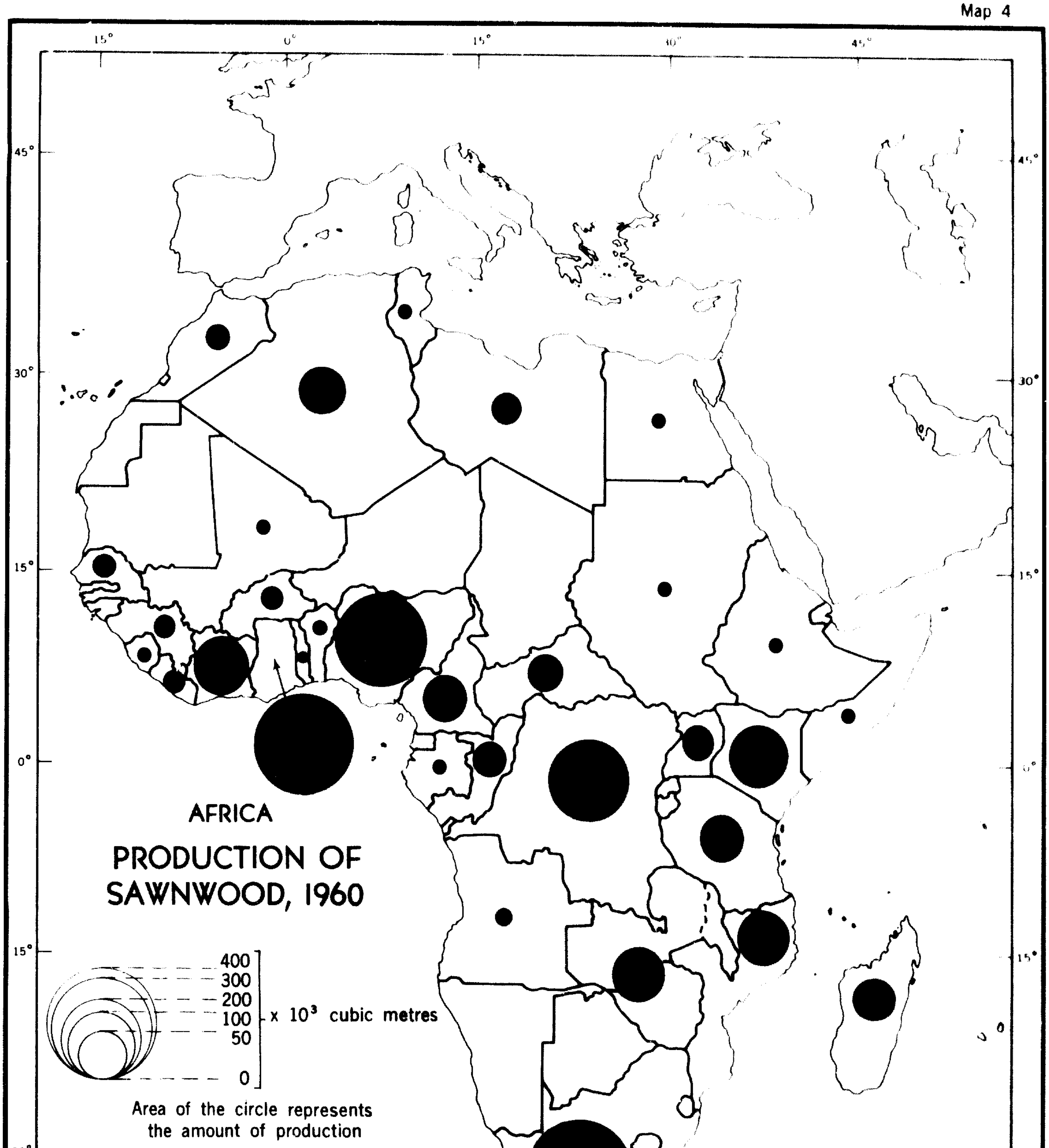


Map 3. Africa: production of cement in 1960



MAP NO. 1741 UNITED NATIONS
JULY 1967

Map 4. Africa: production of sawnwood, 1960



MAP NO. 1742 UNITED NATIONS
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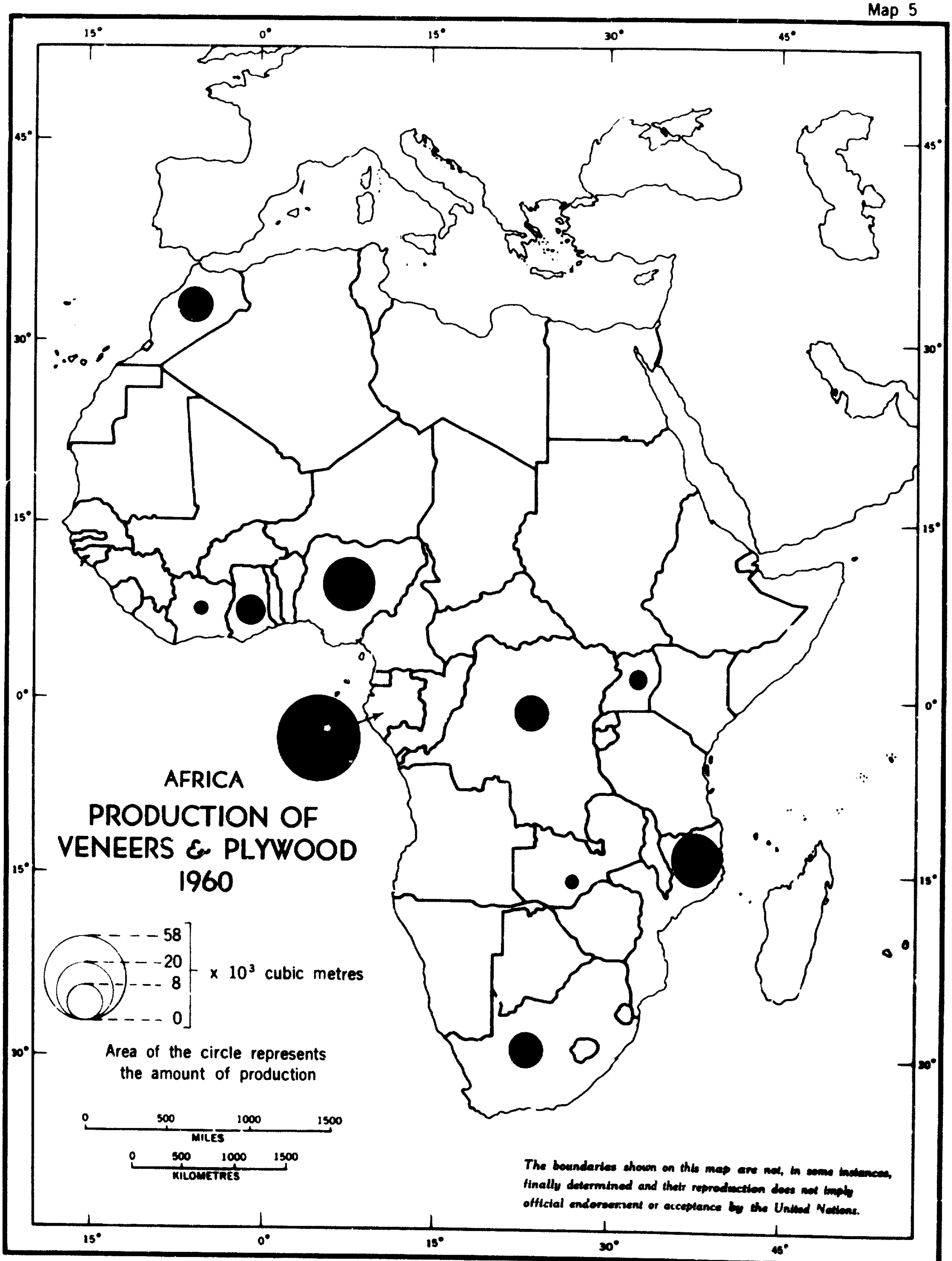
Map 5. Africa: production of veneers and plywood, 1960



MAP NO. 1743 UNITED NATIONS
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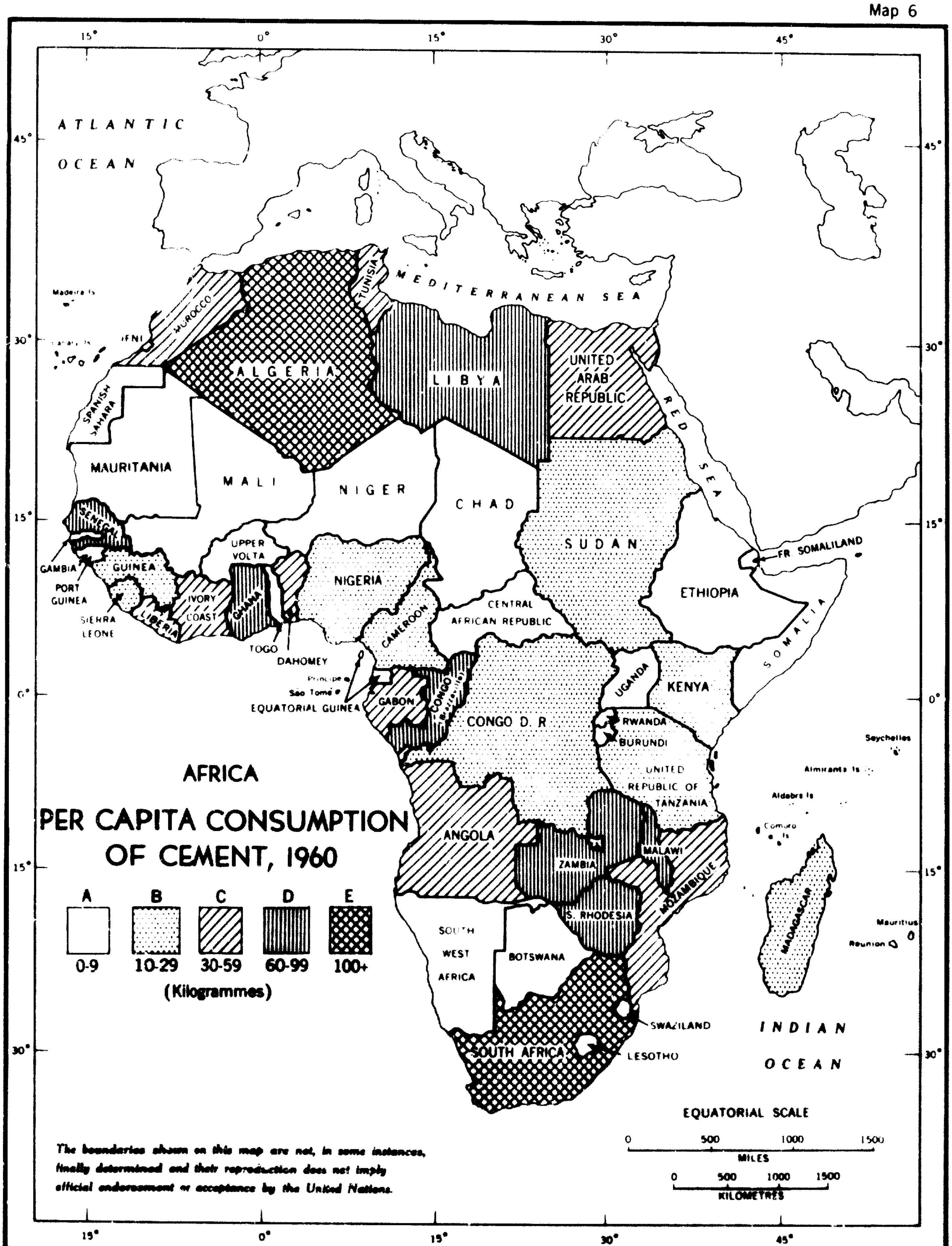
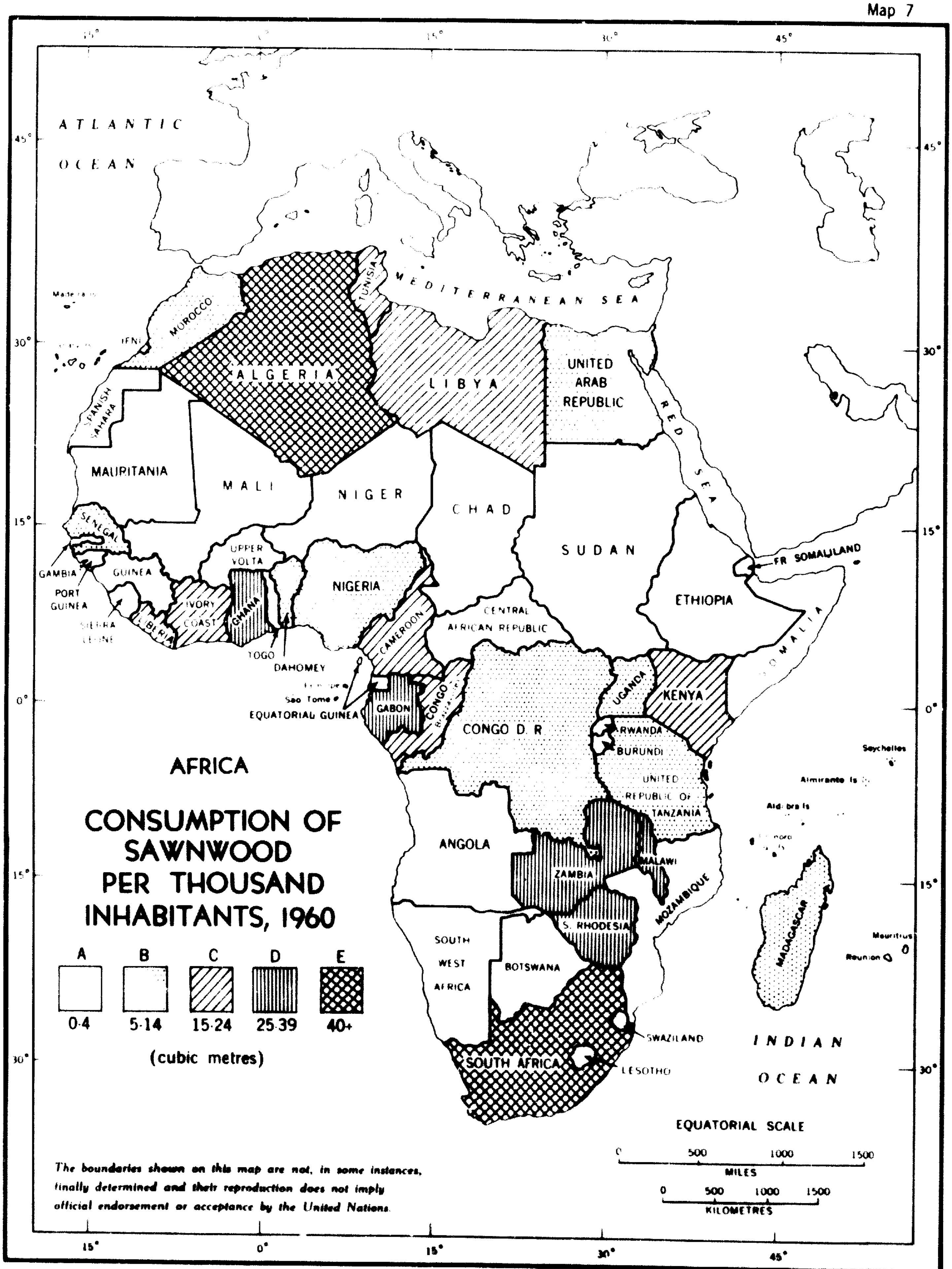
Map 6. Africa: *per capita* consumption of cement, 1960
(Kilogrammes)



Map 7. Africa: consumption of sawnwood per thousand inhabitants, 1960

(cubic metres)



MAP NO. 1745 UNITED NATIONS
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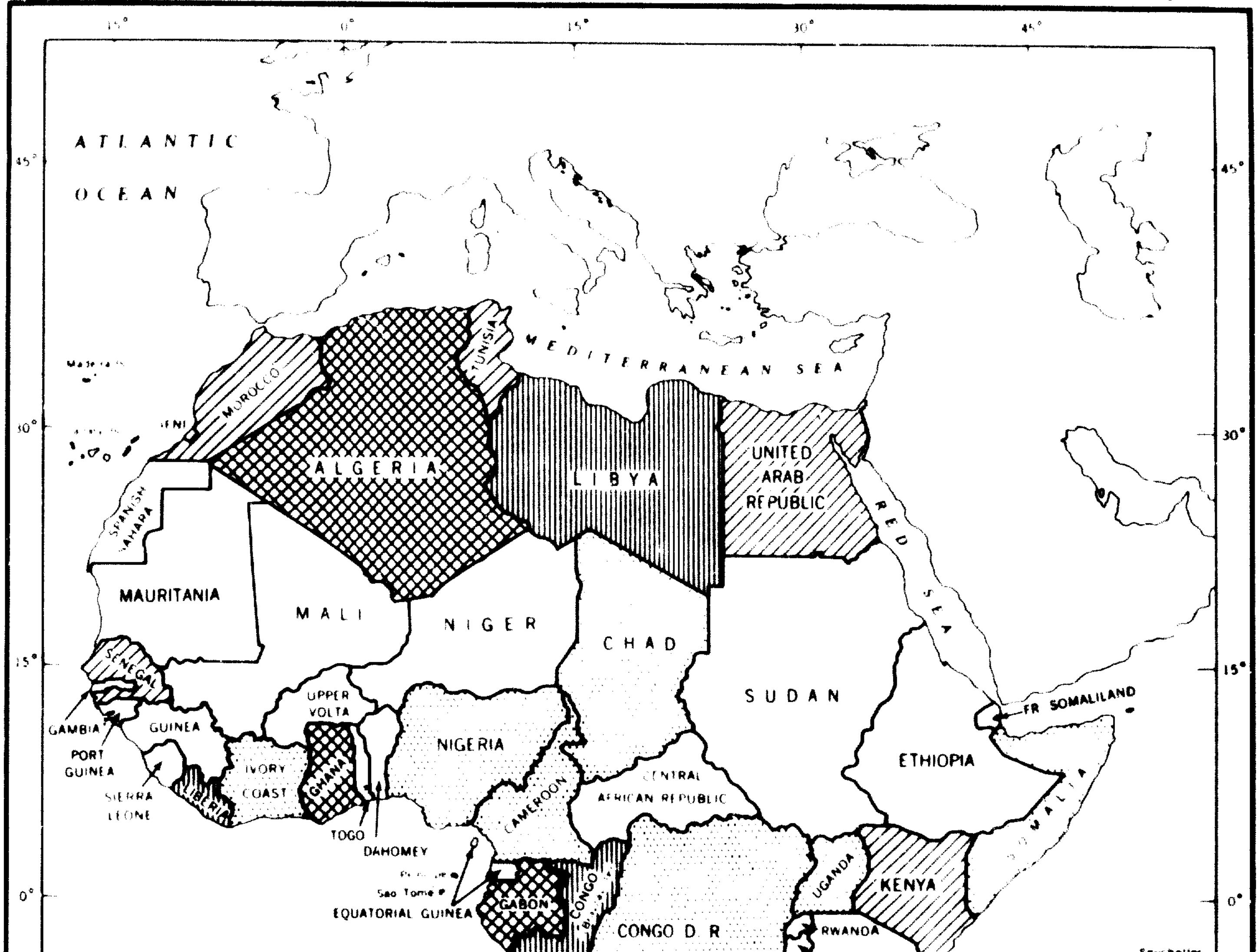
Map 8. Africa: consumption of veneers and plywood per thousand inhabitants, 1960

Map 8



MAP NO 1746 UNITED NATIONS
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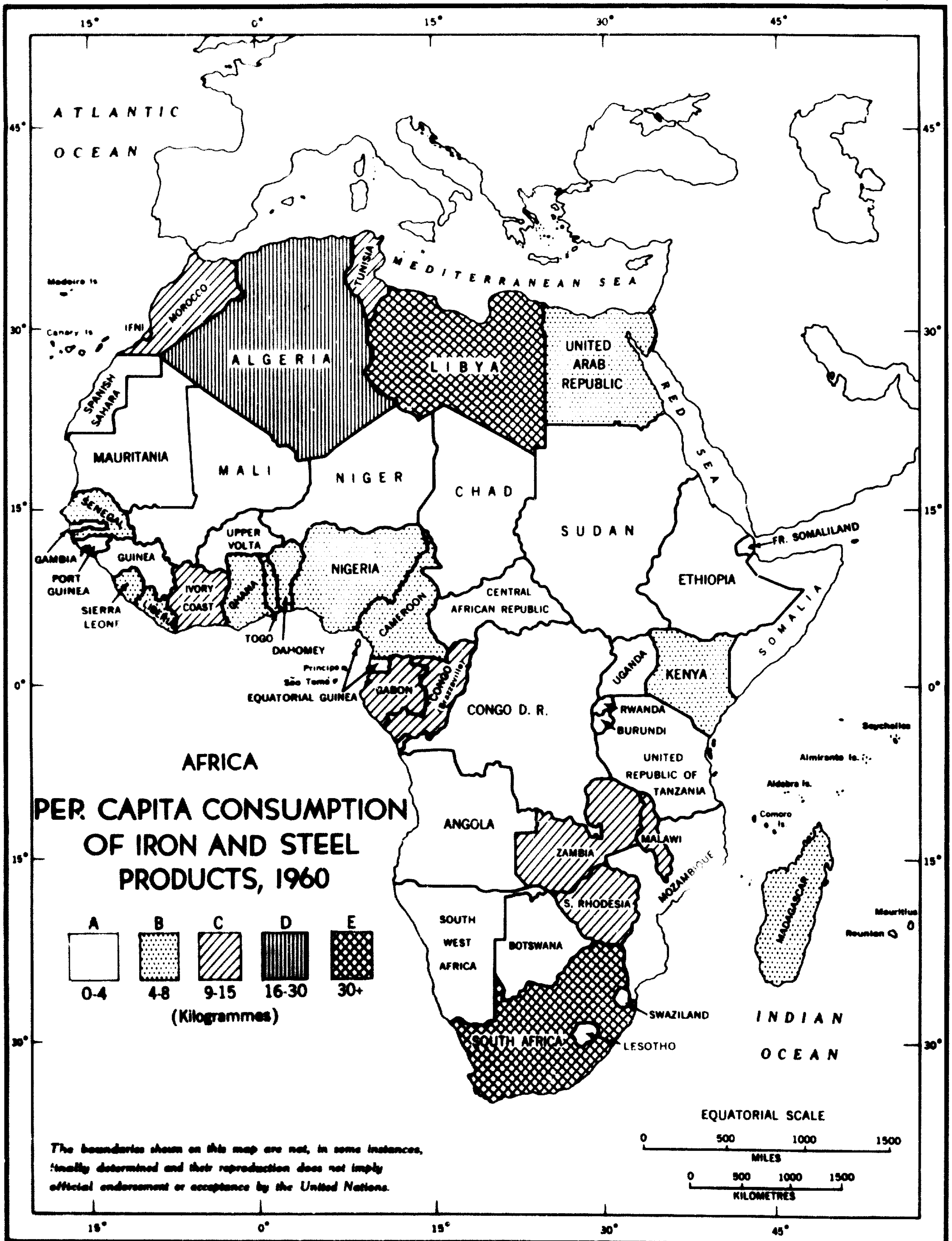
Map 9. Africa: per capita consumption of iron and steel products, 1960

Kilogrammes

Map 9



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JULY 1967

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4. PROSPECTS FOR THE DEVELOPMENT OF THE CHEMICAL INDUSTRY IN AFRICA

Secretariat of the United Nations Economic Commission for Africa

CONTENTS

Introduction

The chemical industry is dynamic, as has been clearly demonstrated by its growth in developed countries—the western European countries and the United States of America, in particular. Since 1958, and even earlier, the industry has consistently registered the highest rate of growth, compared with total industrial growth, in the European member States of the Organisation for Economic Co-operation and Development (OECD) and in the United States of America. In the former group of countries, the index of production in 1962 (1958 = 100) was 154 for chemicals as against 128 for all industry. This contrast becomes sharper when indexes of 180 and over 200 for basic organic chemicals and plastic materials, respectively, are brought into the picture.[1] The situation is broadly similar in eastern Europe. For example, in Poland, the index of production of chemicals rose to 192, while that for all industry rose to 145, according to the 1963 statistics.

These illustrations, although by no means applicable to current African conditions, are, nevertheless, indicative of the important role that the chemical industry plays in the development of the economy as a whole. An assessment of the chemical industry in the region should take cognizance of its significant role; in its studies, the secretariat of the United Nations Economic Commission for Africa (ECA) has given due regard to this fact.

Because of the lack of adequate information and the fact that only two subregions have been studied more thoroughly (East Africa and, to some extent, West Africa[2]), the regional coverage is incomplete. Therefore, it has not been possible in this paper to present a balanced picture of the current and future possibilities of the chemical industry in the region. As will be noted, there are gaps in information, particularly in the last sections of this paper.

One of the objectives of this paper is to identify those chemicals that have or seem to have possibilities for development in the region and to determine possible priorities for their development. Secondly, an attempt has been made to analyse the favourable and unfavourable factors affecting the development of these chemicals.

[1] Organisation for Economic Co-operation and Development, *The Chemical Industry* (Paris, 1962, 1963).

[2] United Nations Economic Commission for Africa, "Investigation on fertilizer and chemical industries in East Africa" (E/CN.14/INR/83), paper prepared for the Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965; "Basic chemicals and fertilizers" (E/CN.14/INR/73 and addendum), paper prepared for the Conference on Industrial Co-ordination in West Africa, Bamako, 5-15 October 1964.

I. Trade and identification of chemicals important to the subregions[3]

A. Regional imports and exports

As is shown in table 1, imports of chemicals into Africa are substantial, in terms of value. For the period 1956-1963, imports increased by an average rate of 6.5 per cent, from $385 million to $600 million. The African share in world imports reached its peak (8.1 per cent) in 1958, and since then it has been on the decline, being 6.5 per cent in 1963. The share of chemicals in total African imports, however, has been on the increase, amounting to 5.6 per cent in 1956 and 7.2 per cent in 1963.

With regard to exports, the situation is slightly different: the average rate of growth of 4.3 per cent has been lagging behind that of imports. Export value in 1963 stood at $110 million. African exports, as a percentage of world exports, ranged between 1.2 in 1963 and 1.5 in 1957, showing an over-all decrease in the African share. The share of chemicals in total imports seems to be increasing, although some irregularities are evident.

As might be expected, a large part of the trade in chemicals is with developed countries. The origin of over 90 per cent of 1963 imports was as follows: European Economic Community (EEC), 48 per cent; European Free Trade Association (EFTA), 28 per cent; North America, 11 per cent, and Eastern Europe (2.7 per cent). These groups of countries are also the leading importers of chemicals from Africa, with 30, 10 and 6.4 per cent going to EEC, EFTA and North America, respectively.

[3] The subregional groupings of countries referred to here are as follows: *North Africa:* Algeria, Libya, Morocco, Sudan, Tunisia, United Arab Republic; *East Africa:* Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Reunion, Rwanda, Somalia, Southern Rhodesia, Uganda, United Republic of Tanzania, Zambia; *Central Africa:* Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Democratic Republic of), Gabon; *West Africa:* Dahomey, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta. The category "Other countries" includes the following: Angola, Basutoland, Bechuanaland, Mozambique, South Africa, South West Africa, Spanish Sahara, and Swaziland.

B. Imports and exports: by groups of chemicals and by subregion

Import and export values of chemicals for 1952, 1956 and 1961 are set forth in table 2. As regards 1961 imports, medicinal and pharmaceutical products ranked highest, accounting for 26.4 per cent of total imports of chemicals. Excluding the group of chemical materials and products not elsewhere specified, manufactured fertilizers (12.9 per cent) took second place and were followed by soaps, cleansing and polishing preparations (9.5 per cent); pigments, paints, varnishes and related materials (7.2 per cent); explosives and pyrotechnic products (5.7 per cent); and perfumery and cosmetics, dentifrices and toilet preparations (4.8 per cent).

The situation with regard to exports is somewhat different. Manufactured fertilizers led the other groups by far, and accounted for 39.5 per cent. Among the remaining groups, the most important were medicinal and pharmaceutical products (19.3 per cent); essential oils, perfumes and flavour materials (17.9 per cent); and dyeing and tanning extracts and synthetic tanning materials (8.9 per cent).

As may be seen from table 3, 50 per cent of the total imports of chemicals into the subregions went to North Africa. The remaining 50 per cent was distributed as follows: West Africa, 24.0 per cent; East Africa, 20.3 per cent; and Central Africa, 5.7 per cent. The same table shows the percentage share within each group, according to subregion. In all groups, excepting ex-

Table 1. Africa: regional imports and exports of chemicals, compared with that of the world, and total commodity regional imports and exports

(Millions of dollars)

	1956	*1957*	*1958*	*1959*	*1960*	*1961*	*1962*	*1963*	*Rate of growth (percentage)*
Imports	385	465	480	490	540	570	550	600	6.5
Exports	81	89	84	95	91	110	115	110	4.3
Net imports	304	376	396	395	449	460	435	490	7.0
World imports = world exports	5,220	5,770	5,900	6,620	7,450	7,910	8,470	9,330	8.3
African share in world imports (percentage)	7.4	8.1	8.1	7.4	7.2	7.2	6.5	6.5	
African share in world exports (percentage)	1.5	1.5	1.4	1.4	1.2	1.4	1.4	1.2	
Total imports	6,640	7,380	7,330	7,190	7,830	7,750	7,480	8,250	3.2
Total exports	5,650	5,700	5,600	5,820	6,360	6,520	6,710	7,490	4.0
Share of chemicals in total imports (percentage)	5.6	6.2	6.3	6.8	6.7	7.2	7.1	7.2	
Share of chemicals in total exports (percentage)	1.1	1.6	1.5	1.6	1.4	1.7	1.9	1.5	

SOURCE: Data derived from the United Nations, *Monthly Bulletin of Statistics*, issues of February 1960, March 1962, 1963 and 1965.

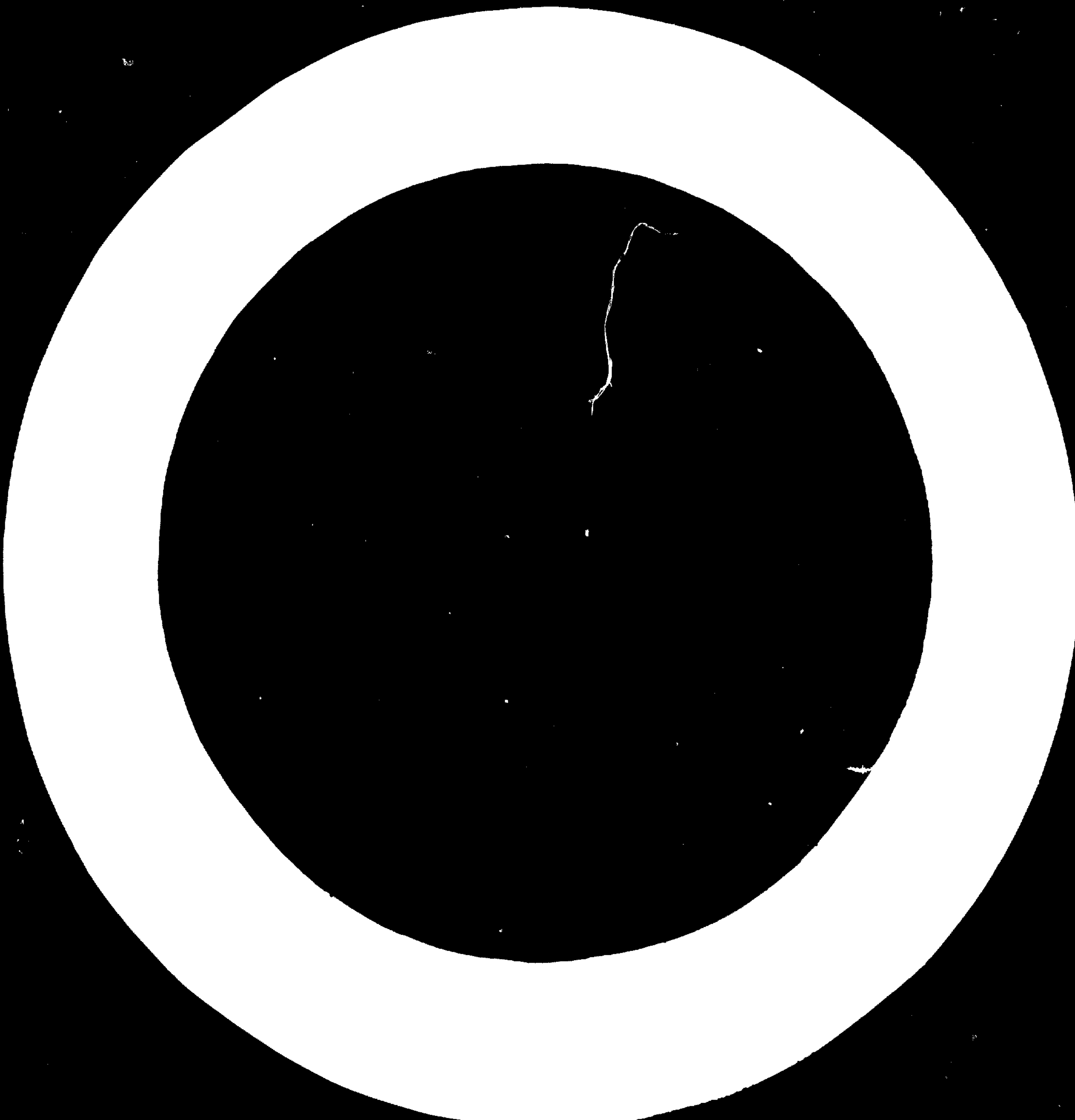

Table 2. Imports and exports of chemicals into and from the four subregions of Africa

(Thousands of dollars)

Group	Commodity description[a]	Imports [illegible]	Imports [illegible]	Imports 1961	Exports [illegible]	Exports [illegible]	Exports 1961	1961 percentage share of commodity: Import	1961 percentage share of commodity: Export
512	Organic chemicals	2,649	7,577	17,350	496	888	458	1.24	1.90
513	Inorganic chemicals			17,819			297	4.35	1.23
514	Other inorganic chemicals	26,287	30,563	13,469	1,797	4,590	148	3.30	0.61
515	Radio-active and associated materials			33			4		
521	Mineral tar and crude chemicals from coal, petroleum and natural gas	925	510	1,348				0.33	
531	Synthetic organic dye-stuffs, natural indigo and colour lakes	3,160	4,217	6,681		2	5	1.63	
532	Dyeing and tanning extracts and synthetic tanning materials	5,467	1,260	2,968	4,433	5,498	2,143	0.30	8.85
533	Pigments, paints, varnishes and related materials	15,037	31,346	29,383	95	425	155	7.15	0.64
541	Medicinal and pharmaceutical products	47,743	80,022	108,171	877	2,216	4,663	26.40	19.30
551	Essential oils, perfumes and flavour materials	10,024	11,103	6,259	1,271	3,023	4,316	1.51	17.90
553	Perfumery and cosmetics, dentifrices and toilet preparations (except soaps)	23,946	44,973	19,610	186	1,200	327	4.78	1.35
554	Soaps, cleansing and polishing preparations			38,941			124	9.50	0.53
561	Fertilizers, manufactured	53,507	41,905	52,589	1,521	1,463	9,500	12.90	39.50
571	Explosives and pyrotechnic products	10,912	19,233	23,229	25	165	36	5.65	0.14
581	Plastic materials, regenerated cellulose and artificial resins			13,970			10	3.40	0.04
599	Chemical materials and products not elsewhere specified	23,408	47,673	58,120	206	553	1,927	14.20	8.00
	TOTAL	223,065	321,382	409,940	13,910	23,023	24,122	100.00	100.00

SOURCES: United Nations, Foreign Trade Statistics of Africa, Series B, No. 8, *Trade by Commodity* (United Nations publication, Sales No.: 66.II.K.2); European Economic Community, Associated Overseas Areas Trade Statistics, and national publications.

[a] Revised Standard International Trade Classification.

Table 3. Africa: imports and exports of chemicals by subregion, 1961

(V = value in thousands of dollars)

Group	Commodity description[a]		Imports: North Africa	Imports: West Africa	Imports: Central Africa[b]	Imports: East Africa[c]	Imports: Total	Exports: North Africa	Exports: West Africa	Exports: Central Africa	Exports: East Africa	Exports: Total
512	Organic chemicals	V	9,468	1,886	276	5,720	17,350	363	85	6	4	458
		%	54.5	10.8	1.7	33.0	100	79.0	18.7	1.4	0.9	100
513	Inorganic chemicals	V	7,718	1,293	7,664	1,144[d]	17,819	220	46	27	4	297
		%	43.3	7.3	43.0	6.4	100	74.0	15.5	9.1	1.4	100
514	Other inorganic chemicals	V	8,653	1,771[e]	1,575	1,470[d]	13,469	146	2			148
		%	64.0	13.6	11.6	10.8						
515	Radio-active and associated materials	V	32[f]	—	—	1[g]	33	—	4	—	—	4
		%	97.0	—	—	3.0	100	—	100	—	—	100
521	Mineral tar and crude chemicals from coal, petroleum and natural gas	V	796	292	11	249	1,348	—	—	—	—	—
		%	59.0	21.6	1.0	18.4	100	—	—	—	—	—
531	Synthetic organic dye-stuffs, natural indigo and colour lakes	V	4,003	2,072	28	578	6,681	3	2	—	—	5
		%	60.0	31.0	0.4	8.8	100	60.0	40.0	—	—	100
532	Dyeing and tanning extracts and synthetic tanning materials	V	1,925	139	11	893	2,968	—	—	—	2,143	2,143
		%	64.8	4.8	0.4	30.0	100	—	—	—	100	100
533	Pigments, paints, varnishes and related materials	V	10,835	11,436	1,317	5,795	29,383	138	9	3	5	155
		%	36.7	39.0	4.6	19.7	100	89.0	5.8	2.0	3.2	100
541	Medicinal and pharmaceutical products	V	53,409	32,488	4,686	17,588	108,171	4,617	14	16	16	4,663
		%	49.4	30.0	4.4	16.2	100	99.1	0.3	0.3	0.3	100
551	Essential oils, perfumes and flavour materials	V	3,083	2,264	99	813	6,259	2,645	74	1	1,596	4,316
		%	49.2	36.1	1.6	13.1	100	61.2	1.7	—	37.1	100
553	Perfumery and cosmetics, dentifrices and toilet preparations (except soaps)	V	7,217	7,048	1,458	3,887	19,610	265	24	38	—	327
		%	36.6	35.8	7.9	19.7	100	81.0	7.4	11.6	—	100

Table 3 Africa: imports and exports of chemicals by subregion, 1961 (*continued*)

(Value in thousands of dollars)

SITC[a]	Commodity groups		Imports: North Africa	Imports: West Africa	Imports: Central Africa[c]	Imports: East Africa[d]	Imports: Total	Exports: North Africa	Exports: West Africa	Exports: Central Africa	Exports: East Africa	Exports: Total
551	Soaps, cleansing and polishing preparations	$	15,157[b]	14,151	1,799	7,834	38,941	76	39	8	1	124
		%	39.0	36.1	4.6	20.0	100	61.3	31.4	6.5	0.8	100
561	Fertilizers manufactured	$	35,675	3,176	891	12,847	52,589	8,976	353	2	178	9,509
		%	68.0	6.0	1.7	24.3	100	94.4	3.8		1.8	100
571	Explosives and pyrotechnic products	$	5,556	7,294	1,224	9,155	23,229	16	3	13	4	36
		%	24.1	31.0	5.4	39.5	100	44.3	8.3	36.4	11.1	100
581	Plastic materials, regenerated cellulose and artificial resins	$	7,382[h]	2,562	493	3,533	13,970	4	5		1	10
		%	52.8	18.3	3.5	25.4	100	40.0	50.0		10.0	100
599	Chemical materials and products n.e.s.	$	33,255	10,768	1,849	12,248	58,120	1,263	532	40	92	1,927
		%	57.2	18.6	3.2	21.0	100	65.2	27.4	2.7	4.7	100
	TOTAL	$	204,165	98,640	23,381	83,755	409,940	18,732	1,192	154	4,044	24,122
		%	50.0	24.0	5.7	20.3	100	77.5	5.1	0.7	16.7	100

SOURCE: Data derived from table 2.
[a] Revised Standard International Trade Classification.
[b] Excluding the Democratic Republic of the Congo.
[c] Excluding Ethiopia.
[d] Excluding Malawi, Southern Rhodesia and Zambia.
[e] Excluding Nigeria.
[f] Algeria and Tunisia only.
[g] Madagascar only.
[h] Excluding Morocco.
[i] Excluding Algeria, Morocco and the United Arab Republic.

plosives and pyrotechnic products, and pigments, paints, varnishes and related materials, North Africa occupied first place. With regard to the former group, East Africa led with 39.5 per cent. West Africa, with 39.0 per cent, took first place in the latter group.

The export pattern was somewhat similar to that of imports, North Africa accounting for 77.5 per cent and Central Africa for 0.7 per cent. The difference here was that East Africa, with 16.7 per cent, ranked second and West Africa, with 5.1 per cent, third.

From among the groups of products exported from Africa, some four are of importance. Manufactured fertilizers came first. These consisted of phosphate fertilizers and were almost entirely from North Africa. Medicinal and pharmaceutical products came next. This group was again a North African export item. In the essential oils, perfumes and flavour materials group, the first and last items made up for the bulk, with North Africa exporting the largest amount, 61.2 per cent, and East Africa exporting 37.1 per cent. The last major group is dyeing and tanning extracts and synthetic tanning materials. The value figures in the table refer mainly to wattle bark and extract entirely originating from East Africa.

There are two major items of export from East Africa not specifically mentioned in the table. These are soda ash from Kenya and pyrethrum flowers and extracts from East Africa.

C. Selection of chemicals important to the region

One of the objectives of this section is to determine what chemicals or groups of chemicals are of importance to the region from the point of view of imports and exports.[4] The obvious conclusion that may be drawn from the preceding paragraphs is that medicinal and pharmaceutical products are the most important imports and manufactured fertilizers the most important exports. Therefore, the logical conclusion is that these groups should be given the highest priority for development in the chemical industry in the region. As regards the former group, successful development will depend mainly upon:

(*a*) Basic chemical industries (prerequisites for the manufacture of many basic medicinal and pharmaceutical products). These are as yet non-existent in most countries;

(*b*) Well-organized laboratories and research institutes, which are very costly and have not yet been established in most countries of the region;

(*c*) Skilled and experienced high-level personnel essential for quality control;

(*d*) Ability to cope with the rapidly changing nature of the products put on the market.

Briefly, the pre-conditions for the creation of this sector of the chemical industry are still in the very early stages of development. This sector has, consequently, not been given the priority it seems to deserve in the first phase of the ECA secretariat's studies on chemicals.[5]

The next group, as mentioned above, is manufactured fertilizers. In terms of tonnage, this is the leading group. As has been noted, this group occupies first place among the groups of chemicals exported from Africa. Therefore, from the point of view of both imports and exports, fertilizers should be accorded high priority.

In addition to the current volume of trade, there are other reasons that fertilizers deserve special attention in the development programme. These include the significant rise in future demand and the impact of the fertilizer industry on the development of the whole economy. In addition, fertilizers are the largest consumers of basic chemicals, such as sulphuric acid and ammonia; hence, developing the fertilizer industry would stimulate growth of some of the basic-chemical

[4] As, in most African countries, imports can be equated for consumption, the question of consumption is, to some extent, implied in the objective.

[5] This does not refer to establishments which prepare and pack medicinal and pharmaceutical products imported in finished or semi-finished forms. A number of them are in operation and more are coming up.

industries.[6] As basic chemicals are the foundation of the chemical and related industries, their development in connexion with the fertilizer industry is desirable. The importance of basic chemicals in metallurgy, textiles and other branches of industry cannot be overemphasized. It is today hardly possible to find an industry which does not make use of basic chemicals, either directly or indirectly. The fertilizer-basic chemical relationship is, therefore, an advantage in introducing and developing the chemical industry in most African countries, and, as such, fertilizers and basic chemicals have been given the highest priority in the work programme of the ECA secretariat in the field of chemicals.

With regard to the remaining groups, it was considered advisable to deal with individual chemicals which are prerequisites for the further development of industry in general or whose demand is peculiar to a country, subregion or region. Sodium xanthate, a floatation agent for non-ferrous metal ores is, for example, peculiar to Zambia. Basic chemicals (not related to the manufacture of fertilizers), explosives, calcium carbide, aluminium sulphate, pesticides,[7] synthetic resins, viscose rayon and others which appear to offer scope for development were considered to be subregional possibilities. Among the groups which offer scope for development on a regional level is that of medicinal and pharmaceutical products. Most of the chemicals in this group are low-volume, high-value commodities. In other words, transport costs, which are a major item of the cost of goods in Africa, are very small (in relation to value) for this group. This advantage, coupled with the expected improvement of the unfavourable pre-conditions currently existing, would, it is hoped, offer scope for the development of this group on a regional scale.

In the following sections an attempt is made to deal with individual chemicals or groups in greater detail.

[6] This has been the case in Africa. With the exception of sulphuric acid plants in the Congo (Democratic Republic of) and Zambia, the sulphuric acid plants in Africa have been developed as units of fertilizer plants. This applies also for ammonia.

[7] The best known of these are *pp'*-dichlorodiphenyl trichlorethane (DDT) and bezene hexachloride (BHC).

II. Factors for and against the development of the chemical industry in the region

As might be expected, there are a number of factors influencing the development of the chemical industry in the region in one way or another. Because of the limited scope of this study, only the most important factors are considered.

A. Unfavourable conditions

1. High investment cost

A number of factors contributing to the high cost of investment are discussed below.

(a) *Limited market*

From among the factors which may hinder or retard the establishment of chemical industries, the limited market in most African countries appears to be the most important. Current consumption of and future demand for most chemicals in individual countries do not justify their production on a country basis. This is true of many chemicals, even when considered on a subregional scale. As a result of this limited size of the market, the advantages to be derived from the economies of scale of large integrated chemical complexes cannot be attained.[8] At first, the capacity for the basic product will, in most cases, be small. Next, the intermediates or end-products that can be derived from the basic product will be limited in both number and volume. In other words, the numbers and sizes of the facilities that can be incorporated with the complex or that can draw raw material from the basic plant to form a complex is limited in scope. Under such conditions, that is, in the absence of adequate interdependence of products and processes, the investment per unit of product would be very high.

[8] See United Nations, "The role of the domestic market in the development of petrochemical industries and the need for exports in relation to economies of scale", *Studies in Petrochemicals*, presented at the United Nations Interregional Conference on the Development of Petrochemical Industries in Developing Countries (United Nations publication, Sales No.: 67.II.B.2), vol. I, chap. II, paper 3. According to this paper, fixed plant investment for an integrated nitrogen fertilizer complex has, for example, been estimated to be 20 to 30 per cent less than for a plant with the same output, but made up of separate, individual units.

(b) *Site*

Site is another factor which may increase investment costs per unit considerably. As is the case in most developing countries, many ancillary facilities are not readily available in the vicinity of the site. Provisions for one or more of the following facilities may have to be made: (*a*) generation of electric power and/or steam; (*b*) water purification and/or sewage and waste disposal; (*c*) workshop for maintenance and repair; and (*d*) laboratory etc.

Additional investment that may be required over and above that of the battery-limit investment cost will vary according to the ancillary processes that would be needed. It can be minimized by planning off-site or ancillary facilities to serve other industries as well.

(c) *High cost of equipment and installation*

Transportation of machinery, equipment, building materials, construction tools and equipment, spare parts and supplies from the place of origin to the site involves an expenditure which is not incurred in developed countries. Additional cost is also incurred in installation. This is because of lack of skilled labour and specialists, who have to be obtained from abroad at a high cost.

The sum of the extra investment due to site and equipment and installation may result in making the plant or complex more expensive (by as much as 100 per cent) than that in a developed country.

(d) *High cost of production*

All the disadvantages considered above are reflected in the form of capital charges which assume a role out of proportion to their normal share in the cost of production. The necessity for importing and stocking spare parts, supplies and possibly some raw materials for a longer period and the longer period required to get the plant or complex started up and to reach production are other factors contributing to the high cost of production, especially during the first few years of operation.

(e) *Lack of trained labour*

The problem of manpower is another unfavourable factor. Unlike that of many other industries, the personnel requirement for the chemical-process sector is small, but of high calibre, involving a high proportion of chemical and other engineers, chemists and managerial and clerical staff. There is, obviously, a shortage of trained people competent to operate even the most simple chemical plants. The chemical plants in existence in many countries depend upon highly paid foreign specialists and skilled staff. As a result, although representing a small fraction of production costs in most chemical processes, the labour cost component in the cost of production is higher than that in a developed country.

As there are not so many chemical industries in Africa at the current time, the problem of personnel is probably not acute in most countries. This is, however, bound to be the case shortly. Recently, a certain country in Africa, for instance, found it difficult to obtain labour with a chemical engineering or chemistry background for a plant that it is putting up. It had to resort to training workers with backgrounds in other fields of engineering. This, evidently, is a waste that African countries cannot afford, for those engineers could be usefully employed in their own fields.

Training personnel for the chemical industry is a long process. Because of the complex and unlimited scope of the chemical industry, the graduate chemical engineer is, in reality, not ready to assume a responsible position in a chemical plant just after graduation. He has a lot to learn in the plant itself; that is, in-plant training is as essential to a chemical engineer as it is to the other workers. This training period is not a matter of months, but of years.

From the preceding paragraphs, it is clear that preparing personnel for the chemical industry is an urgent matter, and it should be done without further delay. In the long run, this would mean a lot of savings for the chemical industries that will in future be established throughout the region.

(f) *High cost of distribution*

In Africa, cost of distribution assumes a disproportionally large part of the sales-value of goods. This is particularly the case with high-volume, low-value products, such as fertilizers. The transport cost of fertilizers from Apapa (Lagos) to Northern Nigeria, for example, amounts to as much as 100 per cent of the c.i.f. price at Apapa. Reducing the transport cost will evidently play a major role as an incentive to the development of the chemical industry, especially those producing bulky commodities.

Transport facilities, which were originally developed mainly for the purpose of facilitating the movement of goods from the hinterland to the ports, are being expanded and improved in many of the countries. The rate of this progress may not, however, be high enough to cope fully and efficiently with the future transport demand. In view of the crucial nature of the current and future transport situation, that is, the constraints imposed on the potential growth of not only the chemical sector but also the economy as a whole, it is of the utmost importance to improve and develop those modes of transport systems best fitted to the different areas.

(g) *Inadequacy of applied-research organizations*

Laboratories capable of evaluating raw materials, fuels and supplies, as well as intermediate and final products, are very essential to the development of the chemical industry. Because of their total absence in most countries and, with a few exceptions, their limited services in others, a number of African countries resort to laboratories outside the region. This is expensive, especially when dealing with bulky samples, and it is one of the reasons why evaluation of natural resources has been slow in some countries.

In addition to evaluating materials, such research organizations, together with technological institutes, are badly needed to help: (*a*) improve the efficiency of existing industries and the qualities of their products; (*b*) adapt existing technology to African conditions; (*c*) develop techniques for processing local materials hitherto not developed; and (*d*) train industry personnel.

It would, therefore, be in the interests of all countries to establish one or more scientific research centres in each of the subregions.

B. Favourable conditions

This section has so far dealt with factors which hinder the development of the chemical industry in Africa. Factors which favour the development of the industry are examined below.

1. Raw materials and fuels

In general, Africa is endowed with abundant raw materials and fuels necessary for the development of the chemical industry. These, together with the huge electric-power potential, are major assets for the chemical sector simply because they account for 60 to 80 per cent of the cost of production of many chemical products. It is because of this that a fairly detailed description of these resources has been included in the present report.

As regards both raw materials and fuels, although not evenly distributed, most of those needed for the manufacture of chemicals are available in the region.

(a) *Coal and hydrocarbons*

These are fuels as well as raw materials. Their distribution in the region follows a certain pattern. The Equator roughly divides the continent into two halves: the coal-rich south and the petroleum- and natural-gas-rich north.

Of the known coal reserves of over 77,000 million tons, about 80 per cent is in South Africa, 8.5 per cent in Malawi, Southern Rhodesia and Zambia, 6.5 per cent in Swaziland and most of the remaining in Mozambique, Nigeria, the United Republic of Tanzania, Madagascar, Morocco and Congo (Democratic Republic of), according to descending order of importance (see table 4). In general, African coal is not of high quality and is non-coking. Certain deposits, such as those at Wankie (Southern Rhodesia) and some in South Africa and the United Arab Republic, are exceptions.

The hydrocarbon-rich north has about 97 per cent of the 2,400 thousand million tons of crude-oil reserve in the continent. Excluding the Nigerian reserves, the

Table 4. Availability of raw materials, fuels and electric power for fertilizer industries in Africa

Subregion and country	Proved crude petroleum, 1963 est. reserves (millions of barrels)	Natural gas, 1960-1961 total reserves (thousand millions of cubic metres)	Hard coal, measured and inferred reserves (millions of tons)	Hydroelectric power, estimated exploitable potential (thousand millions of kWh per annum)	Phosphate reserves (Millions of tons)	Potash reserves (Millions of tons)
North Africa	15,915	2,000.65	166	85		
Algeria	6,500	2,000.00	20	15[a]	Over 800 (57% BPL)	
Libya	8,000	...	...	1[a]		Over 1.6 (65% K_2O)
Morocco	15	0.50	96	3	20,000 (74% BPL)[b]	? (10% K_2O)
Sudan		—	—	50[a]		
Tunisia		0.15	...	1[a]	1,150 (65% BPL)	Substantial
United Arab Republic	1,400	...	50	15	179 (63% BPL)	
East Africa		44.00	7,313	366		
Burundi						
Ethiopia		...		45[a]		Over 50 (25% K_2O)
Kenya				50		
Malawi						
Southern Rhodesia		—	6,613	36	16 (14% BPL)	
Zambia		—				
Rwanda		44.00[c]				
Somalia		...	...	1[a]		
Uganda		...	...	45[a]	220 (28% BPL)	
United Republic of Tanzania			400	75[a]	10 (65% BPL)	
Madagascar			300	114		
Mauritius						
Reunion						
Central Africa	160	0.40	90	723–743		
Cameroon				80–100[a]		
Central African Republic			—	28		
Chad		...	—	13[a]		
Congo (Democratic Republic of)		...	90	530		
Congo (Brazzaville)	160	0.40	—	24[a]	4.8 (52% BPL)	30 (25% K_2O av.)
Gabon		...	...	48		
West Africa	555	375.00	406	140		
Dahomey		...	...	3		
Gambia		...	...			
Ghana		...	—	9		
Guinea		—	—	25[a]		
Ivory Coast		—	—	20		
Liberia		—	—	25[a]		
Mali		—	...	13[a]		
Mauritania		—	...	—	1 (56% BPL)	
Niger		—	—	...		
Nigeria	550	375.00	406	17		
Senegal	5	...	—	16[a]	197 (65% BPL)	
Sierra Leone		—	...	10[a]		
Togo		...	—	2[a]	120 (65% BPL)	
Upper Volta		—	...	...		
Other Countries	250		69,085	278		
Angola	250	...	8	230[a]	42 (up to 74% BPL)	
Basutoland		—		3		
Bechuanaland		—				
Mozambique		...	700	45[a]		
South Africa		—	63,355	...	93 (30% BPL)	
South West Africa						
Spanish Sahara		...		...	600 (48% BPL)	
Swaziland		—	5,022	...		
TOTAL (AFRICA)	16,880	2,422.05	77,060	1,602	17,000 (100% BPL)	Over 20 (100% K_2O)
WORLD TOTAL	312,705.7	15,000.00		5,000	46,697 (?)[d]	48-68,000 (100% K_2O)[e]
Percentage of world total	5.4	16.0		32	52[f]	0.04

SOURCES: For proved crude petroleum: *World Petroleum Report, 1964* (Houston, Texas, Gulf Publishing Company); for natural gas (except figures for Rwanda, the Congo (Brazzaville) and world total, which were taken from various sources), hard coal and hydroelectric power: United Nations, "The situation, trends and prospects of electric power supply in Africa" (E/CN.14/EP/3), part I; for phosphate and potash reserves: various sources.

[a] Estimate of United Nations Economic Commission for Africa.

[b] Currently over 30,000 million tons of all grades.

[c] Reserve which is probably recoverable.

[d] 1953 world reserve; phosphate content unknown.

[e] Based on estimate of United States Bureau of Mines.

[f] Based on 1953 African and world reserves.

North African subregion reserves account for 94 per cent, with Algeria, Libya and the United Arab Republic as the most important petroleum countries. Of the remaining subregions, Central Africa has 1.0 per cent and East Africa, none. The rest is mainly concentrated in one country, Angola.

In general, African crude oils are of the light type, and their sulphur content is small, if present at all.

With regard to natural gas, the distribution pattern is about the same as that for petroleum. The North African subregion, with 82 per cent, leads the others and is followed by West Africa (15.2 per cent) and East Africa (1.8 per cent).

(b) *Sulphur and sulphur-bearing materials*

Sulphur and salt are the very basic raw materials upon which the chemical industry is built. Their availability in abundant quantity at reasonable prices will greatly facilitate the development of the chemical sector.

In spite of the generally favourable conditions with regard to resources for the chemical industry, the supply of sulphur is a limiting factor. There are no known significant sulphur deposits in the continent. As is shown in table 5, most of the sulphur produced in Africa comes from pyrites, which is also not available in sufficient quantity. Excess of demand over production is met from imported sulphur or pyrites.[9] As years go by, this gap between demand and local output will certainly widen. This, coupled with the rising trend of the international price of sulphur, will, in all probability, have a retarding effect on the development of the sulphuric acid and, consequently, of the entire chemical industry of the region.

[9] As there is not a sufficient supply of pyrites in Southern Rhodesia, the sulphuric acid unit which is being added is based on imported sulphur.

Table 5. Production of salt and sulphur in Africa, by subregion

(Thousands of tons)

	Salt						*Sulphur*				
	1948	*1957*	*1959*	*1961*	*1963*[a]		*1948*	*1957*	*1959*	*1961*	*1963*[a]
North Africa		820.2	718.4	974.8	822.7[b]				49	98	
Algeria	73.0	116.7	127.6	128.4		B	14	8	13	22	9
Canary Islands		15.1	13.1	14.1	17.9	C		3	4	5	7
Libya	7.1	17.0	15.0	12.0	18.5						
Morocco	40.0	52.0	33.8	21.2	37.3	B		2	5	5	7
Sudan	36.8	53.4	53.9	53.1	37.0						
						C			21	21	
Tunisia	105.0	150.0	92.0	247.0	320.0						
United Arab Republic	126.0	416.0	383.0	517.0	392.0	C	...		6	45	
East Africa		241.4	203.8	217.9[c]	283.2[c]	B	5	8	15	22	24
Ethiopia		177.0	140.0	151.0	225.0						
French Somaliland	60.7	2.3	0.4								
Kenya	16.8	23.0	19.6	22.9	17.0						
Mauritius	3.4	3.8	3.8	4.0	4.2						
Rhodesia						B	5	8	15	22	24
Uganda	3.0	9.7	8.9	6.6	3.1						
United Republic of Tanzania	11.6	25.6	31.1	33.4	33.9						
Central Africa		0.3	0.6	0.6	0.4						
Congo (Democratic Republic of)		0.3	0.6	0.6	0.4						
West Africa		80.7	89.8	67.3	87.0						
Cape Verde Islands	13.6	19.7	20.3	23.9	27.0						
Ghana	...	61.0	22.0	18.0	...						
Senegal		61.0	69.5	43.4	60.0						
Other countries	241.4	282.5	375.1	330.4[d]	331.3[d]	B	15	162	198	177	155
Angola	63.4	52.3	69.2	66.8	68.6						
Mozambique	10.1	18.0	18.6		...						
South Africa	153.0	146.0	237.0	208.0	198.0	B	15	162	198	177	155
South West Africa	14.9	66.2	50.3	55.6	64.7						
TOTAL	...	1,425.1	1,387.7	...	...		...	...	262	297	...

SOURCE: United Nations, *Statistical Yearbook, 1964* (United Nations publication, Sales No.: 65.XVII.1).

[a] Provisional.
[b] Excluding Algeria.
[c] Excluding French Somaliland.
[d] Excluding Mozambique.
B = Sulphur content in pyrites used.
C = Mine production of sulphur other than under B.

In view of the serious nature of the sulphur and pyrites situation in Africa, it is of utmost importance for African countries, especially those with known occurrences of sulphur, e.g., Ethiopia, immediately to begin prospecting for sulphur and sulphur-bearing materials. Equally important is the exploitation and utilization of gypsum, which is available in a number of countries, including Libya, Somalia and the United Republic of Tanzania.

(c) *Salt*

Both rock-salt and solar salt are available in the region. The extent of the rock-salt reserve is not known. The open surface deposit in the Danakil Depression in Ethiopia is said to be huge and awaits exploitation on a larger scale. Other rock-salt deposits in Africa are known, but they are probably of lesser importance.

Brine is a source of salt which is probably the least exploited in Africa. The Sua Pan brine of Makaribari Pan in Bechuanaland has recently been investigated by the Southern Rhodesian Government. It has been reported that the results of the investigation have shown that this brine can be economically exploited to yield common salt and other salts. As this is the only known source of salt in this part of Africa (exluding coastal countries), its importance to land-locked neighbouring countries cannot be overlooked.

At the current time, the share of both rock-salt and brine salt in the total output is small. By far the largest part of the salt produced is solar salt. Data for the total production of salt are given above in table 5. According to descending order of importance the subregions producing salt are North, East, West and Central Africa, with the United Arab Republic, Tunisia, Ethiopia and Algeria as the major producers.

Conditions for solar-salt production vary from coast to coast. Because of unfavourable climatic conditions, certain coastal areas in West Africa, for example, are not suitable for economic solar-salt production. In contrast, in terms of climate and a high salt content of the Red Sea, the coastal area along the Red Sea is one of the most, if not the most, suitable. Climatic conditions in other areas would not be outside the range represented by the Red Sea area and some West African coastal areas.

From what has been said and the fact that part of the African salt output is currently exported, the prospect for the supply of salt for the chemical industry is bright. In fact, it would be advisable for some African countries to consider possibilities for expanding their salt industry for the purpose of earning foreign exchange.

(d) *Limestone*

This raw material is widely distributed in the region. It has so far been exploited mainly for the manufacture of cement. In a number of cases, the quality of a limestone deposit is described as suitable for cement manufacture. In such countries as Burundi, Nigeria and the Sudan, occurrences of pure limestone, suitable for the chemical industry, are known. The difficulty with the high-quality deposits is their inaccessibility at the current time. This situation will, of course, be expected to improve with the improvement of transportation facilities. On the whole, chemical industries utilizing limestone may be expected to experience no difficulty in obtaining the right quality of limestone.

(e) *Rock-phosphate*

The region is rich in rock-phosphate. About 50 per cent of the world reserves of rock-phosphate are in Africa. By far the largest part of the African reserves is in the Maghreb countries (North Africa), especially Morocco. The other subregions have appreciable deposits, some of which are being exploited for local or export purposes.

The quality of the African rock-phosphate varies considerably, ranging from 74 per cent bone phosphate of lime (BPL) in Morocco to less than 20 per cent BPL in Malawi, Southern Rhodesia and Zambia. A number of the deposits which are being worked have beneficiating facilities. Senegal and Togo, for instance, enrich their phosphates to over 80 per cent BPL, and Southern Rhodesia (which began exploitation quite recently) to about 76 per cent BPL.

Africa produces about one-third of the world output, with Morocco and Tunisia alone accounting for over 80 per cent. In 1963, net exports of rock-phosphate accounted for 88 per cent of the 13 million tons output in the same year.[10] Consumption, according to the same source, was less than 12 per cent. These figures are but indicative of the future potential of the phosphate industry in Africa.

(f) *Potash*

There is as yet no production of potash in the region. All the subregions except West Africa have potash deposits, and all of them have projects to exploit them. Both the East African (Ethiopia) and the Central African Congo (Brazzaville) deposits have an average content of 25 per cent K_2O and those of North Africa (Morocco), 10 per cent K_2O. Although information on the actual sizes of some deposits is lacking, the deposits currently known are estimated to contain at least 20 million tons of 100 per cent K_2O (see table 4).

(g) *Electric power*

Although the current electric-power situation in Africa is, perhaps, not satisfactory, the potential for its development is tremendous. Africa possesses over 30 per cent of the world hydroelectric potential (see table 4). A very small part of this potential is currently being exploited.

The last few years have seen the beginning of the harnessing of this huge potential. Hydroelectric power-plants, such as the Kariba (Zambia-Southern Rhodesia) and the Koka (Ethiopia), have recently been put into operation. Some of the future giants are under construction: the Aswan High Dam in the United Arab Republic; the Volta Dam in Ghana; and the Kainji Dam in Nigeria. These and others that will appear in the future (including thermal power-plants based on natural gas, petroleum products and even coal) will ensure an adequate and cheap power-supply for the continent. In fact, the availability of power may be expected to play a major role in promoting chemical industries, e.g., those producing ammonia, chlorine and caustic soda, calcium carbide and other electrothermal and electrolytic products. Electric-power consumption in these industries represents a large item in the cost of production.

2. Trend of plant locations towards raw-material locations

In addition to the advantages expected to be gained as a result of the presence of natural resources, there is another factor which may be expected to play an increasing role in favour of the development of the African chemical industry. This is the tendency of some basic-chemical industries to be located near the sources of the major inputs, especially raw materials.

[10] International Superphosphates Manufacturers Association Ltd., *Phosphate Rock Statistics* (London, 1963).

Recent technological breakthroughs have made it possible for some developing countries with abundant and relatively cheap raw materials to put up large ammonia plants primarily for export purposes. Trinidad and Tobago provides an example of the success of such a venture. This example is being followed by a number of developing countries. It is expected that Algeria and Libya will be among the first in Africa.

Although only a concept at the moment, the idea of phosphoric acid plants near the source of rock phosphate is a possibility to be realized. It has been reported that a group in the United States of America has already shown interest with regard to the establishment of a huge superphosphoric acid plant in Morocco. If this proves successful, it will set a precedent for the other phosphate producing countries in the region.

The beneficial effects that may be expected from this new trend could be far reaching. Availability at low cost of such basic chemicals would result in generating more economic activities, among other things, by way of down stream integration than would be possible if separate, fully integrated complexes were created.

A conclusion which may be drawn from the preceding paragraphs is that the obstacles to the development of the chemical industry are probably temporary. In other words, the picture may not be as gloomy as it might seem on the surface.

III. Fertilizers

A. Fertilizer trade

Table 6 summarizes fertilizer production, consumption, exports and imports for Africa. Africa is a substantial importer of fertilizer, and imports are still growing. The largest quantities imported are nitrogen fertilizers. Potash fertilizers, which are entirely imported, take second place. Imports and exports of phosphate fertilizers are roughly balanced. The only exports of phosphate fertilizers are from Southern Rhodesia and Tunisia (concentrated superphosphate), and from South Africa and the United Arab Republic (single superphosphate). Nitrogen is imported by the majority of the African countries as ammonium sulphate, ammonium nitrate and urea. Potassium is imported as potassium sulphate and muriate over 45 per cent K_2O.

Table 6. Fertilizer production, consumption and trade in Africa, 1957/1958 to 1962/1963

(Thousands of tons of pure nutrients)

Item	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63
Production						
N	46	51	59	77	145	184*
P_2O_5	243	257	259	282	254	283
K_2O	1	—	—	—	—	—
	290	308	318	359	399	467
Consumption						
N	256	290	223	324	366	405
P_2O_5	263	259	260	286	276	314
K_2O	72	78	85	102	104	114
	591	627	568	712	746	833
Exports						
N	—	—	—	—	1	4
P_2O_5	54	54	54	55*	57*	64*
K_2O	—	—	—	—	—	—
	54	54	54	55	58	68
Imports						
N	210	238	163	245	220	221
P_2O_5	65	58	52	60	81	85
K_2O	76	80	84	102	100	110
	351	376	299	407	401	416
Exports minus imports						
N	−210	−238	−163	−245	−219	−217*
P_2O_5	−11	−4	2	−5*	−24*	−21*
K_2O	−76	−80	−84	−102	−100	−110
	−297	−322	−245	−352	−343	−348

SOURCE: Food and Agriculture Organization of the United Nations, *Fertilizers; An Annual Review of World Production, Consumption and Trade*, 1962 and 1963 (Rome, 1963 and 1964).

* Unofficial figure.

It should be mentioned that Africa is a large producer and exporter of rock-phosphate. Morocco is today the largest exporter in the world, accounting for about 40 per cent of the total exports. At the current time, some quantities of rock-phosphate are also directly applied in Morocco, Southern Rhodesia, South Africa, Tunisia and other countries. The total amount of rock-phosphate used directly is about 60,000 tons, against 1.2 million tons of world consumption.

B. Estimation of potential fertilizer demand

Table 7 summarizes the current and future fertilizer consumption in Africa, by subregion. For 1970 and 1980, the anticipated requirements are based on food demand for the increasing population and on the expansion of cash crops.

The growth of population is very rapid. It is expected that the population of Africa, which was 273 million in 1960, will reach 346 million in 1970 and 449 million in 1980.[11] The assumption used here is that the increase of population between 1960 and 1980 will be 176 million.

It is realized that the additional population will not have enough food with the current methods of land cultivation. There is currently a rough sort of balance in Africa between the existing population and the food-supply. Even with this balance, many people in the continent suffer from under-nourishment and malnutrition, especially in respect to animal proteins. With a continually growing population, the existing balance between the number of people and the food-supply will be upset, and new, improved methods of agricultural production will have to be introduced in order to produce more and better food. These will certainly

[11] United Nations, *World Population Prospects as Assessed in 1963* (United Nations publication, Sales No.: 66.XIII.2), "medium" estimate.

Table 7. Fertilizer consumption in Africa, by subregion

(Thousands of tons of pure nutrients)

Subregion and region	Nitrogen (N) 1951-52	1956-57	1961-62	1970	1980	Phosphate (P_2O_5) 1951-52	1956-57	1961-62	1970	1980
North Africa	120.8	146.9	245.5	450.0[a]	900.0[a]	59.5	63.6	98.7	300.0[a]	600.0[a]
Southern Africa	15.5	27.7	57.1	200.0[a]	450.0[a]	105.2	143.4	152.0	350.0[a]	650.0[a]
East Africa	13.0	28.9	46.9	220.0[a]	465.0[a]	6.5	24.3	31.7	220.0[a]	460.0[a]
				110.0[b]	215.0[b]				105.0[b]	185.0[b]
West Africa	1.7	2.0	5.2	17.0[c]	250.0[a]	0.4	1.0	7.6	53.0[c]	150.0[a]
Central Africa	0.2	2.3	2.3	40.0[a]	200.0[a]		0.7	0.7	25.0[a]	100.0[a]
Not identified		4.8	9.0				−1.0	14.7		
TOTAL	151.2	203.0	366.0	957.0	2,265.0	171.6	232.0	276.0	948.0	1,960.0

Subregion and region	Potassium (K_2O) 1951-52	1956-57	1961-62	1970	1980	Total plant nutrients 1951-52	1956-57	1961-62	1970	1980
North Africa	20.0	15.4	28.9	75.0[a]	200.0[a]	200.3	225.9	373.1	825.0[a]	1,700.0
Southern Africa	8.1	20.4	34.9	100.0[a]	300.0[a]	128.8	191.5	244.0	650.0[a]	1,400.0
East Africa	5.1	15.7	25.0	110.0[a]	235.0[a]	24.6	68.9	103.6	550.0[a]	1,160.0
				70.0[b]	110.0[b]			285.0	285.0[b]	500.0[b]
West Africa	0.2	1.7	9.4	43.0[c]	150.0[a]	2.3	4.7	22.2	143.0[c]	550.0[a]
Central Africa	—	2.1	1.9	25.0[a]	100.0[a]	0.2	5.1	4.9	90.0[a]	400.0[a]
Not identified		−2.3	3.9				−8.1	−1.8		
TOTAL	33.4	53.0	104.0	353.0	985.0	356.2	488.0	746.0	2,258.0	5,210.0

SOURCES: Food and Agriculture Organization of the United Nations, *An Annual Review of World Production and Consumption of Fertilizers, 1953* (Rome, 1954); Food and Agriculture Organization, *Fertilizers — An Annual Review of World Production, Consumption and Trade*, 1962 and 1963 (Rome, 1963 and 1964).

[a] Potential requirement based on potential food demand as estimated by United Nations Economic Commission for Africa.

[b] Country targets, close to estimate presented by United Nations Economic Commission for Africa (ECA), "Investigation on fertilizer and chemical industries in East Africa" (E/CN.14/INR/83), paper prepared for the ECA Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October - 2 November 1965.

[c] See Food and Agriculture Organization of the United Nations, "Soil fertility and fertilizers" (E/CN.14/INR/70), paper prepared for the United Nations Economic Commission for Africa Conference on Industrial Co-ordination in West Africa, Bamako, Mali, 5-15 October 1964.

require an important increase in the use of fertilizers. In the light of the results of experiments and demonstrations carried out for years in Africa, fertilizers seem to offer the best possibility for a substantial increase in agricultural production between now and 1980.

Other technical inputs in agriculture are also important, but it is probably less likely that they can be brought into action rapidly enough on a sufficiently massive basis to play a major role. It is true that in agriculture a wide range of different inputs should be applied in order to obtain the most effective results from each of those inputs. But it is also obvious that a high level of agricultural production would not be possible at all without the application of plant nutrients to the soil. The other inputs significantly increase the efficiency of the use of fertilizer: improved seeds, increased irrigation, pesticides and all other technical inputs must be utilized to the fullest possible economic extent; yet, it should be recognized that the principal means of raising agricultural productivity will have to be fertilizers.

The agricultural production increment for 1980 can be assumed to have to cover two different requirements: (*a*) the total food demand of the 176 million additional people; and (*b*) improvement in the basic nutrition of the population of 273 million people (1960), at least 20 per cent of that which is calculated *per capita* under (*a*).

On the assumption that one man needs about 2,400 [12] calories daily and that 1 kilogramme of grain (maize, wheat, rice, millet, sorghum, barley, teff etc.) contains approximately 3,400 [13] calories, the daily requirement of one man is around 710 grams of grain, or about 260 kg of grain annually. Adding this to the estimated losses in storage and wastage (about 20 per cent of yields), one would get about 330 kg of grain. To simplify the accounts, it can be assumed that 1 ton of grain feeds three persons. To provide enough grain for 176 million people, the region then would require about 58.7 million tons of grain (176 : 3).

To present the problems in another fashion: 1 kg of grain containing 3,400 calories will not necessarily be the only food. Other foods and even animal products on the basis of grain are represented here in their grain equivalent. Grain has been used as a symbol and the equivalent of that which is necessary to sustain a human being. It must be understood that the grain symbol is a considerably simplified and conservative one. In practice, the problem is much more complicated, and the demand perhaps may be greater than the assumption made here. But neither the simplification nor the underestimation of food demand weakens the

[12] V. Ignatieff, J. J. Doyle and J. W. Couston, "Future fertiliser requirements of developing countries and crop response to fertiliser in these countries", *Proceedings of the Fertiliser Society* (London), No. 83, 1964, p. 6.

[13] C. Chatfield, *Food Composition Tables — Minerals and Vitamins — For International Use*, FAO Nutritional Studies, No. 11 (Rome, 1954).

argument since the estimates presented in this paper are really conservative ones, how large must the future demand be in reality?

It has already been assumed that improvement in the nutrition of the existing population (*b*) can be represented by 20 per cent of that which was estimated for the total food demand of 176 million additional people (*a*). This means that 1 ton of grain will be sufficient for fifteen persons ($3 \times \frac{100}{20}$). In other words, there would be needed 18.2 million tons of grain (273/15). This, when added to the 58.7 million tons already computed under (*a*), gives 76.9 million tons of grain required.

How can such an amount of grain be obtained? In the light of the results of trials and demonstrations carried out for years in Africa and on the basis of the experience of other countries, for example, India[14], Japan[15], and the United States of America[16], it can be assumed that (*a*) 50 per cent of the grain required, or 38,450,000 tons, can be obtained by increasing fertilizer applications and another 50 per cent by improved use of other inputs; and (*b*) 1 kg of fertilizer yields 10 kg of grain. Assuming (*a*) and (*b*), in 1980 it would be necessary to apply 3,845,000 tons of fertilizer in Africa in order to obtain enough food for the future population.

Additional amounts of fertilizer will be necessary for the expansion of cash crops for export, but it is difficult to determine how large this increase should be. Assuming a combination of both expansion and intensification, cash crops alone may require double the 1960 over-all fertilizer consumption. Thus, about 1.4 million tons of plant nutrients will be required.

According to the estimates outlined above, the potential demand for fertilizer in 1980 will be about 5.2 million tons of pure nutrients (see table 7), consisting of about 2,260,000 tons of N, about 1,960,000 tons of P_2O_5 and about 980,000 tons of K_2O.

The figures in table 7, especially those for 1980, may very well appear to be too ambitious, but they should be regarded as showing the potential requirement. It must be understood that this potential demand for fertilizer can only be met under especially favourable conditions. For instance, country targets in East Africa plan a much lower level of fertilizer application in the future (see table 8).

Many of the African countries have development plans of one sort or another, but they are usually not very specific with respect to planned increases of fertilizer use. Some of the plans reflect the result of Fertilizer Programmes of the Food and Agriculture Organization of the United Nations (FAO) operating since 1961 under the Freedom from Hunger Campaign (FFHC). Gambia, Ghana, Nigeria, Senegal and Togo in West Africa, and Morocco in North Africa are included in these programmes. The results obtained from thousands of trials and demonstrations are very

Table 8. Comparison of various estimates of future fertilizer consumption in the East African subregion

(Thousands of tons of pure nutrients)

Specification	1965	1970	1975	1980
Continuity of actual yearly increment	140	180	220	260
Country targets	170	286	403	520
ECA estimate[a]	118[b]	215	315	444
Total potential demand	244	550	855	1,160

SOURCE: Figures under ECA estimate taken from "Investigation on fertilizer and chemical industries in East Africa (E/CN.14/INR/83), paper prepared by the Secretariat of the United Nations Economic Commission for Africa for the Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965.

[a] N and P_2O_5 only.

[b] 1964.

promising and allow for the planning of future fertilizer consumption in order to cover food production demand.

When it is considered that from 1944/1945 to 1964/1965, world fertilizer consumption has increased from about 7 million tons to over 30 million tons, an increase of fertilizer consumption in Africa from 750,000 tons to 5.2 million tons in nineteen years does not seem to be impossible. But considering the factors which make it difficult for the farmers in this region to use fertilizers, the level of 5.2 million tons of fertilizer will be very difficult to reach.

C. Factors limiting the use of fertilizers

Some of the factors limiting the use of fertilizers are summarized below:

(*a*) The high cost of fertilizers. Transport charges represent a large proportion of the total cost of fertilizers. Transportation cost could only be reduced by bulk handling, which cannot be justified at the current rate of use;

(*b*) The low value of many crops grown in the region, such as cassava, bananas and maize. Most of the non-export crops have a very low cash value and although most of them show marked responses to fertilizer application, the resultant increases in yield may not be sufficiently large to warrant applying fertilizer;

(*c*) The relatively low standard of crop husbandry for most African crops. Fertilizers are not a substitute for good farming; rather, they must be regarded as an integral part of good farming practice;

(*d*) Very low basic yielding of some crops, particularly food crops. Production of new varieties by the plant breeder could result in a gradual increase in basic yields;

(*e*) Lack of adequate supplies of fertilizers and an inadequate distribution system. This is perhaps the key problem in increasing fertilizer application;

(*f*) Lack of information on the kinds and amounts of fertilizer needed and on methods of application in specific circumstances. It is relatively easy to introduce fertilizer to the large farm units where continuous cultivation is practised, but the most important task is the introduction of fertilizers to small farmers. There are great possibilities for extension services to contribute to increasing fertilizer use in Africa;

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[14] Moule S. Williams and J. W. Couston, *Crop Production Levels and Fertilizer Use* (Rome, Food and Agriculture Organization of the United Nations, 1962).

[15] W. Y. Yang, *Farm Development in Japan* (Rome, Food and Agriculture Organization of the United Nations, 1962).

[16] United States of America, Department of Agriculture, Development and Trade Analysis Division, Economic Research Service, *How the United States Improved Its Agriculture* (Washington, D. C., 1964).

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3. A REVIEW OF THE BUILDING MATERIALS INDUSTRY IN AFRICA AND THE POSSIBILITIES FOR A RAPID EXPANSION

Secretariat of the United Nations Economic Commission for Africa

CONTENTS

I. Scope of the report and definitions

In this report, the building materials and components industry is assumed to embrace the activities of manufacturing enterprises that produce wholly or partially those materials which are incorporated permanently or temporarily in housing, building, civil engineering and public works, including materials for repair and maintenance. Excluded from this broad definition of the building materials and components industries are those activities which are undertaken prior to the incorporation of the materials in constructions, such as transporting to site, shaping, cutting, bending, mixing at site to cast the materials to the desired or essential state of final utilization and so on. These activities form part of the construction industry proper.[1]

Building materials and components are processed from a wide variety of basic resources. For purposes of clarity and convenience, the finished and semi-finished materials and components are classified in this report mainly according to the preponderant natural resources from which they are derived. Corresponding to the International Standard Industrial Classification (ISIC) of manufacturing activities, the major building materials and components are then adequately covered by the following five major groupings of manufactures: (*a*) stone quarrying, clay and sand pits; (*b*) wood manufactures; (*c*) non-metallic mineral manufactures; (*d*) metal manufactures; and (*e*) manufactures of chemical origins.[1]

By the very broad concepts that these terms suggest, however, such a classification, without the essential qualifications, falls far short of the precise definitions desired. It might even lead to confusion in that, first, the end-uses of the products of any of the manufacturing groups listed above do not wholly take place in the construction industry; secondly, the classification would tend to conceal the relative importance of specific materials and components; and, finally, it would not make possible the grouping of those materials with the same end-uses (substitute materials) for purposes of comparison.

With these points in mind, the classification of building materials and components adopted in this report is thought to present a workable compromise solution and follows the pattern indicated below in table 1.

The list is by no means exhaustive; nevertheless, it adequately represents the range of major and significant building materials and components used in the construction industry as a whole. It would be unduly ambitious, however, to attempt to cover in this report all the materials listed above. The emphasis of the report is, therefore, directed to a few selected basic materials, whose immediate development in Africa is likely to play a significant and essential role in the economic development of the continent.

Under the heading of "basic materials", priority is given to cement and allied products, timber and iron and steel building products. These materials have vital roles in all construction activities in general and in many instances are irreplaceable. Cement and steel, as the essential ingredients for reinforced concrete, have uses ranging from small dwellings and major building structures to dams, reservoirs and bridges. The same is also true of timber, which is used as shuttering and scaffolding material for concrete casting, as joinery material in housing and building (in its finished form) and also as a structural material in place of steel and concrete.

In addition to the above-mentioned materials, the report also considers flat glass, paints and varnishes, and electrical installation materials, as basic materials. Although their importance from the point of view of savings through import substitution is not considerable, yet the development of these industries in Africa is inevitable and desirable from the point of view of the advantages of their domestic availabilities, and their contributions to employment and the acquisition of technical "know-how".

[1] See United Nations, *International Standard Industrial Classification of All Economic Activities*, Series M, No. 4, Rev.1 (United Nations publication, Sales No.: 58.XVII.7).

(*g*) Tenure systems that still exist in most African countries. Such systems tend to discourage the economic use of fertilizers;

(*h*) The lack of adequate seed, and of disease and insect control measures and other practices that are necessary if fertilizers are to have their best effect;

(*i*) Additional labour required to apply fertilizer at a busy time of the year. Adoption of fertilizer seed drill by mixed farmers could reduce the labour requirements involved in the application of fertilizers;

(*j*) Reluctance on the part of farmers to accept new techniques. This may be expected to be gradually overcome by education, propaganda and demonstration systems.

D. Measures for promoting use of fertilizers

All these impediments and obstacles will have to be overcome if fertilizer use is to become more common in Africa. In this connexion, government action is necessarily very important. The following policies are most important and are possibly even required if modern agricultural methods are to be used to increase agricultural production:

(*a*) Provision for greatly expanded research and extension services to supply information to cultivators and to assist them in applying improved methods;

(*b*) Provision of practical field demonstrations with fertilizers, in combination with other means of extension and publicity (film shows, radio broadcasts, leaflets, articles etc.);

(*c*) The development of an effective pricing and distribution system for farm products and farm supplies that they must have in order to make use of modern methods;

(*d*) An effective distribution system for fertilizers, possibly combined with a subsidy system which would cover transportation costs to very distant regions and make the price of fertilizer equal for every farmer;

(*e*) The development of a system of farm credit for cultivators which would provide adequate protection against uncontrollable risks, such as severe drought in some regions.

E. Rates and patterns of growth in production of fertilizers

Fertilizer output in the region is comparatively low (see table 9). According to 1953/1954 figures, it consisted of 0.34 and 2.85 per cent of the world output of N and P_2O_5, respectively. Corresponding percentages for 1962/1963 were 1.45 and 2.57, showing an increase in N and a decrease in P_2O_5 in share of world output. Output of potash fertilizer was negligible.

During the period from 1953/1954 to 1962/1963, the output of nitrogen fertilizers increased steadily from 19,000 to 184,000 tons, at an average annual rate of growth of 29 per cent. The United Arab Republic and South Africa were the only producers, the former taking the lead with 73 per cent of the 1961/1962 output of the region. Ammonium nitrate accounted for 47 per cent of the nitrogenous fertilizer output in 1961/1962. The United Arab Republic produced 95 per cent of this and South Africa the balance. In descending order, the other types of nitrogen fertilizers produced in Africa were calcium nitrate (29 per cent), ammonium sulphate (14 per cent) and urea (8 per cent). The first was entirely produced in the United Arab Republic and the second and third in South Africa.

Excluding 1961/1962, during which time the output fell to 254,000 tons, the output of phosphate fertilizer showed a steady increase from 187,000 to 283,000 tons during the period in question. In terms of annual growth rate, output grew by an average of 4.7 per cent. Unlike the region as a whole, the output in some countries, such as Algeria, Morocco and South Africa, has been erratic. According to 1960/1961 figures, South Africa, with a share of 48 per cent, occupied first place and was followed by Tunisia, the United Arab Republic, Rhodesia, Morocco, Algeria and Kenya.

Single superphosphate was by far the leading type of phosphate fertilizers produced in the region. In 1960/1961, it accounted for over 70 per cent of total phosphate fertilizers, with about 66 per cent of this being contributed by South Africa. From among the other types, concentrated (triple) superphosphate was the most important, and Rhodesia and Tunisia were the major, if not the only, producers.

As has already been stated, output of potash fertilizers has been negligible. South Africa produced an average of 600 tons per annum from molasses during the period 1954/1955-1957/1958. It appears that there has not been any production since the end of this period.

The proportions in which the three plant nutrients were produced in the region show a dramatic change. Output ratio changed from 1:10:0 in 1953/1954 to 1:1.54:0 in 1962/1963, while the corresponding ratios for the world were 1:1.19:1 and 1:0.86:0.74, respectively. Disregarding potash, it seems that the output ratio in Africa was tending towards that of the rest of the world.

Comparison of output with consumption shows that the region is heavily dependent upon imports of nitrogen and potash fertilizers (wholly in the case of the latter). Output of the former, as a percentage of consumption, however, increased from 12.6 per cent in 1953/1954 to 45.5 per cent in 1962/1963.

The picture concerning the output of phosphate fertilizers in relation to consumption is different. For the period 1953/1954-1962/1963, the output of phosphate fertilizers, as a percentage of consumption, ranged from 89 per cent in 1954/1955 to 100 per cent in 1956/1957 and 1959/1960. This shows that the region has, more or less, been self-sufficient in phosphate fertilizers.

F. Current and future state of the fertilizer industry

The preceding section concluded by showing the existence of disparity between production and consumption of potash and nitrogen fertilizers for the period 1953/1954-1962/1963. In the absence of a reliable inventory of fertilizer industries for that period, it is rather difficult to relate capacity utilization to consumption, a relationship which is probably a better indicator of disparity.

The current and future state of the fertilizer industry in the subregions, as well as in the whole of Africa, is discussed in this section in the light of available information.

Table 9. Comparison of fertilizer production and consumption in Africa, 1953/1954 to 1962/1963

(Tons of pure nutrients)

Subregion or region	1953/1954	1954/1955	1955/1956	1956/1957	1957/1958	1958/1959	1959/1960	1960/1961	1961/1962	1962/1963	Compounded annual rate of growth (percentage) 1953/1954-1960/1961	1953/1954-1962/1963
Nitrogen fertilizers (N)												
North Africa	18,600	21,700	29,590	26,660	32,240	34,302	38,077	55,024	106,464	(120,400)	17.0	23.0
United Arab Republic	18,600	21,700	29,590	26,660	32,240	34,302	38,077	55,024	106,464	(120,400)		
Other countries	400	4,620	7,963	13,338	13,338	16,230	21,024	22,346	38,185	(59,300)	78.0	145.0
South Africa	400	4,620	7,963	13,338	13,338	16,230	21,024	22,346	38,185	(59,300)		
Africa (total)	19,000	26,000	38,000	40,000	46,000	51,000	59,000	77,000	145,000	184,000	22.0	29.0
World (total)	5,540,000	6,300,000	6,650,000	7,280,000	8,530,000	9,390,000	9,780,000	10,740,000	11,700,000	12,750,000	10.0	10.4
African share in world output (percentage)	0.34	0.41	0.57	0.55	0.54	0.54	0.60	0.72	1.24	1.45		
Consumption	151,000	186,000	203,000	202,000	256,000	290,000	223,000	324,000	336,000	405,000	11.5	11.6
Output as percentage of consumption	12.6	14.0	18.8	19.8	18.0	17.9	26.5	23.8	39.6	45.5		
Phosphate fertilizers (P_2O_5)[a]												
North Africa	75,252	83,590	98,209	97,088	103,574	119,683	118,108	(123,987)	(120,063)	(118,800)	7.4	5.2
Algeria	20,223	19,680	20,000[b]	20,000[b]	14,317	13,268	15,397	14,153	(8,800)	(7,500)		
Morocco	14,630	17,300	16,453	8,774	13,892	18,746	15,682	14,349	12,799	(13,300)		
Tunisia	25,957	32,300	40,020	43,000[b]	47,850	59,981	62,039	(64,000)	(68,800)	(66,700)		
United Arab Republic	12,942	10,710	20,558	23,680	27,515	27,688	24,990	31,458	29,664	(31,000)		
East Africa	750	1,800	589	817	600	12,553	17,756	19,218	...	...	59.0	...
Kenya	750	1,800	589	817	600[b]	600[b]	600	611	...			
Rhodesia	—	—	—	—	—	—	11,953	(16,756)	18,607			
Other countries	112,000	104,192	112,964	138,805	138,805	124,666	125,438	136,297	118,579	(142,000)	3.0	2.7
South Africa	112,000	104,192	112,964	138,805	138,805	124,666	125,438	136,297	118,579	(142,000)		
Africa (total)	187,000	187,000	211,000	235,000	243,000	257,000	261,000	282,000	254,000	283,000	4.0	4.7
World (total)	6,570,000	7,100,000	7,340,000	7,540,000	8,620,000	9,120,000	9,710,000	10,060,000	10,400,000	10,990,000	6.2	5.8
African share in world output (percentage)	2.85	2,63	2.87	3.12	2.82	2.82	2.70	2.80	2.44	2.57		
Consumption	198,000	210,000	217,000	234,000	263,000	259,000	260,000	286,000	276,000	314,000	5.4	5.2
Output as percentage of consumption	94.0	89.0	97.0	100.0	93.0	99.0	100.0	98.0	92.0	90.0		
Potash fertilizers (K_2O)												
Other countries	...	636	675	551	555	—	—	—	—	...	...	...
South Africa	...	636	675	551	555	—	—	—	—	...		
Africa (total)	...	636	675	551	555	...	—	—	—			
World (total)	5,600,000	6,150,000	6,410,000	6,810,000	7,720,000	8,170,000	8,660,000	8,740,000	9,240,000	9,370,000	6.8	5.8
African share in world output (percentage)	...	1,101	0.11	0.01	0.01	—	—	—	—	—		
Consumption	47,000	63,000	65,000	62,000	72,000	78,000	85,000	102,000	104,000	114,000	11.7	11.0
Output as percentage consumption	...	0.1	0.1	0.09	0.08	—	—	—	—	—		

SOURCES: Food and Agriculture Organization of the United Nations, *An Annual Review of World Production, Consumption and Trade of Fertilizers, 1959* (Rome, 1960); Food and Agriculture Organization, *Fertilizers: An Annual Review of World Production, Consumption and Trade, 1963* (Rome, 1964).

NOTES: ... Not available. —None or negligible. ( ) Figures from other sources, phosphate figures are for calendar year.

[a] Excluding production of rock-phosphate in which Africa, with 30 per cent of world output, is second to the United States of America.

[b] Unofficial figures.

1. West Africa

On the basis of papers presented at the ECA Conference on Industrial Co-ordination in West Africa,[17] a number of fertilizer industries were recommended for the West African subregion. These plants are expected to meet the 1970 estimated demand of 51,000 tons of N[18] and 53,000 tons of P_2O_5. Data extracted from the above-mentioned papers are given below in table 10.

[17] United Nations Economic Commission for Africa, "Basic Chemicals and fertilizers" (E/CN.14/INR/73 and addendum); Food and Agriculture Organization of the United Nations "Soil fertility and fertilizers in West Africa" (E/CN.14/INR/70), papers prepared for the Conference on Industrial Co-ordination in West Africa, Bamako, 5-15 October 1964.

[18] Including some 3,400 tons of N for explosives.

Table 10. West Africa: selected data on proposed fertilizer production capacity[a]

Fertilizer	Location	Capacity (tons per annum)	Plant cost (dollars)	Production cost	c.i.f. prices	
				(dollars per ton)		
Single superphosphate	Togo	116,000	1,520,000	23.0	45.5	47.3
Single superphosphate	Ivory Coast	93,000	1,320,000	26.5	45.5	47.3
Triple superphosphate	Senegal[b]	35,000	2,380,000	69.5	80.3	82.6
Ammonium sulphate	Nigeria	225,000	11,000,000	31.0	49.3	55.7
Ammonium nitrate		10,000		88.0	280	340[c]

SOURCES: United Nations Economic Commission for Africa, "Basic chemicals and fertilizers" (E/CN.14/INR/73 and addendum); Food and Agriculture Organization of the United Nations, "Soil fertility and fertilizers in West Africa" (E/CN.14/INR/70), papers prepared for the Conference on Industrial Co-ordination in West Africa, Bamako, Mali, 5-15 October 1964.

[a] This table might be modified as a result of the Bamako Conference follow-up study, which is currently being conducted.

[b] According to *Marchés Tropicaux et Méditerranéens* (30 October 1965), a complex fertilizer plant with a capacity of 130,000 tons is to go on stream in 1967 in Senegal.

[c] Explosive based on ammonium nitrate.

An examination of table 10 reveals that it is quite possible to produce both phosphate and nitrogen fertilizers at costs below c.i.f. prices. As there is no known exploitable potash deposit in the subregion, the manufacture of potash fertilizers was not considered in the papers.

2. Central Africa

Because of the low estimated demand for fertilizers in Central Africa, coupled with the unattractive nature of the raw-material situation (excluding potash), it seems that the subregion will have to go a long way before it can locally produce the three nutrients.[19] The subregion will have to look to both the West and East African subregions for nitrogen and phosphate fertilizer supplies for some years to come.

The picture concerning the possibility for potash fertilizer production is, however, bright. The potash deposit at Holle (Congo (Brazzaville)) is to be exploited mainly for exportation. A potash refining plant of 600,000 tons (60 per cent K_2O) annual capacity is reported to be under construction and is expected to go on stream before 1967.

3. East Africa

Unlike the preceding subregions, East Africa has some fertilizer plants already in operation. Some relevant features of these plants and those under construction and planned are presented in table 11.

The results and recommendations of the paper on chemicals prepared for the ECA Conference on the Harmonization of Industrial Development Programmes in East Africa, held in Lusaka (26 October-6 November 1965)[20] are set forth in the same table (see foot-note [a]). The extension of the Tororo and Salisbury phosphate plants, together with the new proposed fertilizer plants, are envisaged to meet the 1970 estimated demands of 120,000 tons of N and 95,000 tons of P_2O_5. As for potash fertilizers, the Danakil Depression (Ethiopia) plant will more than cover the East African requirement even beyond 1980.

4. North Africa

The fertilizer industry in North Africa is the most advanced. Both nitrogen and phosphate fertilizers are manufactured. With abundant reserves of raw materials (phosphate, natural gas, petroleum and, to some extent, potash), the subregion can, with some effort, become a net exporter of phosphate and nitrogen fertilizers.[21] This seems to be the goal envisaged from the number of export-oriented projects set forth in table 12.

Comparison of the maximum ammonia capacity (known existing or under construction) with the much greater amount of 150,000 tons per annum that is considered economically feasible (in North Africa) for export purposes[22], however, shows that the exportation of ammonia (to countries traditionally producing nitrogen fertilizer and competing with their products in the export market) does not appear to be very

[19] According to United Nations, *Report of the ECA Mission on Economic Co-operation in Central Africa* (United Nations publication, Sales No.: 66.II.K.2), conservative estimate, the Central African fertilizer requirement in 1975 is expected to consist of 24,000 tons of N, 15,000 tons of K_2O and more or less static phosphate demand.

[20] "Investigation on fertilizer and chemical industries in East Africa" (E/CN.14/INR/83).

[21] Trends towards the use of hydrocarbon raw materials for ammonia manufacture and tendencies for ammonia and phosphate fertilizer plants to be located near the sources of raw materials could possibly make this subregion one of the leading producers of nitrogen and phosphate fertilizers in the world.

[22] Herman K. Nieuwenhuis, "Developing the petrochemical potentials of North Africa and the Persian Gulf", *Studies in Petrochemicals*, presented at the United Nations Interregional Conference on the Development of Petrochemical Industries in Developing Countries (United Nations publication, Sales No.: 67.II.B.2), vol. II, chap. VIII, paper 5.

Table 11. East Africa: fertilizer plants existing, under construction and proposed

Producer and location	*Product*	*Capacity (tons per annum)*	*Plan for extension*	*Raw materials availability*
Tororo Industrial Chemicals and Fertilizers Ltd., (Tororo, Uganda)	Single super-phosphate (21%)	25,000	To add 75,000[a]	Phosphate from Sukulu Imported sulphur
RODIA of the African Explosives and Chemical Industries (Rhodesia) Ltd. (Salisbury, Southern Rhodesia)	Single super-phosphate (19%) Triple super-phosphate (44%)	50,000 50,000	Being extended by 10,000 (P_2O_5)	Expected to begin using local phosphate from Dorowa in July 1965 Pyrite to be supplemented by imported sulphur
Soda-phosphate plant (Turbo, Kenya)	Soda phosphate (25%)	4,000		Phosphate from Sukulu Soda-ash from Lake Magadi
Mauritius Chemical and Fertilizer Industry Ltd. (Port Louis, Mauritius)[b]	12:9:12 complex	60,000	Adding 60,000 in due course	Imported ammonia, ammonium phosphate and muriate of potash
The Ralph M. Parsons Co. (Danakil Depression, Ethiopia)[b]	Muriate of potash (60% K_2O)	600,000		Sylvinite
Nitrogen fertilizer plant at Umtali (Umtali, Southern Rhodesia)[c]	Ammonium sulphate (21.5%) Ammonium nitrate (34%)	190,000[a] 80,000[a]		Petroleum feed stock
Nitrogen fertilizer plant in Uganda[d]	Ammonium sulphate (21.5%)	190,000[a]		Methane from Lake Kivu
Single superphosphate plant at Dar-es-Salaam (Dar-es-Salaam, United Republic of Tanzania)	Single superphosphate (17%)	160,000[a]		Phosphate from Min Jingu Hills Imported sulphur

[a] Proposed by the United Nations Economic Commission for Africa.

[b] Expected to begin operation in 1967/1968.

[c] Capacity of the ammonia units is 100,000 tons per year, and 14,000 tons of the ammonium nitrate is for the manufacture of explosives.

[d] This location may be shifted to Kenya provided methane from Lake Kivu could not economically be used in Uganda.

Table 12. North Africa: fertilizer plants existing, under construction and planned

Country and producer	*Location*	*Year of est.*	*Products*	*Capacity (tons per annum)*	*Planned expansion (tons per annum)*	*Raw materials*
Algeria						
Soc. Algérienne de Produits chimiques et d'engrais	Oran, Algiers, Philippeville	E	SS (18%)	90,000		Phosphate, pyrite
Société Alger de l'Azote	Arzew	UC	AN (33%) Urea (46%)	20,000 10,000		Natural gas
Complexe Pétrochimique[a]	Arzew		Ammonia	200,000		Natural gas
Libya						
Petrochemical Complex[a]			Ammonia	330,000		Natural gas
Morocco						
Société Chérifienne d'Engrais et de Produits Chimiques	Ain-Sebaa	1923	SS (18%)	150,000		Phosphate, pyrite
Productos Quimicos Marroquies[a]	Tétouan	1956	DCP (35%)	2,000	5,000 1960-1964	Phosphate
Société Marocaine des Engrais Pulvérisés	Safi, Kenitra, Berrechid	1944	HP (34%)	100,000		Phosphate
Le Complexe Chimiques de Safi[a]	Safi	1965	TS (48%) AS (21%) AP (11-18% N, 48-55% P_2O_5)	200,000 36,000 150,000		Phosphate, pyrrhotine, natural gas
Potash project			PC (60%)	250,000		Canalite or sylvite

Table 12. North Africa: fertilizer plants existing, under construction and planned (*continued*)

Country and producer	*Location*	*Year of est.*	*Products*	*Capacity* (tons per annum)	*Planned expansion* (tons per annum)	*Raw materials*
Sudan						
International Development and Investment Co. Ltd.	Port Sudan		AN (33%)	75,000		Petroleum feed-stock
Tunisia						
NPK engrais[a]	Sfax	1965	TS (45%)	150,000	30,000 (1968)	Phosphate, sulphur (I)
SIAPE	Sfax	1951	TS (45%)	170,000	Over 30,000	Phosphate, sulphur (I)
La Société Tunisienne des Engrais Pulvérisés[a]	Sfax	1956	HP (25-30%)	130,000	Conversion envisaged	Phosphate
SPACE[a]	Tunis	1919	SS (16%)	60,000		Phosphate, pyrite (I)
Industries Chimiques Maghrébines	Ghamoud	1964	AP (16% N-48%, P_2O_5)	200,000		Phosphate, naphtha, sulphur
			AN (20.5%)	85,000		
United Arab Republic						
Abu-Zaabal for fertilizers and chemicals	Cairo	1948	SS (15%)	70,000	140,000 (15%) 1965-1970	Phosphate, pyrite (I), sulphur
Financial and Industrial Company	Kafr el Zayat	1937	SS (15%)	220,000		Phosphate, pyrite, sulphur
Assayut Fertilizers and Chemical Industries Co.	Assayut	1967	SS (15%)	200,000		Phosphate, sulphur
Egyptian Chemical Industries Co. (KIMA)	Aswan	1960	CAN (20.5%)	480,000		Water, limestone
Phosphorus complex	Aswan	1965-1970	TS (45%)	100,000		Phosphate
El Nasr for Fertilizers and Chemical Industries Co.	Suez	1951	CN (15.5%)	252,000		Refinery gas, limestone, sulphur
		1963	AS (20.6%)	100,000		
		1965-1970	SS (15%)	400,000		
		1965-1970	AS (20.6%)[a]	200,000		Naphtha, gypsum
		1968	CN (15.5%)	258,000		
		1968	CAN (20.5%)	160,000		
Petrochemical Complex[a]	Alexandria	1965-1970	CAN (20.5%)	200,000		Naphtha, limestone
El Nasr Co. for Coke and Chemicals	Helwan	1967	CAN (20.5%)	200,000		Coke-oven gas, limestone
		1968	CAN (20.5%)	200,000		
		1965-1970	Urea (46%)[a]	95,000		
		1965-1970	CAN (20.5%)	200,000		
Potash plant		1965-1970	PS	5,200		Mother-liquor, ethyl alcohol

NOTES: Data on countries other than Tunisia and the United Arab Republic are inadequate and sometimes conflicting. These data are, therefore, tentative and subject to correction.

[a] Export-oriented operation.

E = existing
TS = triple superphosphate
HP = hyperphosphate
CN = calcium nitrate
AS = ammonium sulphate
UC = under construction
DCP = dicalcium phosphate
AN = ammonium nitrate
SS = single superphosphate
CAN = calcium ammonium nitrate

promising. If nitrogen fertilizer plants in North Africa are to break through those markets, they should have ammonia capacities well above 150,000 tons. It would, in addition, be advisable to begin by exporting intermediate chemicals, such as ammonia. Even with intermediates, it is essential for North African countries to have assured access to markets before establishing the plants.

Examination of the foregoing tables reveals that each subregion is directly or indirectly concerned with fertilizer projects. If all goes well, most, if not all, of these projects may be realized before or about 1970. An attempt has been made to classify capacities into the following categories: existing; under construction; country project and ECA recommendation. The figures thus obtained are presented in table 13.

Comparison of total expected capacities with the estimated potential consumption in 1970 indicates an excess of output over consumption in all three nutrients. From the number of export-oriented projects (see table 12) it appears that about 45 per cent of the N and 36 per cent of the P_2O_5 total expected capacities (see table 13) are envisaged for exportation mainly to countries outside the region. In other words, the

Table 13. Probable fertilizer industry capacities in Africa around 1970, by subregion
(Thousands of tons of pure nutrients)

	Existing	*Under construction*	*Country project*	*ECA recommendation*	*Total 1970*	*Estimated potential demand, 1970*
Nitrogen (*N*)	183	252	672	171	1278	757
North Africa	183	252	672	—	1107	450
East Africa	—			120[a]	120[a]	220
Central Africa				—		40
West Africa				51[a]	51[a]	47
Phosphate (P_2O_5)	281	341	166	111	898	598
North Africa	244	341	166		750	300
East Africa	37			58	95	220
Central Africa						25
West Africa				53	53	53
Potash (K_2O)		720	150		870	253
North Africa			150		150	75
East Africa		360			360	110
Central Africa		360			360	25
West Africa						43

[a] Including N for explosive purposes.

excesses in N and P_2O_5 are apparent as far as the region is concerned. As the 1970 estimated demands are, however, based on potential requirements, they may be considered to be on the high side. This would, in reality, mean that the gap between the practical expected consumption and production will not be as wide as it may appear to be. In other words, it is unlikely that Africa will face a major over-all shortage of locally manufactured fertilizers around 1970.[23]

The grouping of capacities by kind of fertilizer and by subregion shows that North Africa will still be leading the other subregions in 1970. About 86 per cent of the N and 84 per cent of the P_2O_5 production figures given in table 13 refer to North Africa. About 83 per cent of the K_2O production will be shared equally between East Africa and Central Africa.

[23] Admittedly, the reliability of the conclusion on the likelihood of the fertilizer industry situation in Africa in 1970 is questionable. It should be considered in the light of the shortcomings, such as those expressed in the foot-note to Table 12 and the possibilities that some of the projects may not materialize in time, or never at all.

IV. Pesticides: plant protection chemicals

A. Need for pesticides and identification of the important ones

As regards agriculture, pesticides are complementary to fertilizers. The latter increase yield directly and the former indirectly by decreasing the loss due to insects, weeds, fungi, etc. in both the field and storage. It has been estimated that over $13,000 million worth of agricultural products are lost annually in the United States of America because of agricultural pests.[24] This loss would have been much larger had pesticides not been used. It is, therefore, obvious that pesticides will have to play an important role in increasing the productivity of the African soil.

The need for and importance of insecticides for public health and animal husbandry cannot be overemphasized. Their role in these spheres may be expected to increase considerably with the rising standard of living of the people of the region.

The wide variety of pesticides (literally thousands of them appearing in the form of liquids, dusts, wettable powders and emulsions) present in the market, the relatively small quantities of individual pesticides used and the inadequate information available on their use in the region call for further investigation. As it would not be practical to consider the very large range of pesticides in use, it will be necessary to limit the range or even select the basic pesticides (technical grades) that may have possibilities in the region.

It appears that insecticides are, in general, the most important pesticides in the region. A huge number of them—chlorinated hydrocarbons, organo-phosphorous insecticides, sulphur compounds, lead arsenate, pyrethrum, etc.—are in use. The first group, DDT and BHC in particular, are the most significant in a number of countries in the region. This has been and is still the case in many parts of the world. The 1954 production situation in the United States of America could be cited in support of the foregoing statement. Of the 419 million pounds produced, 23.2 and 18.4 per cent represented DDT and BHC, respectively. This situation applies to developing countries as well. The production of technical-grade pesticides in a number of developing countries in Asia is, for instance, limited to DDT and BHC.

Why do DDT and BHC appear to be most popular insecticides? First, both of them are used for both plant and animal protection. This combination of application means convenience and relatively larger volume of sales with all the advantages resulting thereof.

[24] R. Norris Shreve, *The Chemical Process Industries*, 2nd ed. (New York, McGraw-Hill Book Company, Inc., 1956).

Secondly, because of their properties, they are, to some extent, comparatively easier to manufacture and apply and cheaper than many insecticides. Thirdly, as they have a broad control spectrum, the scope of their application is comparatively large, thereby reducing the number of types of insecticides to be used.

B. Demand for and production and formulation of pesticides

Identifying the most important insecticides is one thing and estimating current and future demand is another. As far as insecticides are concerned, imports, if available, can be equated to consumption. Unfortunately, statistical data rarely show a breakdown of imports by type of pesticide, much less distinguish individual items, such as DDT and BHC. The data given in table 14 for East and West Africa were collected mainly from importers and dealers in pesticides.

The current and future demand situation with respect to Central and North Africa is less well known. No attempt has been made in this paper to indicate orders of magnitudes, for there is no adequate background information on which rough estimates could be based.

Table 14. Current and probable production and consumption by 1970 of DDT and BHC in Africa, by subregion

(Tons)

	Current			*1970*		
	Consumption	*Production*	*Capacity*	*Estimated demand*	*Capacity envisaged*	*Remarks*
DDT						
North Africa		300	600			
East Africa	1,880			5,250	5,500	75%
Central Africa						
West Africa	5,400			8,000	8,000	50%
BHC						
North Africa						
East Africa	1,790			3,480	7,000	25% (Ca. for 1975)
Central Africa						
West Africa	10,800			15,000	15,000	25%

As regards the production of pesticides, it is known that there are a number of pesticides establishments in the region. Information on their activities are, however, scanty. With the possible exception of a DDT plant of 600-ton capacity in the United Arab Republic and a sodium arsenate plant with a capacity of 220 tons, all of these establishments are formulating plants depending upon imported basic materials. These formulating plants are the fore-runners of those that may be expected to be set up to produce some of the technical-grade synthetic pesticides.

The production situation described in the preceding paragraph refers to inorganic and synthetic insecticides only. The region is a leading producer of one plant derivative insecticide, that is, pyrethrum flowers and extract. In 1961, African production accounted for 65 per cent of the world output of 11,000 tons of dried flowers. In the same year, Kenya alone exported 2,540 tons of flowers and 296 tons of extracts from two existing plants. Other countries producing pyrethrum are Congo (Democratic Republic of) and Tanzania.

Pyrethrum is non-toxic to man and warm-blooded animals. It has a quick knock-down effect on flies, but it is not persistent. It is mainly used in insecticide formulations for fly sprays to be put in aerosol containers for household purpose. Unlike the case of synthetic insecticides, insects have as yet not shown a tendency for developing resistance to pyrethrum. All these properties, coupled with the fact that no economic synthetic substitute has so far been found for pyrethrum, indicate that pyrethrum will continue to play its role as an important export item of the East and Central African subregions.

C. Measures for promoting use of pesticides

As is the case with fertilizers, government action is imperative if farmers are to benefit from pesticides. All measures and policies which are used and may be expected to be used to promote the use of fertilizers should be applicable to pesticides as well. Both fertilizers and pesticides can be handled by the same organizations, institutions and people promoting the application of fertilizers.

V. Basic chemicals

A. Sulphuric acid

Due to the existence of fertilizer industries, superphosphates in particular, sulphuric acid production has been substantial in Africa. Installed capacity is of the order of magnitude of 954,000 tons, 32 per cent of which is for uses other than fertilizers. About 60 per cent of the total capacity is in North Africa and 26 and 14 per cent in East and Central Africa, respectively (see table 15).

A number of existing sulphuric acid facilities are undergoing extension. This, together with those under construction, will, in a matter of about two years, raise the total current capacity to the order of 1.9 million tons. North Africa will account for almost all of the increase.

Table 15. Production and current and future capacities of sulphuric acid, caustic soda and ammonia in the subregions of Africa

(Thousands of tons)

Subregion and country	Sulphuric acid (100%) 1954	1957	1960	1963	Capacity Current	Capacity 1970	Caustic soda (100%) 1954	1957	1960	1963	Capacity Current	Capacity 1970	1970 est. consumption	Ammonia Capacity Current	Ammonia Capacity 1970
North Africa	113	171	190	164	571	1,787	4.1	5.0	5.7	19.9	33.0	50.0	150	223	1,340
Algeria	48	41	40	32	47	47	2.5	2.0	2.2	2.2	5.0	18.0		—	200
Morocco	38	30	33	36	50	160					3.8	3.8			
Tunisia					200	673									60
Libya															330
United Arab Republic	57	89	103	88	260	593	1.6	3.0	3.5	17.7	24.0	28.0		223	720
Sudan															30
Canary Islands		11	11	13	14	14									
East Africa					252	694						21	50		150
Kenya					—	160								—	50
Southern Rhodesia					122	270									100
Uganda					10	40									
United Republic of Tanzania						64									
Zambia					120	120									
Other countries						40									
Central Africa	84	123		94	136	136							5[a]		
Congo (Democratic Republic of)	84	123		94	132	132									
Gabon	—	—	—		4	4									
West Africa	—	—				340	—	—	—	—		20	90		62
Nigeria	—		—	—		174		—						—	62
Senegal						70									
Togo		—				50									
Other countries				—	—	46									
TOTAL (subregions)					959	2,957					33	91	295	223	1,552

SOURCES: United Nations, *Statistical Yearbook, 1964* (United Nations publication, Sales No.: 65.XVII.1); and national publications.

NOTE: 1970 capacities were computed from the requirements of the basic chemicals for industries (existing, under construction, recommended by the United Nations Economic Commission for Africa and planned) expected to be in operation around 1970.

[a] Current consumption.

With more fertilizer plants and other sulphuric acid-consuming projects envisaged, capacity may be expected to increase to over 3 million tons in 1970. This relatively large increase confirms the importance of sulphuric acid as the "grandfather of all business indicators".

In terms of sulphur, the 1970 expected capacity of sulphuric acid is equivalent to over 1 million tons. As brimstone is almost non-existent and as the availability of pyrites is limited so far, most of the future sulphuric acid plants will have to depend upon the supply of imported sulphur. This, of course, means a great burden on the sulphuric acid plants. In view of this situation and the rising trend of world sulphur prices (because of decreasing availability), it would be advisable to consider the utilization of other sulphur-bearing materials and to investigate possibilities for substituting other acids for sulphuric acid in some fields of application.

Sulphuric acid from gypsum (anhydrite) is technologically feasible, provided there is a market for the acid and the cement that is obtained as a co-product. Countries with gypsum deposits and a cement industry not yet developed would do well to consider the sulphuric acid-cement approach. This approach lowers the high capital cost per unit of the acid by sharing it with that of the cement.

Another way of using gypsum is in the manufacture of ammonium sulphate. In the gypsum-sulphate process or the Merserberg Process, as it is called, gypsum is directly reacted with ammonium carbonate, resulting in ammonium sulphate and calcium carbonate. As was the case with the sulphuric acid from gypsum, combining this process with the manufacture of cement is a necessary condition for its success. This process is currently being used in India and the United Kingdom of Great Britain and Northern Ireland. Fertilizers and Chemicals, Travancore Ltd., of the former country, has recently succeeded in utilizing by-product gypsum instead of natural gypsum. This development is welcome to those countries with no resources of sulphur-bearing materials. It will enable them to reduce the importation of sulphur, as by-product gypsum from a phosphoric acid plant can be utilized in the manufacture of ammonium sulphate.

Sulphur dioxide from smelters is another source of sulphuric acid. Both Congo (Democratic Republic of) and Zambia have sulphuric acid plants with a combined capacity of over 230,000 tons per annum based on smelter gases. Countries with similar possibilities should explore the economics of using smelter gases before deciding on other sources of sulphur.

At one time, the presence of sulphur in natural gas or crude petroleum was considered a disadvantage. This is no longer the case. Take the example of the Lacq natural-gas field in France. The gas contains 15.2 per cent hydrogen sulphide whose sulphur is extracted at the gas processing plant at Lacq. About 1.4 million tons of sulphur are recovered annually, thereby making France a large producer of sulphur.

Unfortunately, African natural gases and crudes, most of them at least, do not appear to offer this kind of prospect. They are either sweet or contain very little sulphur. It is of interest to note here that the United Arab Republic does recover over 30,000 tons of sulphur per annum from its refineries. African countries with prospects similar to that of the United Arab Republic would be advised to follow the example.

Turning to the question of substitute acids, it is encouraging to note here that some success has already been observed. The Israel Mining Industries Institute for Research and Development has, for instance, developed a process for the production of phosphoric acid, using hydrochloric acid as an acidulant with subsequent solvent extraction of the resulting phosphoric acid. The phosphoric acid produced is said to be comparable to thermal acid in both quality and concentration. This new process is under operation in Japan, under construction in Brazil and may, therefore, prove practical in countries in the region with excess hydrochloric acid disposed of at reasonable prices. If successfully implemented, this would partially do away with sulphur and, at the same time, solve the problem of the excess chlorine that will be inevitable if the chlorine-caustic industry is to develop to satisfy the demand for caustic soda.

Research on the use of nitric acid as an acidulant for rock-phosphate does not appear to have been as successful as in the use of hydrochloric acid. A successful application in substituting nitric acid for sulphuric acid would mean a lot, especially to those countries with large petroleum or natural-gas resources.

B. Caustic soda

After sulphuric acid, caustic soda is probably the basic inorganic chemical with the widest application in both the chemical and other industries in the region. Soap, alumina, textiles, vegetable oils, pulp and paper, petroleum refining and rayon have been the major consumers in Africa so far.

Algeria, Morocco and the United Arab Republic are the only producers of caustic soda, their joint production in 1964 totalling about 22,000 tons, with total capacity being equal to over 33,000 tons (see table 15). African demand in excess of production was met by imports, with East, Central and West Africa importing about 13,000, 5,000 and 48,000 tons, respectively. From available information, 1970 capacity of caustic soda may be expected to be over 90,000 tons. The potential requirement will, of course, exceed this for the estimated consumption (excluding additional requirements for new aluminium plant) is of the order of magnitude of 300,000 tons.[25]

[25] The aluminium plant in Guinea is the largest single consumer of caustic soda (30,000 tons). The viscose rayon plants and pulp and paper mills envisaged will account for the major part of the increase in the region.

Technically speaking, the potential demand can be met, provided the large excess of chlorine that may result from salt electrolysis plants can be disposed of economically. Unlike that of the developed countries where chlorine demand exceeds that of caustic soda, the over-all situation in the region is just the opposite. This unfavourable situation will undoubtedly improve with the development of the important chlorine-consuming industries, such as plastics, insecticides, solvents, pulp and paper, and textiles. Until such a time is reached, however, the economic utilization of chlorine will be the main limiting factor for the development of the chlorine-caustic and related industries.

Causticization of soda ash (lime-soda process) is an alternative to caustic soda production. It does not involve chlorine as a by-product. Unfortunately, according to a preliminary investigation in connexion with natural soda ash from Lake Magadi (Kenya), the cost of production per unit is said to be substantially higher than that for the process involving the electrolysis of salt.[26] Within the last ten or twenty years, because of the progressively higher demand for chlorine, the change-over to salt electrolysis has been effected. At the current time, over 90 per cent of the caustic soda in developed countries is obtained from salt electrolysis. In view of the completely different current situation in developing countries, those countries with natural soda-ash deposits would be advised to prove conclusively the unfavourable statement made above on the higher cost of production before embarking on the production of caustic soda based on salt electrolysis.

C. Chlorine

As was stated earlier, outlet for chlorine in the region is very limited at the current time. Excluding Algeria, Morocco and the United Arab Republic, with a combined production of about 20,000 tons per annum, production or, for that matter, consumption is not significant. This situation will continue as long as the chlorine-consuming industries are not developed on a relatively large scale.

The realization of the proposed chlorine-caustic plants (capacities of 19,000 tons for East Africa and 18,000 tons for West Africa), together with the Algerian planned expansion of 12,000 tons, may be expected to raise the current total capacity of approximately 29,000 tons to 80,000 tons in 1970. This capacity could be much higher, provided sulphuric acid could economically be replaced by hydrochloric acid in acidulating rock-phosphate.

D. Soda ash

Current consumption figures (even their order of magnitude) of soda ash in the region are not available. In addition to this paucity of information, the interchangeability of soda ash and caustic soda in many fields of application makes the estimation of soda ash consumption the more difficult. Presumably, the major consumer is the glass industry. Soda phosphate, soap, petroleum refining and textiles are among the others.

Economies of scale for a Solvay process are rather high, and this partly explains why there has not been a single Solvay plant in any of the subregions as yet.

[26] "Investigation on fertilizer and chemical industries in East Africa" (E/CN.14/INR/83).

Before or by 1970, both Morocco and the United Arab Republic expect to operate Solvay plants with installed capacities of 18,000 tons and 100,000 tons, respectively.

A relatively new development for soda ash production is the dual process. This is a modified Solvay process in which no limestone is used and ammonium chloride is produced as a co-product. This process is successfully used in China (Taiwan) and Japan where ammonium chloride has been found to be suitable as a fertilizer for rice. It may be adapted in Africa, provided a market is available for ammonium chloride.

The preceding paragraphs may have given the impression that the region depends entirely upon imported soda ash. This is not so. Soda ash from Lake Magadi in Kenya has been exploited for years. It reached a maximum production of 147,000 tons in 1961. As a result of the economic sanctions against South Africa, the largest buyer of Kenyan soda ash, exports and consequently, output of soda ash are on the decline. In all likelihood, the rising demand for soda ash in other African countries will, in the not too distant future, enable Kenya to revive and develop further the soda ash industry.

Although perhaps not as promising as that of Lake Magadi, Lake Chad in Chad is another known source of natural soda ash. Its current production is around 8,000 tons per annum. It would be advisable to investigate the feasibility of a large-scale exploitation of soda ash from this lake. The importance of this investigation for Chad and for the West African subregion cannot be over-emphasized.

E. Ammonia

This basic chemical is the starting point for the manufacture of nitrogen fertilizers and other nitrogen chemicals. At the current time the United Arab Republic is the only country in the subregions producing ammonia. Current capacity utilization is 83 per cent of the total installed capacity of 223,000 tons (see table 15). All of the output is used captively in the production of fertilizers.

A large expansion of this industry in the United Arab Republic is foreseen by 1970. Both Algeria and Libya are planning for large-scale ammonia projects modelled on that of Trinidad and Tobago, mainly for export purposes. According to ECA recommendations, both East and West Africa are expected to go ahead with the establishment of ammonia plants. The realization of all these plans, projects and recommendations will raise the current installed capacity by sevenfold, to 1,550,000 tons by about 1970.

With the exception of the existing Aswan ammonia unit based on water electrolysis in the United Arab Republic, ammonia plants in the region will possibly be based on natural-gas and petroleum feed-stocks. This is to say that the trend towards hydrocarbon feed-stocks will, in all probability, manifest itself in the ammonia plants to be built in the future in the region.

Within the last few years, capacities of ammonia-synthesis plants installed in developed countries have gone up beyond the limit that would be possible for the small demand in developing countries. Single-train units of 1,000 tons per day and over are becoming common. Due to cost advantages arising from such economies of scale, the developed and some developing countries are expected to lower the prices of ammonia. Further development of tanker transportation is another factor that may further reduce the price of ammonia.

This trend of falling prices may have an adverse effect in retarding, if not stopping, the establishment of ammonia plants in many developing countries. This will, in turn, deprive these countries of a number of industrial activities that could be induced by the presence of ammonia plants. Who knows what will happen next? New developments may result in widening the gap in the cost of production. What then? If a "wait and see" approach is adopted, no developing country may be able to manufacture this basic chemical.

Fortunately, small package ammonia plants with capacities ranging between 60 and 100 tons per day have been developed recently. These low-priced "turn-key" plants are currently being manufactured by some firms in the United States of America. These are, of course, not very good substitutes for large plants designed to serve a number of countries. In view of the declining trend of ammonia prices, it may, in the long run, pay to put up a few large ammonia plants than many small ones.

VI. Petrochemicals

A. Definition of petrochemicals

Organic chemicals may be defined as hydrocarbon chemicals and their derivatives, or as carbo-chemicals. They are derived from raw materials of hydrocarbon (petroleum, natural gas), coal and vegetable origins. Those originating from petroleum and natural gas are known as petrochemicals.

Aliphatics (paraffins and olefins) and aromatics are the basic intermediates for the petrochemical industry, and ethylene, acetylene, butadiene and benzene among the most important intermediates. Some of the organic chemicals, aromatics in particular, used to be made and are still being made in some countries as by-products of cokeries, (coal-tar industry) and from raw materials of vegetable origin.

Petrochemicals may be broadly classified into the following categories: (*a*) ammonia and nitrogen fertilizers; (*b*) plastics; (*c*) synthetic fibres; (*d*) synthetic rubbers; and (*e*) others, including benzene, toluene, detergents, insecticides, solvents, acetone, carbon black, sulphur etc.

B. Importance of petrochemicals

The scope of the petrochemical field is extensive and is expanding from day to day. New products are being put in the market, and new uses found for the old ones. Such traditional materials as natural rubber, natural fibres, soap, paper, wood, aluminium and steel have been, and are still being replaced by petrochemicals in many fields of application. In short, the petrochemical industry is a strategic industry which, by its nature, induces further economic development.

Basic organic chemicals are increasingly being manufactured from products of petroleum and natural-gas

Table 1. Classification of building materials and components[a]

Broad grouping	SITC No.[a]	Major materials, mainly according to relative importance within the group	Remarks
A. Stone quarrying	273	Sand and gravel, aggregates, stone	Clay mining for brick and other clay products manufactures included under B
B. Non-metallic mineral building materials	661, 662, 664	Cement, clay products (bricks, blocks, clay pipes, tiles, etc.), asbestos-cement products, cement products including pipes, prefabricated units etc., flat-glass products	
C. Wood-based building products	631, 632, 641.6	Sawnwood, plywood, board products, poles	
D. Metal building materials and components	673, 674, 675, 676, 677, 678, 682-687, 691	Iron and steel products (bars, rods, light and heavy sections, sheets and plates, tubes and pipes), non-ferrous metal products (aluminium sheets and window frames, tin sheets, lead and copper pipes etc.); finished structural parts of all metals	Does not include heating, lighting and plumbing fixtures
E. Building fittings and fixtures	812	Heating fixtures, sanitary wares in all materials, fittings and fixtures in all metals, lighting fixtures and fittings	Excluding electrical installation materials
F. Electrical installation materials	723	Insulated wire and cable, electrical insulating equipment, including conduits	
G. Miscellaneous materials	521.1, 533.3, 581	Paints and varnishes, mineral tar, plastic sheets and pipes	

SOURCE: United Nations *Standard International Trade Classification, Revised* (United Nations publication, Sales No.: 61.XVII.6).

[a] Standard International Trade Classification.

The report also makes reference to "secondary materials" and "new materials", but this is done in a superficial and admittedly inadequate manner. With regard to secondary materials, which include walling, drainage and sanitary materials of clay products, and joinery, roofing and sanitary materials of metals (notably steel and aluminium), the report is aimed at identifying the important roles they play in the diversification of building materials production and the improvement of quality and efficiency, as well as at stressing their special relevance under given technical conditions or given availability of resources and profitable productions. The scope for the introduction of such new materials as plastics, pressed-wood products and the by-products of chemical and other industries is also briefly discussed with the purpose of attaining the same results as were mentioned for secondary materials.

A further limitation on the scope and coverage of the report is imposed by the inadequacies of industrial statistical data in Africa. This limitation is not, however, experienced in the case of the basic materials (cement, timber and iron and steel products), in general. In the case of other building materials, adequate statistical series are not, by and large, available—a situation which limits seriously the proper and satisfactory coverage of these materials in a report of this kind. A typical example of these are production data for stone quarries and sand-pits. Very few countries in Africa report such productions. In other instances, the practice of reporting import statistics by values only (e.g., building fittings and fixtures, electrical distribution materials etc.) makes the assessment of the demand for these materials a difficult task. The report, however, largely avoids such issues and, on the whole, attempts to concentrate the analysis of the current situation on official and readily available statistical data.

II. The broad outlines of the problem

The building materials industry is an important first step towards industrialization. Yet, its stage of development in Africa is far from satisfactory. In the early 1960's, the shortfall in supply for the continent as a whole was made up by imports of the order of 50-60 per cent of the value of total consumption. This figure was, moreover, considerably higher in most subregions[2] and for the majority of individual countries. Observation of long-term trends further indicates that the situation has not improved appreciably from that in past years.

[2] In the present report, the following subregional groupings of countries are used: *North Africa:* Algeria, Libya, Morocco, Sudan, Tunisia, United Arab Republic; *West Africa:* Dahomey, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta; *Central Africa:* Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Democratic Republic of), Gabon; *East Africa:* Burundi, Comoro, Ethiopia, French Somaliland, Kenya, Madagascar, Malawi, Mozambique, Reunion, Seychelles, Somalia, Southern Rhodesia, Uganda, United Republic of Tanzania, Zambia; *Southern Africa:* Basutoland, Bechuanaland, South Africa, South West Africa and Swaziland.

origin. In Western Europe, basic organic chemicals (petrochemicals) obtained from petroleum and natural gas accounted for 58 per cent and those from coal for 39 per cent in 1962. It is in the United States of America, however, that the shift from coal and other sources to petroleum and natural-gas raw materials has been spectacular. The 1962 share (58 per cent) in Western Europe was attained in 1950 in the United States of America. This rose to 85 per cent in 1960 and 93 per cent in 1962. In terms of the percentage of total chemical production in the United States of America, the share of petrochemicals increased from 5 in 1935 to 20 in 1950 and 32 in 1960. In 1970 it is expected to reach 50.[27]

C. Possibilities for petrochemical industries in the region

In spite of the problems involved in establishing petrochemical plants in developing countries, some of these countries (with raw-material resources), realizing the increasingly important role of the petrochemical industry in economic development, have embarked on the development of this sector. Recent experiences, that of Trinidad and Tobago, for example, have shown the tendency for petrochemical (mainly intermediate) plants to be located near the source of raw material. It appears that the majority of the few petrochemical projects that are being planned or considered by some African countries are to be modelled on that of Trinidad and Tobago.

Of the sixty-one petrochemical plants reported for the developing countries in 1963, only one was being put up in Africa. The situation with projects in the same year was no better, the African share being four out of seventy.[28]

From tables 12 (p. 90) and 16 (given below), it appears that the number of plants and projects reported above for Africa were on the low side. The number of existing plants should have been more than three. Assuming all studies and recommendations under consideration as projects, the number of projects comes to about five or more.[29] As may be expected most of these plants and projects are for the production of ammonia and its derivatives.

[27] Organisation for Economic Co-operation and Development, *The Chemical Industry* (Paris, 1963); and A. L. Waddams, *Chemicals from Petroleum* (Shell Chemical Co. Ltd., 1962).

[28] United Nations, "General characteristics of petrochemical industries and factors conditioning their development", *Studies in Petrochemicals*, presented at the United Nations Inter-regional Conference on the Development of the Petrochemical Industries in Developing Countries (United Nations publication, Sales No.: 67.II.B.2), vol. I, chapter I, paper 1.

[29] Excluding plants and projects in South Africa.

Table 16. Petrochemical complexes in Algeria and United Arab Republic[a]

	Year of est.	*Location*	*Product*	*Capacity*	*Remarks*
Algeria					
Complexe Petro-chimique (preliminary study)		Arzew	Ammonia[b]	200,000	From natural gas
			Methanol[b]	66,000	
			Acetylene	9,000	
			PVC[b]	20,000	
		Alger	Propylene	30,000	From cracking 200,000 tons of naphtha from refinery at Algiers
			C_4 Cut[b]	20,000	
			Polypropylene or	27,000	
			Acrilonitrile[b]	12,600	
			Polypropylene[b] or	18,000	
			Polyethylene or	19,500	
			Ethylene-propylene	20,000	
		Gué de Constantine	Calcium ammonium nitrate[b] or	100,000	26 per cent N
			Ammonium sulphate-nitrate or	100,000	26 per cent N
			NPK complex	150,000	
United Arab Republic					
Petrochemical Complex at Alexandria (Project prepared by SNAM for the General Organization for Executing the Five-Year Industrial Plan, Jan. 1965)	1969		Polyethylene	15,000	From steam cracking of light naphtha
			PVC	20,000	
			Phenol	6,000	
			Acrylonitrile	5,000	For polyacrylonitrile
			Caprolactam	4,000	Fibres for nylon 6
			Polybutadiene	12,000	For synthetic rubber
			Calcium ammonium nitrate	200,000	20.5 per cent N
			Methyl alcohol	10,000	For formaldehyde

[a] Excluding nitrogen fertilizers.
[b] Recommended for first-stage production.

As most of the relevant information on the individual plants and projects is given in the tables mentioned above, it may not be necessary to discuss each one of them. A few words may not, however, be out of place with regard to some of them.

The petrochemical projects under consideration in Algeria are to be geared to develop stage by stage. They are expected to begin producing mainly basic intermediates — ammonia, methanal, C_4 — cut and polypropylene — for exportation. Further processing to polyvinylchloride (PVC), nitrogen fertilizers and possibly acrilonitrile for local consumption is envisaged. The latest available information concerning these projects is that the United Nations Special Fund has committed itself to contribute $835,000 for a further study of the projects.[30]

Unlike the projects in Algeria, that in the United Arab Republic appears to be based mainly on satisfying local demand. In other words, the latter project (which is the most advanced) has as its goal carrying the processing further so as to produce more consumer products, as is shown in table 16.

The Libyan project, for which plans have been submitted by international oil companies, consists of provisions for the liquefaction of associated gas and ammonia synthesis for export. Information on the ammonia capacity recommended by these companies has not been made public, although a capacity of about 330,000 tons has been reported by a different source.

Complexes reported to be under construction in both Morocco and Tunisia are relatively simple, compared with those of Algeria and the United Arab Republic.[31] Their end-products are nitrogen fertilizers, partly for domestic consumption and partly for exportation.

In accordance with ECA recommendations, Nigeria, Southern Rhodesia and Kenya or Uganda may be expected to go ahead with nitrogen fertilizer projects.

In addition to the nitrogen fertilizer industries for East and West Africa, ECA studies have made proposals for other petrochemicals: PVC, polyethylene, DDT and BHC. The 1970 probable situations of PVC and polyethylene in the region have been summarized in table 17.[32] According to this table, total regional capacities of 50,000 tons of PVC and 35,000 tons of polyethylene may be expected in the early 1970's. The latter two, DDT and BHC, have already been discussed in the section on pesticides.

Finally, it is worth mentioning here that some organic chemicals are recovered as by-products of coke-ovens. Benzol, toluol, naphtha, naphthalene, tar and pitch are, for example, produced in Southern Rhodesia, and benzol, toluene, xylene, phenol, ammonium sulphate and coal-tar in the United Arab Republic.

[30] *Marchés Tropicaux et Méditerranéens* (11 September 1965).

[31] The Safi complex in Morocco is to obtain its ammonia requirement from the Arzew plant in Algeria.

[32] Figures for East Africa are considered to be on the low side.

Table 17. Current and probable production and consumption by 1970 of polyvinyl chloride[a] and polyethilene on a subregional basis

(*Tons*)

	Current			*1970*		
	Consumption	*Production*	*Capacity*	*Estimated demand*	*Capacity envisaged*	*Remarks*
***Polyvinyl chloride*[a]**						
North Africa			—		40,000	Algeria and United Arab Republic
East Africa	3,280	—	—	6,800	7,000	60% PVC
Central Africa		—				
West Africa	5,800	—		9,000	9,000	60% PVC
Polyethylene						
North Africa					15,000	United Arab Republic only
East Africa	3,500			10,700	20,000	1973 1974 capacity
Central Africa						
West Africa	3,800		—	8,000		

[a] PVC

VII. Other chemicals

This section deals with some individual chemicals and chemical products not included in the preceding sections. These have been selected from a huge number of chemicals that are consumed in Africa. Their current and future market sizes or their importance in and impact on the development of the economy as a whole, or their role in import substitution or the advantages that give rise to integration are some of the criteria used in their selection. As some of them are heavily dependent upon basic chemicals as raw materials or supplies, their development, like that of the fertilizer industry, is a major factor in promoting the basic-chemical industry. With these basic concepts as background, brief discussions on the following are presented herewith.

A. Industrial explosives

The mining industry is the leading consumer of industrial explosives in Africa. Zambia, for example, with the largest mining activities in the East African subregion, accounted for 70 per cent of 1964 imports into the subregion. Most of the remaining imports (26 per cent), went to Southern Rhodesia, another country with a well-developed mining industry. In the Central African subregion, the Democratic Republic of the Congo, the leading country in mining activities, imported 1,362 tons in 1962 and produced 4,604 tons in 1963, indicating a consumption of the order of magnitude of 6,000 tons. In general, this situation is applicable to the other subregions.

Quarrying and construction of roads, railroads, dams and buildings are other sectors of industry requiring industrial explosives. These and the mining industry practically account for almost all of the industrial explosives consumed in Africa. Because of lack of information on some subregions, the magnitude of this consumption is not known for the entire region. It is expected that demand in East Africa will increase from 21,300 tons in 1964 to 28,400 tons in 1970 and that of West Africa from 7,300 tons to 10,300 tons.

The breakdown of industrial explosives according to type is virtually impossible. In West Africa, dynamite is the most important type and is said to represent about 90 per cent of imports. In East Africa, the oil-bound ammonium nitrate explosive is replacing conventional explosives and is expected to substitute for them to the extent of 55 per cent. This would mean that 55 per cent of the 1970 requirement for explosives (15,000 tons) will be met by oil-bound ammonium nitrate. Assuming that the same conversion factor will apply to West Africa as well, the oil-bound ammonium nitrate explosive requirement for West Africa could come to 5,700 tons in 1970.

Preparing an oil-bound ammonium nitrate explosive involves relatively simple processes. Its manufacturing facilities may be integrated with an ammonium nitrate plant and this is what has been proposed for West Africa. It is assumed that this explosive can be produced most economically in the nitrogen complex recommended in Nigeria.

As for East Africa, there is already a plant in operation in Zambia. This plant is currently obtaining its ammonium nitrate from outside the subregion. Its capacity is 1,000 tons per month, almost 80 per cent of the 1970 expected total consumption of this explosive in the subregion.[33]

B. Viscose rayon

According to *Industrial Growth in Africa*,[34] consumption of rayon in the region increased from 171 million square yards in 1948 to 820 million in 1955 and 942 million in 1960. Demand for rayon in 1970 has been estimated by the same source to be in the neighbourhood of 1,521 million square yards. This is equivalent to 167,000 tons. Using a 1960 distribution pattern, 1970 consumption, by subregions, may look like that shown in the last column of table 18.

[33] The possibilities for the manufacture of accessories, such as fuses and detonators, should be investigated when considering projects for industrial explosives.

[34] United Nations publication, Sales No.: 63.II.K.3.

Table 18. Rayon market in 1960 and forecast for 1970, by African subregion

Subregion	1960 consumption: Millions of square yards	1960 consumption: Tons	1960 consumption: Percentage	1970 demand: Millions of square yards	1970 demand: Total tons	1970 demand: Viscose rayon tons
North Africa	280	30,500	29.3	445	49,000	38,000
East Africa	174	18,900	18.2	276	30,400	24,000
Central Africa	36	3,920	3.8	58	6,350	5,000
West Africa	179	19,500	18.7	285	31,250	24,000
Other countries	287	31,200	30.0	457	50,000	39,000
TOTAL	956	103,020	100.0	1,521	167,000	130,000

As shown in table 18, with the exception of Central Africa, the 1960 level of subregional consumption is high enough to justify one or more rayon plants in each subregion. It would, however, be necessary, if possible, to examine the types of rayon products marketed in Africa before arriving at any definite conclusion. The only indication available so far is that concerning East Africa. Rayon consumption in East Africa is made up of two-thirds continuous filament and one-third discontinuous filament (staple fibre). The major part of the former is in the form of fabric and other finished products. As it will probably not prove economical to produce all varieties of rayon types and goods in the market within the foreseeable future, it does not appear advisable to aim at satisfying demand to the extent of 100 per cent from local production. Assuming 10 per cent of the rayon to represent acetate and cuprammonium and a 13 per cent allowance for viscose rayon goods that may not be available from local factories, 77 per cent of the 1970 estimated consumption may be met from local production of 130,000 tons of viscose rayon. In terms of new capacity, this is about 120,000 tons.

Partly because of the complex nature of the processing technique and the voluminous and varied inputs involved, the viscose rayon industry has not yet established itself in the region. The only output recorded in the 1964 issue of the *Statistical Yearbook*[35] is that of the United Arab Republic, which in 1963 produced 6,500 tons of continuous filament and 4,900 tons of discontinuous filament.

The viscose rayon industry is a major consumer of the two most important basic chemicals: sulphuric acid and caustic soda. In terms of 100 per cent concentration, about 1.3 tons of sulphuric acid and 0.7 ton of caustic soda are required to make 1 ton of viscose rayon. If the total new capacity of viscose rayon is to be realized, the sulphuric acid and caustic soda requirements would amount to 160,000 and 85,000 tons, respectively. It is, therefore, clear that this industry

[35] United Nations publication, Sales No. 65.XVII.1.

depends heavily upon the local availability of these chemicals. In other words, it is an industry which promotes the development of the basic chemical industry.

The other major inputs are carbon disulphide and cellulosic materials (wood-pulp or cotton linters if available in sufficient quantity and at reasonable price). The former can be made locally using charcoal and imported surplus. As regards the cellulosic material, the region has not yet developed conditions for the continuous supply of suitable qualities for the production of dissolving pulp. Until such time, the viscose rayon industries in Africa will have to be based on imported pulp. In developing a local supply of dissolving pulp, account should be taken of the desirability of integrating pulp projects to supply both the pulp and paper and the viscose rayon industries. This idea of integration, which is practised in developed countries, should be brought to the attention of those working on pulp and paper projects.

C. Calcium carbide

Calcium carbide is an intermediate compound for the production of acetylene, which is mainly used as fuel in cutting and welding, and in manufacturing PVC. In Africa, the latter field of application is non-existent at the current time, at least in the four subregions considered here. As PVC is increasingly being derived from petrochemical feed-stocks, the utilization of calcium carbide as a raw material for PVC production may not be expected to develop appreciably.

From the preceding paragraph, it seems that calcium carbide is mostly, if not entirely, used to produce acetylene for cutting and welding purposes in industrial establishments and construction works.[36] Its role in this field of application may be expected to continue and grow for the following reasons. First, it is more convenient to transport calcium carbide than acetylene, say, obtained as a petrochemical. Secondly, almost every country in Africa has one or more acetylene plants based on calcium carbide. It is clear that these plants will have to be supplied with calcium carbide. Both of these facts then indicate the need for calcium carbide plants in the region.

Information on calcium carbide consumption is scanty. Current East African consumption has been estimated to be over 2,200 tons and is expected to increase to 3,500 tons in 1970. In 1964 West African consumption was in the neighbourhood of 5,500 tons. This is estimated to increase to 7,500 tons in 1970. The situation in the other subregions and countries is not known except, that the United Arab Republic is excepted to put into operation a 5,000-ton plant i 1966. This plant will be expanded to 7,000 tons, which is the expected consumption in 1970. In view of the more rapid development that is to be expected in industrialization and construction works, however, the consumption of calcium carbide will surely increase substantially in the r ion.

D. Aluminium sulphate

Aluminium sulphate is mainly used in paper sizing and water purification. At this stage, the latter field of application is the more important, at least in most countries in Africa. Here again, some partial information is available on East and West Africa only. It has been estimated that in 1970, the East African demand for water purification will be about 6,300 tons and that of West Africa, 10,000 tons.

At the current time, East Africa appears to be the only subregion producing aluminium sulphate. The aluminium sulphate unit is an integral part of the RODIA phosphate fertilizer plant in Salisbury, Southern Rhodesia. Its capacity of 7,000 tons per annum is currently being utilized to the extent of 70 per cent. As an aluminium sulphate producing facility can readily be incorporated with a sulphuric acid unit in a country with a source of bauxite, it is possible for each subregion to establish one or more units. Because of the project for an 18,000-ton unit in the United Arab Republic, which is planned to begin operation within the 1965-1970 period, the North African subregion will, in all likelihood, be the first among the remaining subregions to produce this chemical. As ferric chloride from a plant with a capacity of 4,500 tons is being used for water treatment in the United Arab Republic, aluminium sulphate units have been envisaged to meet the requirement of the paper industry mainly.

E. Sodium xanthate

Sodium xanthate is used as a floatation agent in the treatment of non-ferrous metal ores, and its application is limited to Zambia and, to some extent, Southern Rhodesia. Current demand for it is in the neighbourhood of 2,000 tons per annum. As no major increase is expected in the future, a capacity equal to the current consumption has been recommended.

As carbon disulphide is a raw material for the production of sodium xanthate and as a production unit of the former is part of the viscose rayon industry, the incorporation of, the xanthate manufacturing unit with the viscose rayon industry could prove to be advantageous. This is actually what has been recommended.

F. Tanning materials

Demand for both vegetable and chrome tanning materials will increase substantially with the increasing local tanning and processing of hides and skins, which are currently being exported in large quantities. Wattle bark and extract are export items of the East African subregion, the exports of the latter amounting to 36,000 tons in 1961. In North Africa growing of the wattle tree does not appear to have met with success.

Another tannin-yielding tree of significance to the region is mangrove. It occurs in both the eastern and western coastal areas. In the former area, Madagascar and the United Republic of Tanzania in particular, tanbark has been exploited for years. Because of it lower average tannin content, considerably below 30 per cent, the exportation of mangrove bark extract from the latter area is said to be not as promising as that from the eastern area, with a tannin content well above 30 per cent.[37]

Sant pods and tizra are other vegetable tanning materials of significance in the region. The well-known

[36] In such countries as Nigeria, calcium carbide is also used as an agricultural spray. The continuation of its use is, however, doubtful.

[37] F. N. Howes, *Vegetable Tanning Materials* (London, Butterworths Scientific Publications, 1953).

Kano and Moroccan leathers are the results of tanning with the former and the latter, respectively.

Because of the change in tanning technique resulting from a better understanding of the tanning process, it is currently possible to utilize a vegetable tanning material to produce the same type of leather as that of another. Another method of getting the desired quality of leather is to blend tanning extracts from different sources. Wattle, in particular, lends itself to this technique. Wattle extract, when mixed with the right kind and quantity of other extracts, may be made to give the desired result.

In view of the good prospect for the development of the vegetable tanning industry, those countries which are well placed with respect to raw-material resources should take steps to supply the growing demand for tanning materials. The development of a few types may satisfy the major part of the demand.

As regards chrome tanning agents, the East African demand in 1970 was not found to be sufficient to justify an economic unit. This is undoubtedly the case in, at least, Central and West Africa. This industry could be feasible, provided it is planned to supply the demand for both the tanning and pigment industries for more than one subregion. Countries like Southern Rhodesia have most of the material resources for this industry.

Sodium silicate and sodium sulphate are of interest among the remaining chemicals. Sodium silicate which is used in adhesives, detergents, sizing, etc., is being manufactured in some countries, that is, Kenya, Senegal, Southern Rhodesia and the United Republic of Tanzania. It is reported that Morocco has a project for a plant to produce 5,000 tons per annum. As the process for sodium silicate is quite simple and as the demand for it may be expected to increase, the appearance of more plants in the continent could be envisaged.

Sodium sulphate is put to a number of uses, of which the kraft pulp industry is by far the major consumer. Synthetic detergents and glass are among the other consumers. At the current time, this pattern does not apply to Africa. At any rate, although current demand is unknown and possibly small, its future demand could be substantial. It may be possible to satisfy this demand from by-product sodium sulphate from the spin-baths of the viscose rayon plants that may be established.

VIII. Recommendations

The chemical industry is a capital-intensive industry characterized by high economies of scale and obsolescence. These characteristics, together with the limited size of the market, render the development of the chemical industry on a country level impossible for at least many years to come. This unfavourable situation may be improved provided the market is enlarged, thereby ensuring the benefits to be derived from economies of scale of relatively larger integrated chemical complexes. Therefore, the subregional or regional approach is of special significance to the development of the chemical industry in the region. It cannot be over-emphasized that the realization of this approach is a basic prerequisite to the successful development of the chemical industry in Africa.

On the assumption that this approach is acceptable, additional recommendations which are of importance for the accelerated and successful development of the chemical industry in the region are put forward.

1. *Investigation of the availability and possible utilization of certain raw materials*

(*a*) Sulphur and pyrites;

(*b*) Soda ash (from Lake Chad).

2. *Consideration of alternative processes of production*

(*a*) Use of gypsum (natural or by-product) for the production of sulphuric acid and ammonium sulphate;

(*b*) Substitution of hydrochloric acid for sulphuric acid in the acidulation of rock-phosphate;

(*c*) Other processes for maximizing economic disposal of chlorine;

(*d*) Causticization of natural soda ash from lakes Magadi and Chad;

(*e*) Adoption of the dual process for soda ash production.

3. *Training and applied research*

(*a*) Beginning immediately to prepare and train chemical industry personnel;

(*b*) Creation of chemical engineering departments in some universities and polytechnic institutes and the strengthening of existing ones;

(*c*) Establishment of applied research and development centres combining both research and training.

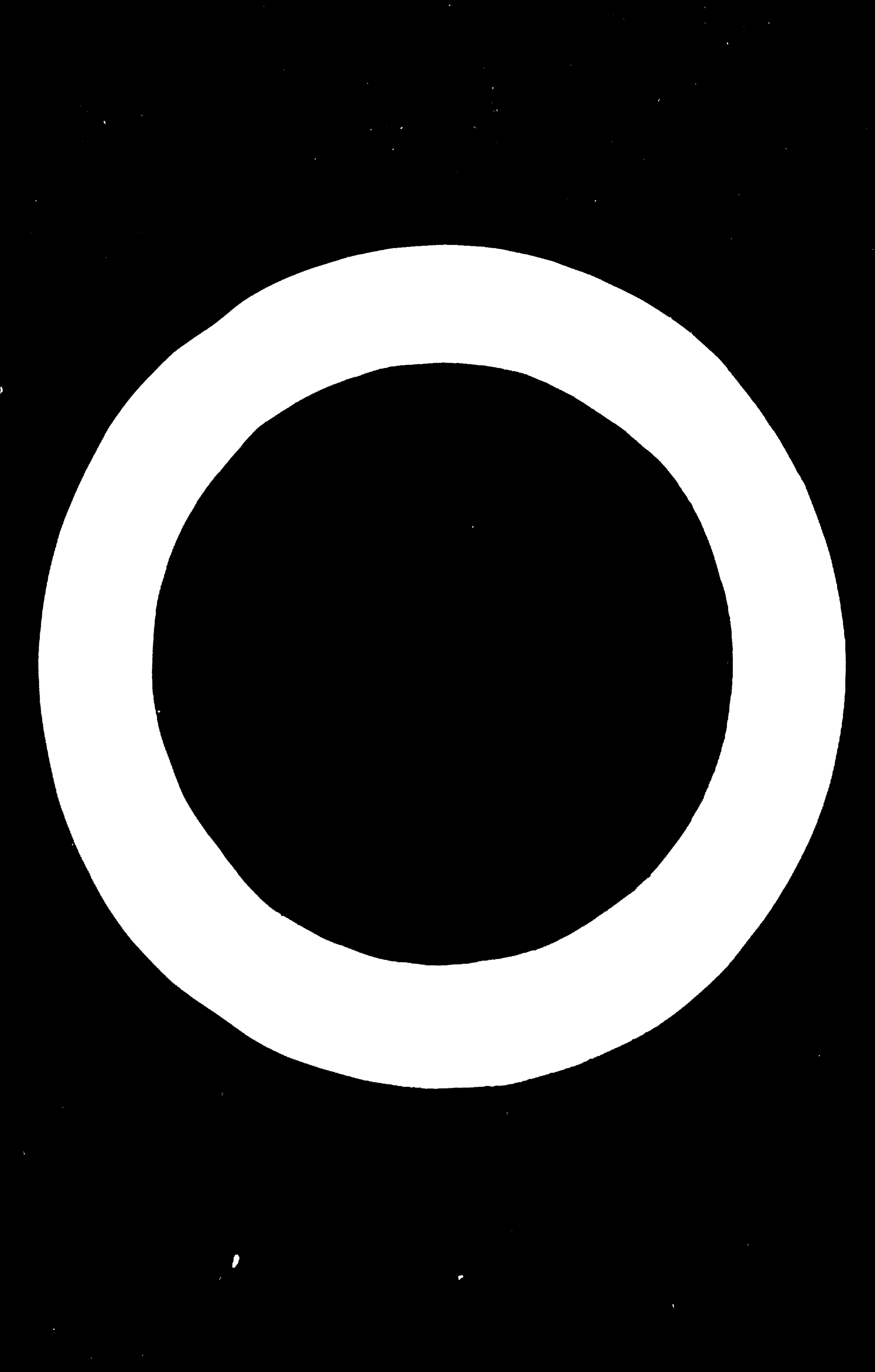
4. *Miscellaneous*

(*a*) Adoption of common means of statistical recording and presentation, that is, the Standard International Trade Classification (SITC) for import-export commodities and the International Standard Industrial Classification (ISIC) with details provided by SITC for industrial production;

(*b*) Decisive actions on the part of Governments to promote use of fertilizers and pesticides;

(*c*) Choice of ammonia capacities larger than small "turn-key" plants;

(*d*) Acceleration of the development of transportation.



5. THE IRON AND STEEL INDUSTRY IN AFRICA

Secretariat of the United Nations Economic Commission for Africa

CONTENTS

Introduction

The present report consists of four chapters. The first deals with the past, current and prospective consumption of iron and steel in Africa and the extent to which it has been supplied thus far from the domestic iron and steel industry. The second chapter is concerned with the availability of raw materials and fuel for the expansion of iron and steel production, and the third chapter deals with the economics of the industry, including economies of scale, transport costs and prices. The last chapter deals with the future development of the industry based on the analysis of the preceding three chapters and on the discussions which have been taking place during the last two years on industrial co-ordination in Africa.

I. Consumption of iron and steel

The following table shows the consumption of iron and steel products in the various subregions of Africa during the last eleven years.[1]

Table 1. Africa: Consumption of iron and steel[a], 1953-1963

(Thousands of tons)

	North Africa	*West Africa*	*Central Africa*	*East Africa*	*Southern Africa*
1953	450	220	180	170	1,100
1954	560	230	190	240	1,390
1955	670	250	230	350	1,510
1956	680	250	230	350	1,550
1957	620	320	240	370	1,760
1958	820	310	150	320	1,650
1959	920	370	130	290	1,300
1960	1,130	360	90	380	1,620
1961	1,100	450	110	420	1,810
1962	1,050	500	110	430	1,770
1963	1,070	530	140	430	1,980

[a] Finished steel, including a small quantity of iron products, mainly cast iron pipes.

Average annual consumption during the period 1961-1963 in the North African subregion amounted to just over 1 million tons, with the United Arab Republic accounting for 420,000 tons. Domestic supplies during this period averaged 300,000 tons from plants in Algeria and the United Arab Republic. In the West African subregion, average annual consumption during the same period amounted to 500,000 tons, of which only 10,000 tons came from domestic sources, namely a scrap-melting plant in Nigeria. Annual consumption in the East African subregion averaged 440,000 tons, of which Rhodesia accounted for 170,000 tons. Domestic supplies came from integrated works in Rhodesia (50,000 tons) and from scrap-melting plants in Ethiopia and Uganda (15,000 tons). Average annual consumption in the Central African subregion was 120,000 tons, of which the Democratic Republic of the Congo accounted for about half. Domestic supplies amounting to about 10,000 tons came from a scrap-melting plant in the Democratic Republic of the Congo. Southern Africa is the largest steel-consuming subregion, with consumption averaging about 1,850,000 tons in the period 1961-1963. Imports amounted to only 130,000 tons, with the South African steel works producing 1,990,000 tons and exporting 270,000 tons.

Iron and steel consumption in Africa, excluding Southern Africa, increased from 1953 to 1963 at an average rate of 7 per cent per annum. In the Central

[1] The following subregional groupings apply in the present paper: *North Africa*: Algeria, Libya, Morocco, Sudan, Tunisia, United Arab Republic; *West Africa*: Dahomey, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta; *Central Africa*: Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Democratic Republic of), Gabon; *East Africa*: Burundi, Comoro, Ethiopia, French Somaliland, Kenya, Madagascar, Malawi, Mozambique, Reunion, Seychelles, Somalia, Southern Rhodesia, Uganda, United Republic of Tanzania, Zambia; *Southern Africa*: Basutoland, Bechuanaland, South Africa, South West Africa, Swaziland.

African subregion consumption declined, while in West Africa it increased by 9 per cent per annum.

Under conditions of steady expansion, it may be expected that iron and steel consumption in any developing country will increase more rapidly than the gross domestic product because the subsistence sector, which makes a substantial contribution to the economy of such a country, uses little steel, so that the increase in gross domestic product coming from an expansion of the monetary sector will bring a more than proportional increase in steel consumption. Moreover, at the initial stages of expansion, there is a tendency for highly steel-intensive activities, such as railway construction, to be embarked upon. A regression line fitted to the figures of steel consumption *per capita* and gross domestic product *per capita* in 1959-1961 for all the African countries suggests, in fact, that for an increase of 1 per cent in gross domestic product *per capita*, steel consumption at the current stage of development increases by 1.7 per cent. Corresponding, therefore, to an increase of 8 per cent in gross domestic product, i.e., 2 per cent increase in population and 6 per cent in income *per capita*, which is the minimum rate of growth in Africa suggested by the United Nations, the increase in steel consumption would be 7.1 per cent. Similarly, an increase in gross domestic product of 6 per cent per annum would give an 8.8 per cent increase in steel consumption.

Detailed estimates of future demands for steel have been made for African countries.[3] Total steel demand, including both direct and indirect demand, is expected to increase by about 7 per cent per annum, and after allowing for the substitution of imports of engineering goods by domestic products, direct steel demand is expected to increase by 8 per cent per annum (excluding rails, by 9 per cent per annum). Alternative estimates for East Africa, using the given projected increases in gross domestic product, suggest an increase in total steel consumption of 6.2 per cent per annum, i.e., slightly less than that given above.[4] This lower rate of total growth is offset, however, as far as direct steel consumption is concerned, by a higher rate of import substitution, it being estimated that the domestic engineering industry can be expanded by 1980 to supply one half of domestic needs, whereas in the first document mentioned above it is estimated that this industry will supply about one third. According to another source, this higher rate of import substitution will result in a rate of increase of direct steel consumption of 8.9 per cent per annum.[5]

As a working rule, therefore, it would appear that under conditions of steady expansion the consumption of iron and steel in African countries is likely to increase at an annual rate of between 8 and 9 per cent. Within this general framework, consumption of certain products, such as railways and galvanized sheet, is expected to increase only slightly because of competition from other means of transport and other materials, respectively, while, on the other hand, that of cold reduced sheet is expected to increase by about half as much again as that of steel generally, because of its use by the expanding engineering industries. The following table shows the consumption figures which have been projected for the various subregions.

[2] For the general relationship between steel consumption and gross domestic product, see annex.

[3] United Nations Economic Commission for Africa, "The development of the iron and steel industry in Africa" (E/CN.14/INR/27). In this document, the subsistence sector is ignored throughout the calculations and the elasticity of steel demand in the monetary sector is taken as unity.

[4] United Nations Economic Commission for Africa, "The development of the engineering industries in East Africa — mechanical engineering" (E/CN.14/INR/90), paper prepared for the Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October - 6 November 1965.

[5] W. S. Atkins and Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the United Nations Economic Commission for Africa Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October — 6 November 1965.

Table 2. Projected steel consumption

(Thousands of tons)

	North Africa		*West Africa*[a]		*Central Africa*[b]		*East Africa*	
	1970	*1980*	*1970*	*1980*	*1970*	*1980*	*1970*	*1980*
Rails	100	150	140	180	30	40		
Bar rod and sections	1,000	2,250	390	990	130	310	340	820
Plate and sheet	600	1,800	300	750	150	400	330	690
Tubes	300	670	100	230	30	80	10	20[a]
TOTAL	2,000	4,520	930	2,150	340	830	680	1,530

SOURCES: For West Africa: United Nations Economic Commission for Africa, "Summary of iron and steel investigation in West Africa" (E/CN.14/IS/3), paper prepared for the West African Meeting on Iron and Steel, Monrovia, 2-7 August 1965; for Central Africa: United Nations, *Report of the ECA Mission on Economic Co-operation in Central Africa* (United Nations publication, Sales No.: 66.II.K.2); for East Africa: W. S. Atkins and Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the ECA Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October - 6 November 1965.

[a] Seamless only.

[b] Including welded tube.

29. 9. 71

The smallness of the African market and the absence or inadequacy of the appropriate resources do not, on the whole, seem to have been the factors mainly responsible for the current state of under-development of the industry. In pre-independence Africa, policy decisions in general favoured the exportation of raw-material resources from Africa and the importation of the finished products. Transport and communication networks were set up to facilitate such a trade flow. Consequently, while a relatively efficient system was put into operation between resources centres in Africa and the rest of the world, that which could have assisted the development of inter-African trade did not materialize to a satisfactory level. This, in itself, created a vicious circle, for it could not link the individual small markets into markets large enough to justify the setting-up of local industries.

The little development that took place was mainly in connexion with those materials whose local production is inevitable. Primary bulk materials, such as walling bricks, concrete blocks, sand and aggregates, evidently do not lend themselves to long-distance haulage, and their production locations are essentially governed by their proximities to the locations of their respective resources and markets. It will be noted (see annex, map 1) that the production of these materials is widespread in all the countries of Africa. Nevertheless, the production processes in the majority of countries are still of rudimentary character. Inferior quality of materials, low productivity and seasonal productions from small artisan groups or inefficient semi-mechanized units are the predominant characteristics of these activities.

At a later period, and especially in the early 1950's the development of the building materials industry would appear to have taken a more hopeful and encouraging character in a number of countries, especially in the North and East African subregions, and, to a lesser extent, in the West and Central African subregions. Primary transformation processes of raw-material resources were begun in several countries. Consequently, the sawmilling industry was expanded and, to a limited extent, the production also of primary metals, such as copper, crude steel, aluminium, tin, lead etc. These developments appear to have favourably influenced the building materials industry, for they were followed by the setting-up of a number of factories to produce finished building material products, such as plywood mills, steel re-rolling mills, metal joinery, metal-sheet corrugating plants, nail and paint factories etc.

These achievements did not, however, change appreciably the over-all continental supply structure, for they were limited to very few countries. The current supply pattern of Africa is summarized below in table 2. It will be noted that imports represent about 55 per cent of the total value of building materials consumed in the continent, excluding Southern Africa.[3] Additional analysis would further demonstrate the considerable contrasts between subregions and between countries concerning their relative dependency upon imports. The majority of countries, in fact, rely upon imports for as much as 60-70 per cent of their domestic requirements.

There have, nevertheless, been some notable developments. For example, the cement industry has made considerable headway in that less than 25 per cent of total requirements are currently imported. The West African subregion is, in fact, the only area where a serious lag in domestic production still persists. Several of the subregions are also more or less self-sufficient in their timber requirements. It is the considerable consumption level of the wood-deficient countries of the North African subregion which has raised the average African share of imports of these products to nearly 50 per cent of total domestic consumption.

Table 2. African supply pattern of building materials and components, value estimates, 1963[a]

(Thousand million dollars)

Building materials	*Domestic production consumed locally*	*Imports*	*Hence domestic consumption*	*Imports as percentage of domestic consumption*
TOTAL	0.64	0.69	1.33	55
Cement	0.20	0.06	0.26	23
Asbestos-cement Other concrete products Clay products Flat glass	0.14	0.06	0.20	30
Timber products	0.14	0.13	0.27	48
Iron and steel products	0.14	0.33	0.47	70
Building fittings and fixtures		0.05	0.05	100
Electrical installation mats		0.03	0.03	100
Paints and varnishes	0.02	0.03	0.05	60

[a] Excluding Southern Africa.

With regard to iron and steel products, however, African countries depend almost entirely upon imports. The exceptions to the supply pattern are South Africa, Southern Rhodesia, Tunisia and the United Arab Republic, which operate iron and steel complexes and are largely self-sufficient, as well as a few countries which have established small but, nevertheless, significant steel re-rolling mills (notably Algeria, Ethiopia, Ghana and Uganda). In Africa, excluding Southern Africa, iron and steel products account for nearly 40 per cent of building materials requirements; yet, over 70 per cent of domestic requirements are covered by imports.

There is considerable scope for import substitution; in the period 1953-1963, nearly $700 million were estimated to have been spent on the acquisition of building materials and components (see table 2). The significance of this order of magnitude is that it represents over 3 per cent of gross national product and nearly 10 per cent of aggregate national imports into Africa.

The current supply situation justifies immediate large-scale development of the building materials industry. Future estimates of needs further stress the urgency of finding effective solutions to contain a trend which will otherwise worsen. The desire for accelerated economic development and its realization will involve the countries of Africa in large-scale construction activities. New dwellings to cope with increases in population and improved housing to replace obsolescence and slum areas are essential for orderly social and economic progress. At the same time, African countries will be faced with the need to build up their economic infra-structure: transport and communication networks, electric power, water-supply, sewerage etc., which will require extensive construction, in addition

[3] Reference to Southern Africa indicates the entire subregion, comprising the countries listed in foot-note 2. Reference to South Africa indicates the Republic of South Africa.

to the construction of industrial and other non-residential buildings.

The available resources to satisfy total needs in the foreseeable future are meagre. But within the framework of economic growth as measured by gross domestic product, the needs that should be satisfied may be estimated for purposes of assessing the development targets for the building materials industry. Table 3 sets out, as a working hypothesis, the possible growth of gross domestic product up to 1980 at an annual rate of 5.5 per cent and a corresponding growth of the share of gross domestic fixed capital formation from one-eighth to one-fifth of gross domestic product. Other assumptions in the table are self-explanatory and are based on assessments by the Secretariat of the United Nations Economic Commission for Africa (ECA) of current situations and trends.

The table shows that the expenditure on building materials may be expected to grow from the 1965 estimate of $1,500 million to $4,700 million in 1980 at an annual compounded rate of 8.5 per cent within the modest perspectives of the assumed growth rate of 5.5 per cent for the economy. The share of these expenditures in the gross domestic product is also expected to grow from the estimated value of 5.2 per cent in 1965 to 7.2 per cent in 1980.

Table 3. Estimated growth of expenditure on building materials and components in Africa, 1965-1980 [a]

(Thousand million dollars at 1960 prices)

Assumptions	*1965*	*1970*	*1975*	*1980*
1. Gross domestic product increasing by 5.5% per annum	29	38	50	65
2. Gross domestic fixed capital formation increasing from 1/8 to 1/5 of gross domestic product in 1960-1980	4.2	6.2	9.1	13.0
3. Investment in total constructions constant at 60 per cent of gross domestic fixed capital formation	2.5	3.7	5.5	7.8

Table 3. Estimated growth of expenditure on building materials and components in Africa, 1965-1980 [a] **(*continued*)**

(Thousand million dollars at 1960 prices)

Assumptions	*1965*	*1970*	*1975*	*1980*
4. Expenditure on building materials constant at 60% of total construction expenditures	1.5	2.2	3.3	4.7
5. Expenditure on building materials expressed as percentage of gross domestic product (in 1963, 4.6%)	5.2	5.8	6.6	7.2
6. Share of imports as percentage of total expenditure on building materials on the hypothesis that the capacity of the domestic industry is not increasing within the period	60	73	82	87

SOURCE: Secretariat of the United Nations Economic Commission for Africa.

[a] Excluding Southern Africa.

These orders of magnitude demonstrate the important role that the development of the building materials industry would be expected to play in economic development. In particular, it will be appreciated that if the industry is not made to cope with growing needs, the drain on foreign exchange will pose a serious problem. In the extreme hypothesis of no progress taking place in the industry within the period 1965-1980, the value of imports would rise from $900 million to $4,000 million, and the share of imports in total expenditure from 60 per cent to nearly 90 per cent.

This is mentioned for the purpose of demonstrating the broad dimensions of the problem. Within this dimension, the development of the industry must aim, in the first place, at arresting the rising trend of the share of imports noted above and, in the second, at reversing the trend in order to bring down this share to the lowest possible level within the shortest time possible. The indications are that there are no serious limitations that could not be overcome for the realization of this goal.

III. The growing demand for building materials

A. Past trends

Consumption of the basic building materials in Africa did not increase as fast as world consumption in the period 1953-1963. This is evident from a comparison of the graphs shown in figure I. The change in the share of African consumption in world consumption of these materials is demonstrated pictorially in figure II. Since 1958, the trend has been a downward one, reflecting the slackening pace of construction activities in several countries during the period 1958-1963. Figure III further stresses the structural change that took place over the period for the subregions.

As a whole, however, a notable growth in consumption took place in the period 1953-1963. Indeed, the consumption of some materials increased dramatically, as is evident from figure I (graph 2). That of cement rose by 62 per cent; of crude steel, by 60 per cent, of sawnwood, by 57 per cent; and of plywood, by 127 per cent. Table 4 summarizes the average compounded annual rates of growth for these materials by subregion.

Table 4. Compounded annual rates of growth of consumption of basic building materials in Africa, 1953-1963

(Percentage)

Subregion	*Cement*	*Crude steel*	*Sawnwood*	*Plywood*	*Board products*
North Africa	7	6	4	12	22
West Africa	8	9	14	16	13
Central Africa	—	—	1	—	—
East Africa	3	3	3	12	—
Southern Africa	5	5	5	15	—
TOTAL AFRICA	6	5	5	8	3

SOURCE: Computation of the Secretariat of the United Nations Economic Commission for Africa.

With the exception of the Central African subregion, significant rates of growth were realized. The trends of the Central African subregion were, however, dominated by those in the Democratic Republic of the Congo, where consumption fell subsequent to 1960.

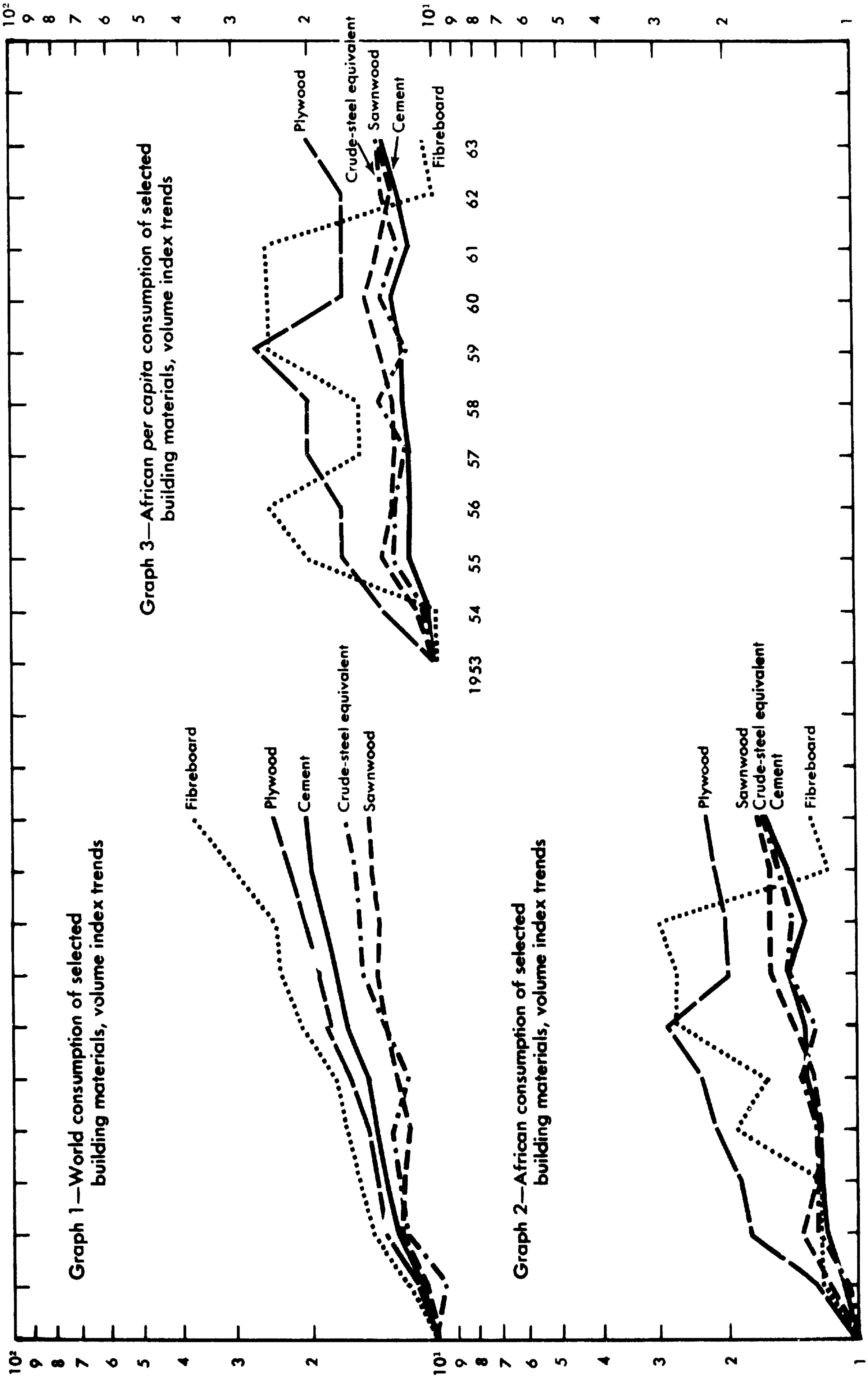


Figure I. Comparison of world consumption and African consumption of selected building materials, volume index trends, 1953-1963

Figure II. Share of Africa in world consumption of selected building materials and components, 1953-1963

(Percentage)

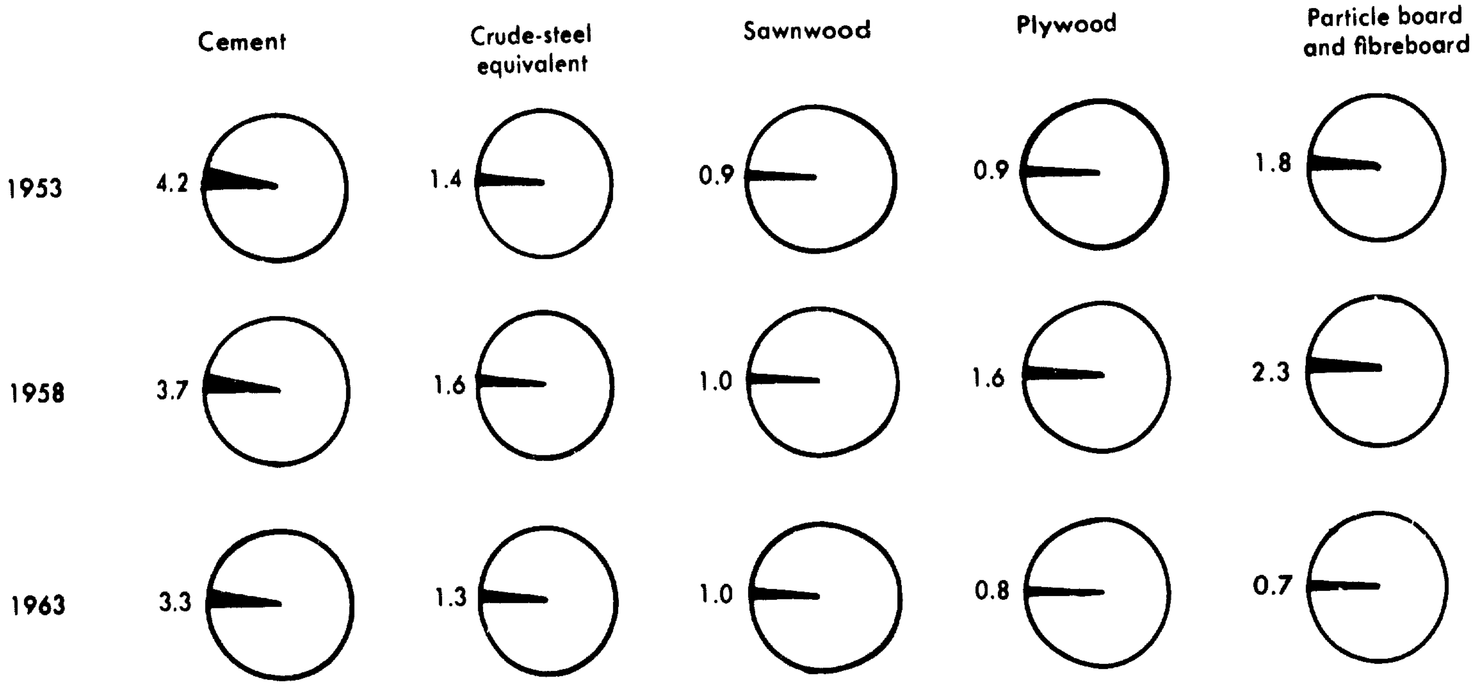
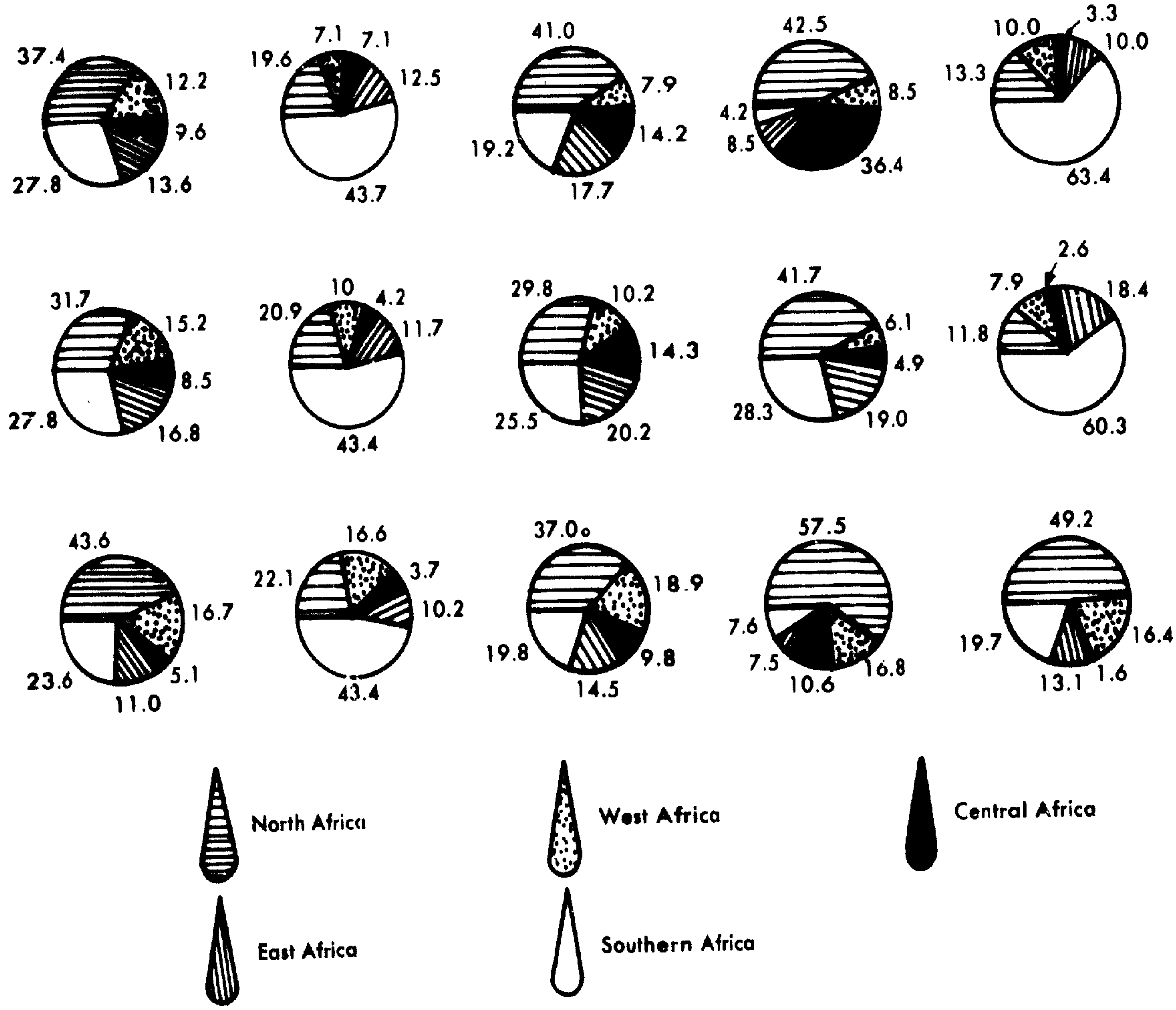


Figure III. Subregional shares of total African consumption of selected building materials and components, 1953-1963

(Percentage)



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6. INDUSTRIALIZATION, ECONOMIC CO-OPERATION AND TRANSPORT: HYPOTHESIS OF WORK IN THE REGION OF THE GREAT AFRICAN LAKES

Secretariat of the United Nations Economic Commission for Africa

CONTENTS

Introduction

The Geneva Conference on Trade and Development, in analysing the imbalance of world trade between developed and developing countries, concluded that the permanent trend is for such imbalance to increase.[1]

On the one hand, the developing countries, whose exports consist mainly of raw materials, find that the value of these products is steadily decreasing because of competition between themselves and also because of technical progress, which has ushered in synthetic products which can replace natural raw materials at a lower price.

On the other hand, manufactured products coming from the industrialized countries and needed for the equipment of the developing countries show a tendency to increase because of pressure on the part of the trade unions for higher rates of pay. This is reflected in prices and cannot always be offset by increased productivity.

Consequently, under the influence of these two series of factors, there is a steady deterioration in the terms of trade, to the detriment of the developing countries, which have to provide more and more raw materials in order to obtain less and less equipment and manufactured products.

The following remedies have been suggested:

(*a*) On a short-term basis, to palliate the deficit in foreign accounts by trying to stabilize the prices of raw materials (stabilization fund, quotas etc.) and by reducing the deficit on invisibles (maritime freight, insurance, redemption of loans etc.);

(*b*) On a long-term basis, to seek a new international division of labour, which would enable the developing countries themselves to produce at least some proportion of the industrial products needed for their development, by industrializing themselves.

Moreover, such industrialization is not intended solely to economize on foreign exchange. It constitutes a means of development in itself by expanding the monetary sector of the economy, establishing a prime sector with various repercussions which could facilitate an economic take-off and creating great additional value through the multiplying effect of distribution of wages etc.

These various effects of industrialization have been studied and evaluated in the case of an industrialization project in Cameroon[2] which provides for the establishment of ten small and medium industries: two cement works, one timber peeling yard, one spinning-weaving centre, one blanket factory, one flour mill, one biscuit factory, one plastic goods factory, one match factory and one meat packing plant.

The effects of such industrialization on the domestic product of Cameroon are shown in table 1.

[1] The permanent nature of this trend is not universally acknowledged, and some are of the opinion that it cannot be seriously maintained.

[2] Société d'études pour le développement économique et social, *Industrial Development in Cameroon* (Paris, 1960).

Table 1. Effects of proposed industrialization project on domestic product of Cameroon

(Dollars)

Total investment in the ten factories	14,000,000
Annual turnover for the ten factories	8,928,000
Total added value	
Value added for factories	4,152,000
Backward and forward linkage effects	224,000
Multiplying effect	5,660,000
Total increase in domestic product	10,036,000

The effects of such industrialization on the trade balance of Cameroon are estimated in table 2.

Table 2. Effect of proposed industrialization project in Cameroon on trade balance

(Dollars)

Imports	
Imports replaced by industrialization	7,360,000
New imports required	-2,500,000
Positive balance: reduced imports	4,860,000
Exports	
Possible new exports	1,080,000
Former exports suppressed	400,000
Positive balance: increased exports	680,000
Direct effects on trade balance of operation of factories: improvement	5,540,000

The figures given above should be regarded as approximate and applying to a specific case. They cannot, therefore, be generalized, but tend to prove that industrialization provides a powerful stimulus for the growth of the domestic product. They explain the determination of the developing countries to industrialize and the efforts they are making for that purpose. In practice, unfortunately, industrialization limits are quickly reached at the national level.

In an interview, Mr. George Woods, President of the International Bank for Reconstruction and Development (IBRD), who is a specialist on the subject, pointed out the limitations of this method. Referring to the ambitions of developing countries with regard to setting up national industries, the interviewer posed the following question: "Yet it seems that industrial efforts will not be enough unless agriculture is given priority?". Mr. Woods replied as follows:

"That is true. More than two-thirds of the population in the under-developed countries are engaged in agriculture. I believe it is not realistic to think that the aim of industrialization is to manufacture and export products towards the industrialized countries, which are much more competitive. The main objective is to satisfy the requirements of the population. As long as the people engaged in agriculture have not achieved a decent living standard and sufficient purchasing power to buy ordinary consumer goods, there can be no market for industrial products. The leaders of the young nations are increasingly aware of this problem, whereas a few years ago they were convinced that industrialization was a miracle solution. Today, they readily give priority to agriculture."[3]

This stresses the importance of the concept of trade, which is easy to explain. The new African products will have to take the place of former imports and must, therefore, be able to compete with them as regards quality and price. Technical progress, however, calls for a system of production which is increasingly capitalistic: production units are becoming increasingly larger, there is more and more automation and the total investment per unit is constantly rising. In determining prime costs, financial commitments and structural costs are beginning to outweigh operational expenses. The law of increasing returns is gaining ground steadily, and the volume of production corresponding to the economic optimum is becoming more and more considerable.[4]

In this respect, those undertakings in the industrialized countries which are exporting to the developing countries are in an extremely good *de facto* position. Backed by an extensive national or community-protected market, they operate in the neighbourhood of optimum production. This enables them to reach the minimum mean production cost per unit in relation to the local price of production factors. Exports, always uncertain, generally account for a small fraction of production which is not indispensable for the balance of these undertakings. According to a recent paper,[5] the world output of steel in 1963 came to 386 million tons, and of that amount only 41 million tons were placed on the international market, including 11 million tons inside the European Economic Community (EEC). The 30 million tons sold on the open international markets thus accounted for only 7.77 per cent of production. In the fight to win over the African markets, these advantages are, however, partly offset by distance. Maritime transport between Europe and Africa costs between $10 and $25 per ton, which constitutes a natural protection for African firms selling on their own national market (see figure I).

Another factor is that of prices c.i.f. African ports because supply is infinitely elastic in relation to the small quantities of goods imported.

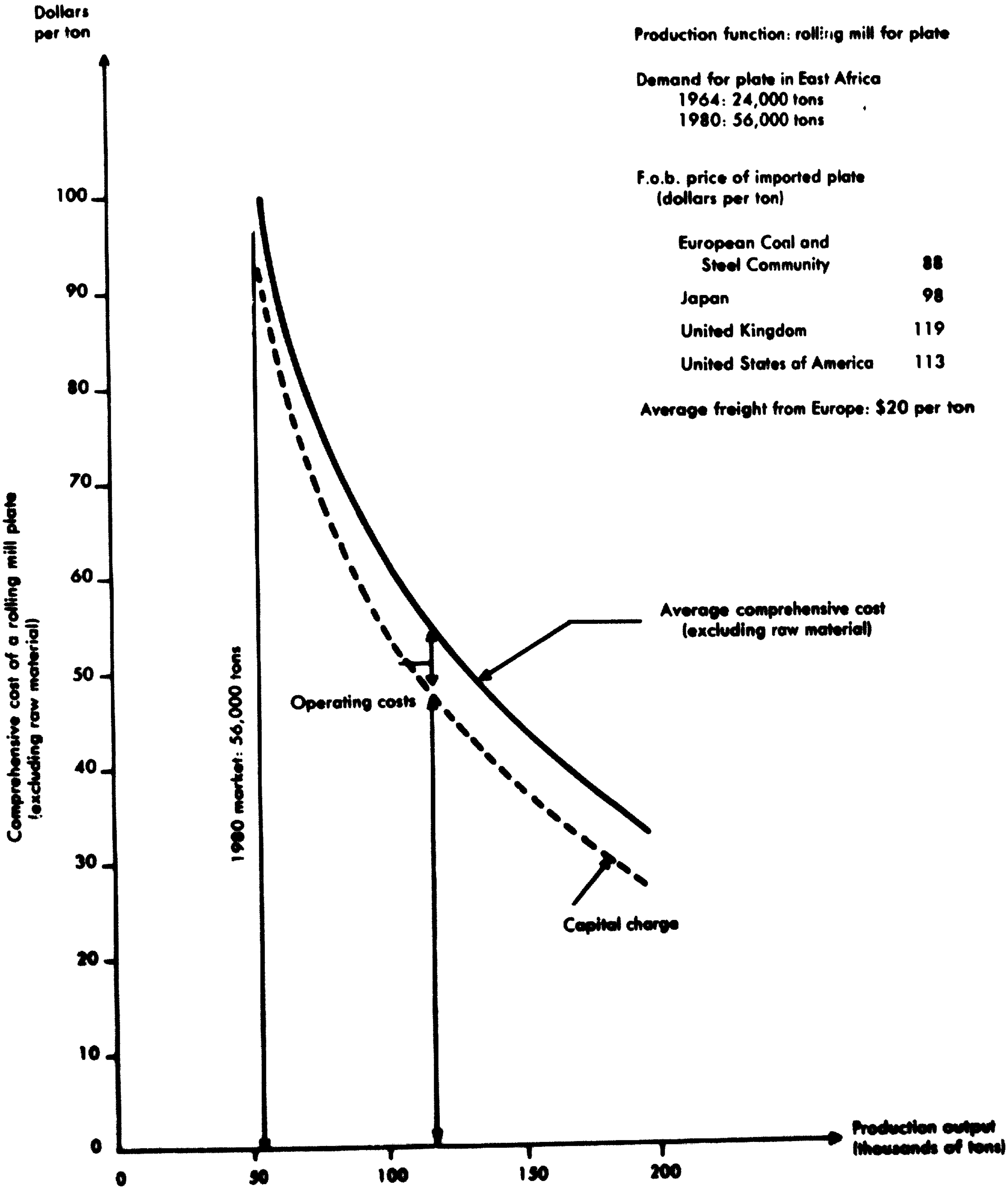
In studying the current prospects of African enterprise, one soon realizes that it is impossible to lay down any general rule concerning the relative position of production operations in Africa, as compared with the confirmed position in any of the industrialized countries. This depends greatly upon local conditions and upon the products themselves. Certain factors may favour Africa, e.g., the lower cost of some raw materials (crude petroleum and natural gas in the Sahara, high-density iron-ore in Gabon, Liberia and Mauritania, bauxite in Guinea, fatty substances, fibres, textiles etc.); considerable reserves of hydroelectric power; taxation, which is usually lower than in Europe; and lower wages than those obtaining in industrialized countries (apart from productivity). As against this,

[3] *Jeune Afrique*, No. 257 (28 November 1965), p. 24 *et seq.*

[4] This does not mean the disappearance of small and medium industries, for which the international market is still considerable. See Herbert Gross, *Petites entreprises et grand marché* (Paris, Les Editions d'Organisation); and *Econ-Verlag* (Dusseldorf SARL).

[5] S. Atkins and Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, 26 October-6 November 1965.

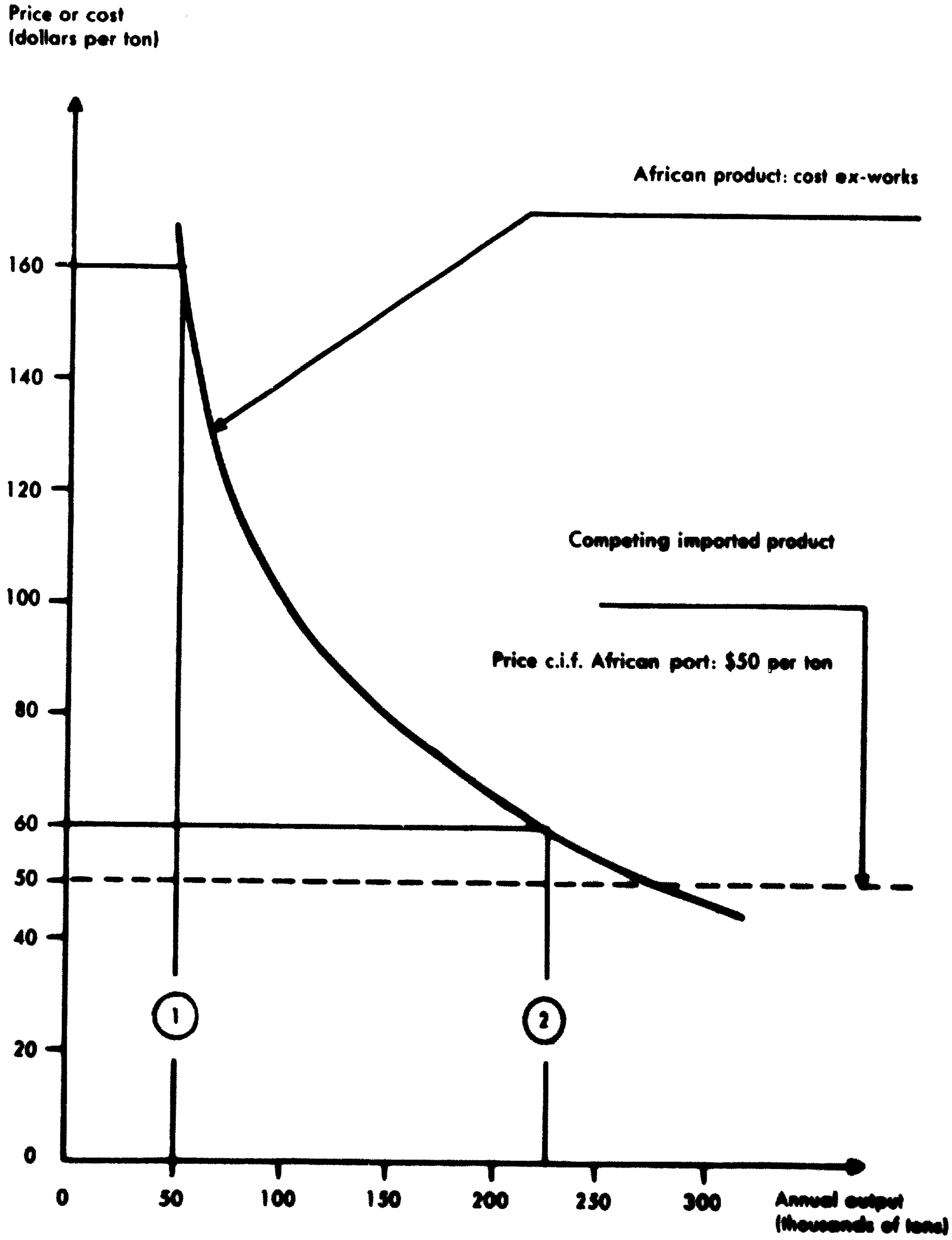
Figure I. East Africa: production function of rolling mill for plate



there are other factors pulling in the opposite direction: a higher total investment when equipment must be imported; provision for increased maintenance services; construction of housing for local and expatriate personnel; and sometimes the provision of water, electricity, air-conditioning etc. Running expenses are likewise increased when it is necessary to employ more highly paid expatriate personnel, when extra spare parts must be provided in the absence of an industrial environment, or when the source of supply is far distant, etc.

In any case, such African production does exist and is subject to the law of increasing returns, which explains the limits of industrialization on the national scale. On the one hand (see figure II), there is a fixed c.i.f. price for imported products, together with an infinitely elastic supply and, on the other hand, a

Figure II. Comparison of prices of African product and competing imported product



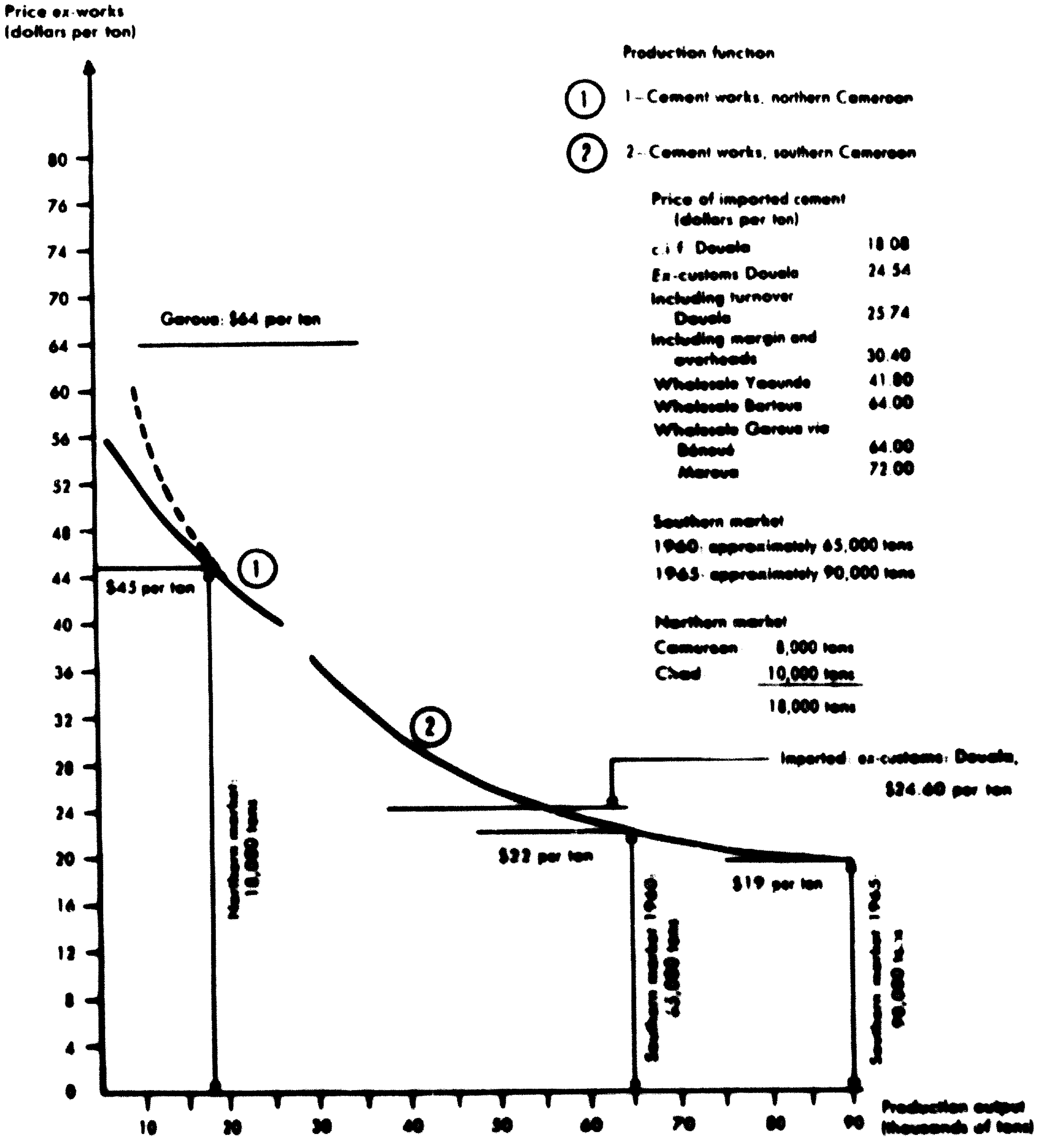
production cost *ex*-African factory based on the volume of production and, therefore, on the accessible market. Several situations may then arise, as follows:

(*a*) The national market is weak (50,000 tons) at the current rate of $50 per ton. For this volume of production, the African product would cost $160 per ton, and there is no hope of seeing the industry in question take root without resorting to such unorthodox methods as subsidies for equipment and balance. Customs protection seems likewise impossible; it would have to be as high as $110 per ton and at that rate would considerably reduce consumption through price-elasticity for the consumer, thus increasing the cost of production still further. To establish such an undertaking would run counter to the aim pursued.

(*b*) At the rate of $50 per ton, the national market is 225,000 tons. For this volume of production, African manufacture is possible at the rate of $60 per ton, that is to say, 20 per cent more than the imported product. Customs protection can then be given (because it is moderate) to help the undertaking to get under way. After a few years, the normal increase in consumption through development will permit it to operate alone and unprotected. Short-term implementation is possible.

There are many examples of such cases. Two cement-works are planned in Cameroon (see figure III). In southern Cameroon, the market came to around 65,000 tons in 1960 at the price of $24.60 per ton *ex*-customs at Douala, and consumption estimated for 1965 amounted to 90,000 tons. Production figures for the

Figure III. Comparison of plans for cement-works in northern and southern Cameroon



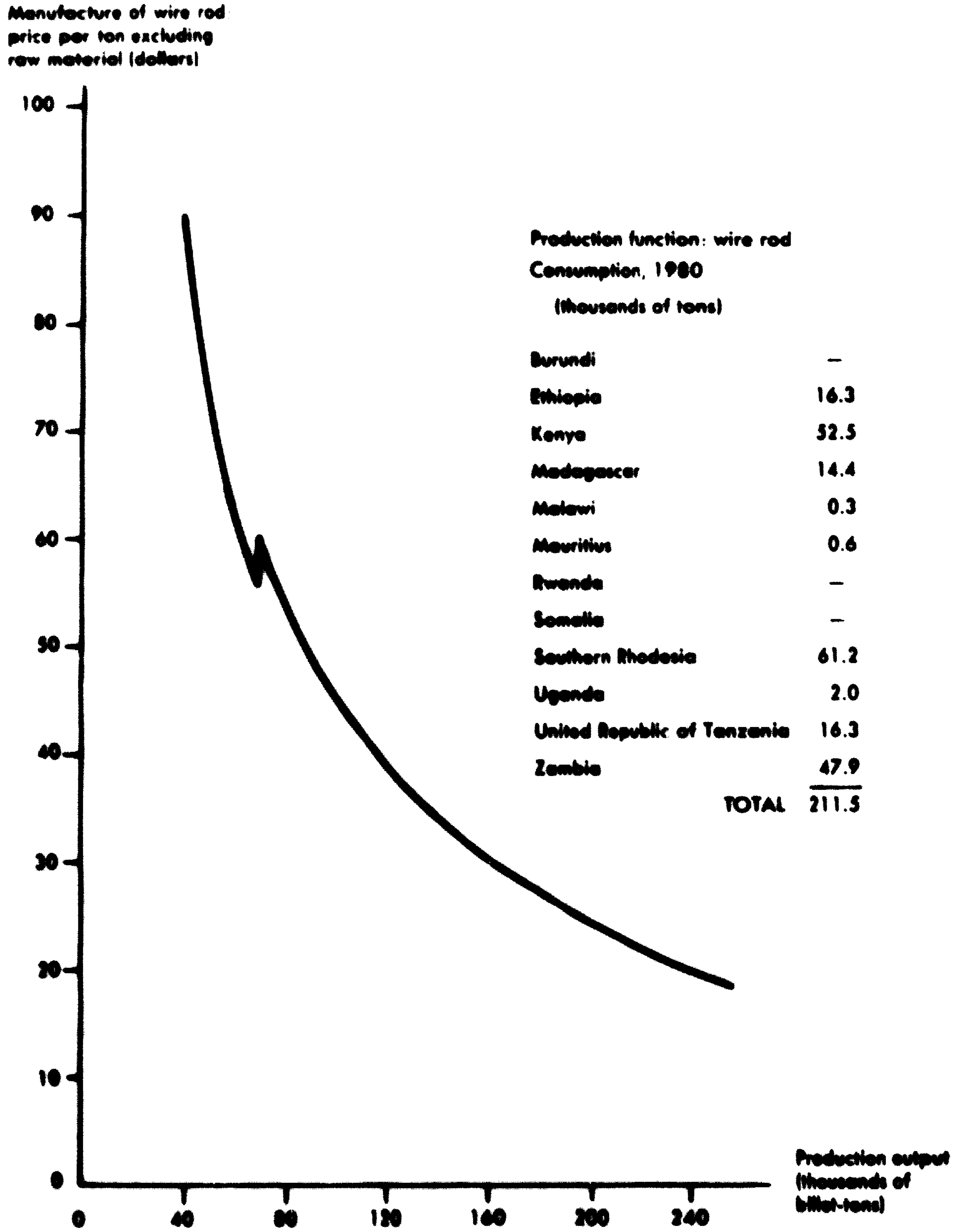
SOURCE: Société d'études pour le développement économique et social, *Industrial Development in Cameroon* (Paris, 1960)

undertaking showed an *ex*-factory cost of approximately $22 per ton for a production of 65,000 tons, and $19 per ton for a production of 90,000 tons. Cameroonian production could, therefore, compete with imports, and the factories were recommended. The position was different in northern Cameroon. In view of the high cost of road transport between Douala, Yaounde and Garoua (1,260 km at $0.04 per ton per km, i.e., $50 per ton for transport), the district was supplied from Benoué via Nigeria, and the cement delivered at Garoua at the price of $64 per ton. Notwithstanding the weakness of the market in northern Cameroon (approximately 8,000 tons) a small cement-works became economically feasible, especially if it could supply part of the market in Chad (10,000 tons). A cement-works with a capacity of from 20,000 to 30,000 tons was proposed. This latter example shows how, all other things being equal, the distance of the port of entry from the market to be supplied (northern Cameroon) can favour industrialization, by adding the cost of road transport to that of the imported product.

According to preliminary studies on industrialization in East Africa, the consumption of wire rods in Madagascar will reach 14,000 tons by 1980. The rods are delivered c.i.f. East African ports at an approximate cost of $135 per ton, and production estimates (excluding raw materials) show that the cost of manufacture would be far in excess of $100 per ton for that amount (see figure IV), whereas at optimum production it would be less than $20 per ton. Manufacture on a national scale, therefore, seems to be ruled out so far as the large island is concerned.

Smallness of the national market is, therefore, an absolute impediment to industrialization with the

Figure IV. Manufacture of wire rods in East Africa versus importation



Production function: wire rod
Consumption, 1980
(thousands of tons)

Burundi	—
Ethiopia	16.3
Kenya	52.5
Madagascar	14.4
Malawi	0.3
Mauritius	0.6
Rwanda	—
Somalia	—
Southern Rhodesia	61.2
Uganda	2.0
United Republic of Tanzania	16.3
Zambia	47.9
TOTAL	211.5

C.i.f. price imported,
East African port: $135 per ton

Source: W. S. Atkins and Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October - 6 November 1965.

exception of the usual cement-works, breweries etc. This is owing to two factors:

(*a*) Insufficient income[6], which means that the people cannot afford to buy manufactured products. No immediate action can be taken without presupposing that the development problem has been solved. The only way to increase income is, therefore, through agricultural priority. With the help of time, the natural increase in the population and the growth of income, the national market will expand, and it will be possible to reconsider the problem. Meanwhile, studies can help to determine which industries may become feasible in the fairly near future.

(*b*) Too few consumers. India, with 397,500,000 inhabitants and a gross national product amounting to $69 *per capita*, can have several iron and steel undertakings to feed the national market, whereas the Ivory Coast, with 3.2 million inhabitants and a gross national product amounting $186 *per capita*, would not be able to do so, even if it had all the necessary natural resources.[7] This lack of consumers may, however, be remedied if it is possible to conquer outside markets.

With regard to the size of national markets, Africa has, on the whole, the most difficult situation, in comparison with the other continents. Not only is the standard of living low, as in all the developing countries, but the population is small and scattered throughout many States and territories, as follows:

Number of States or territories		*Population (millions)*
3	Over	20
5		10–20
5		5–10
5		4–5
7		3–4
6		2–3
4		1–2
14	Under	1

It seems rather unpromising to look for outlets for manufactured products in the developed countries. Their industries are, in fact, highly competitive and, in this case, maritime transport would work against the interests of the African products. As exports are always uncertain, the African national markets would remain too restricted to support an essentially exporting industry, unless by agreement with the large industrial groups which control, in general, all the trade channels for distributing products. Lastly, there is little probability that the developed countries would readily open up their markets to products manufactured in the developing countries.

Only one solution still remains: the African countries must co-operate economically. That is the solution chosen by the Heads of State in 1963 and recommended by the United Nations Conference on Trade and Development (Geneva, 1964). It has now become the declared policy of the United Nations Economic Commission for Africa (ECA)[8].

Economic co-operation raises many problems concerning policy alignment, standard regulations etc.[9]. Only one aspect is envisaged here to permit African industries to take root by extending the market through a regrouping of countries and to permit an industry located in one State to compete on an equal footing with imported products in another State.

Even from this restricted aspect, economic co-operation gives rise to some thorny problems by shifting the difficulties from the technical and economic fields to the political field. It will, in fact, be necessary to determine the following:

(*a*) The framework for co-operation, that is to say, the States wishing to join together;

(*b*) The distribution of industries, an essentially political problem.

The framework for integration could be a first source of conflict, because the localization of raw materials, the geographical position of each State, the distribution of consumers and the structure of the transport system may lead to suggestions for certain regroupings which are not in line with political affinities. From the economic standpoint, the predetermined administrative framework for the ECA subregions is not perhaps the best choice. In practice, and for operational requirements, it is often divided (Committee for the Industrialization of the Maghreb, Committee for Lake Chad, Committee for the Control of the Waters of Lake Tanganyika etc.). The possibility of economic co-operation and industrialization would then be the result of conflicting economic exigencies and political constraints.

Once the framework for co-operation has been chosen, the choice of industries will depend upon available production and the size of the market. The distribution of these industries between the States constituting the community can be determined only by the States themselves. For many industries, indeed, there will be several economically possible sites, and each State will naturally try to reap the greatest benefit from this distribution. Such difficulties can be settled only by negotiations.

The pursuit of economic co-operation presupposes a certain view of the future of Africa. At the dawn of its independence, Africa is deeply stamped by a century of so-called "colonial pact" policy. That policy, closely linking the metropolitan country and the colony, led to transport systems running inland from the coast, in which large sums were invested. The African economy, therefore, is often dominated by the transport system, which forces a State to trade with the outside, rather than with its neighbours.

The will for economic co-operation is a complete reversal of the former trend. It would be astonishing if the instrument installed for the "colonial pact" policy were suitable for a policy of co-operation. To envisage such co-operation within the framework of the current transport system would be to try to use an instrument which is not at all adapted to the purpose in view. One does not hunt buffalo in the forest with a fishing-rod or a butterfly net, but in the savannah with a good gun.

The short-comings of the current transport system are particularly striking in the region of the Great Lakes.

[6] See studies on the relationship between *per capita* income and average consumption of steel, cement, etc.

[7] France, Ministry of Co-operation, *Planification en Afrique*, vol. IV (Paris, 1963), p. 83.

[8] Resolution E/CN.14/RES/149 (VII), Nairobi, 22 February 1965.

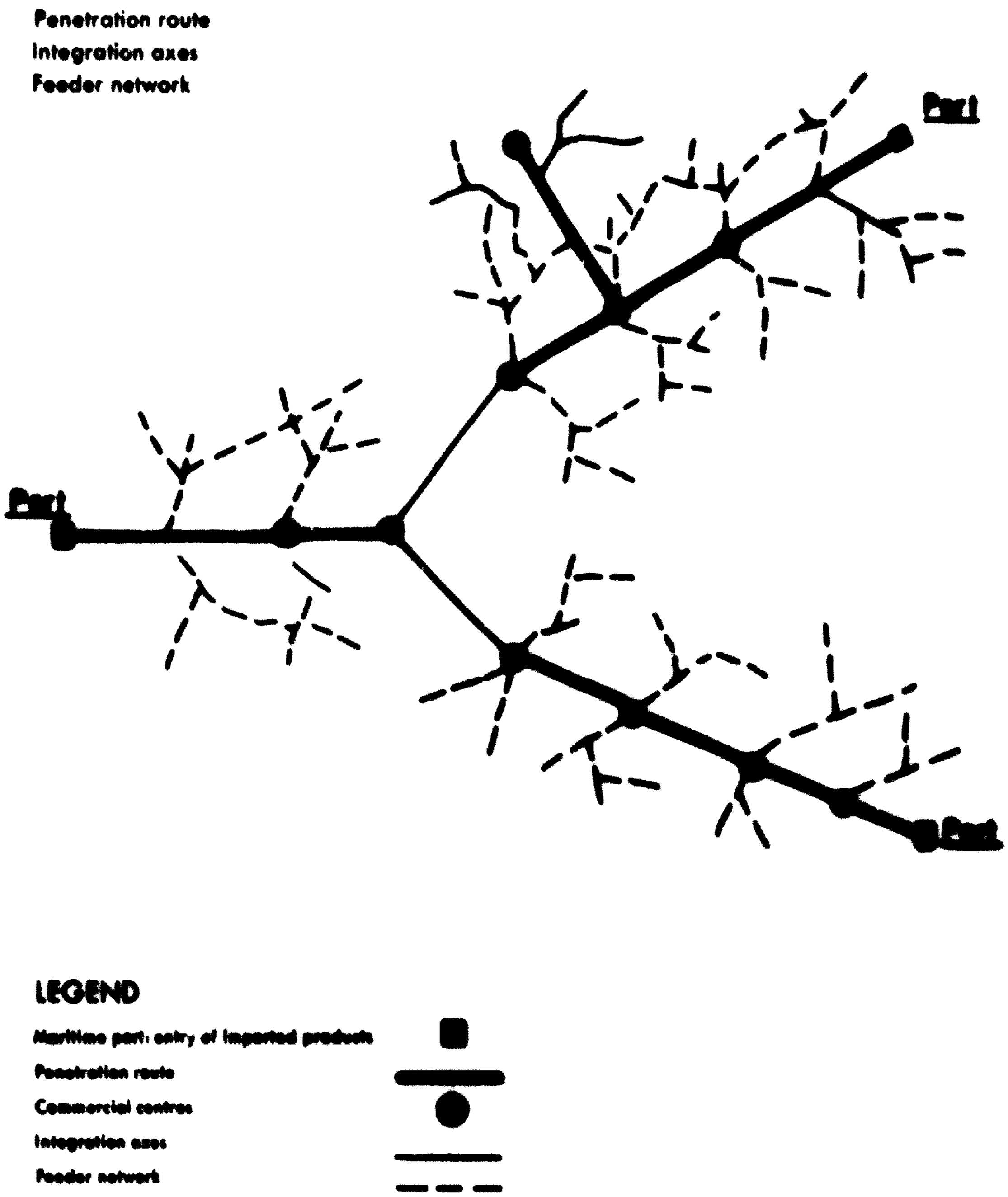
[9] See R. Erbes, "Memorandum on the three conditions governing economic integration: connectivity, compatibility, convergence", *Economic Review* (June 1965); and J. R. Boudeville, "Memorandum on the integration of economic spaces", *Cahiers de l'ISEA* (September 1964).

I. Breakdown of the African market through lines of penetration in the region of the Great Lakes

In contending with imports, African products will above all, encounter competition in the trade distribution centres. Trade in imported manufactured products is organized at different levels: importers, wholesalers and retailers. Importers and wholesalers are found at the ports and at the main towns in the interior, where they have their stores, from which they distribute imported manufactured products and assemble goods for exportation. It is, therefore, access to these trade centres — which are usually administrative centres also — which should be made easier for African products, to permit them to compete with imports.

As regards the operation of economic co-operation, the lines constituting the African transport system may be divided into three categories (see map 1): (*a*) lines of penetration; (*b*) axes of integration; and (*c*) supply network.

Map 1. Types of lines constituting African transport system: penetration routes, integration axes and feeder network



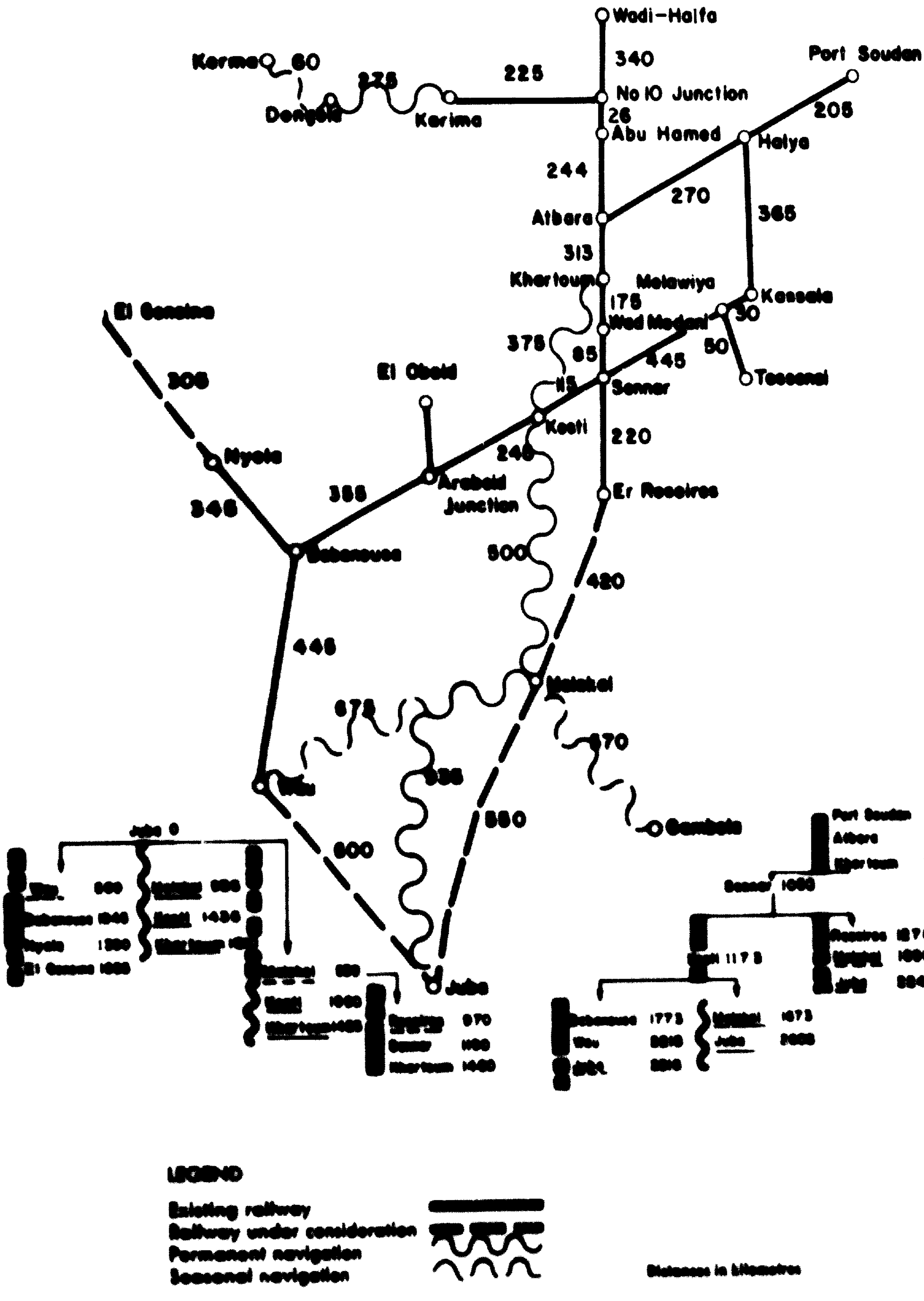
A. Lines of penetration and axes of integration

The lines of penetration are those traditionally followed by imports and exports. They link the large ports and inland towns, and usually handle much traffic. They consist almost exclusively of railways and navigable waterways, along which the trade centres are naturally located.

The axes of integration consist of the lines followed, or to be followed, by African products traded between the African countries in the event of economic co-operation. Since the trade centres of each country are located on the lines of penetration, the axes of integration link, or should link, the lines of penetration of the various countries. At the current time, these axes of integration are very diverse: sometimes they are railways or navigable waterways, but more often they are roads in fair or mediocre condition and even such roads do not always exist.

The supply network includes all the secondary roads which supply the interior from the lines of penetration and the trade centres. Imported goods are distributed through this network, and goods for exportation are conveyed to the exporters' shops. It consists almost entirely of roads and tracks. It is extremely important for national development. From the point of view of economic co-operation and the struggle between African products and imported products, it is of secondary interest, as African products and imported products have to use it from the trading centres on the same footing, and costs are equally affected in both cases.

Map 2. Sudanese penetration route



As the supply network does not involve any disparity between African goods and imports, it will not be considered further.

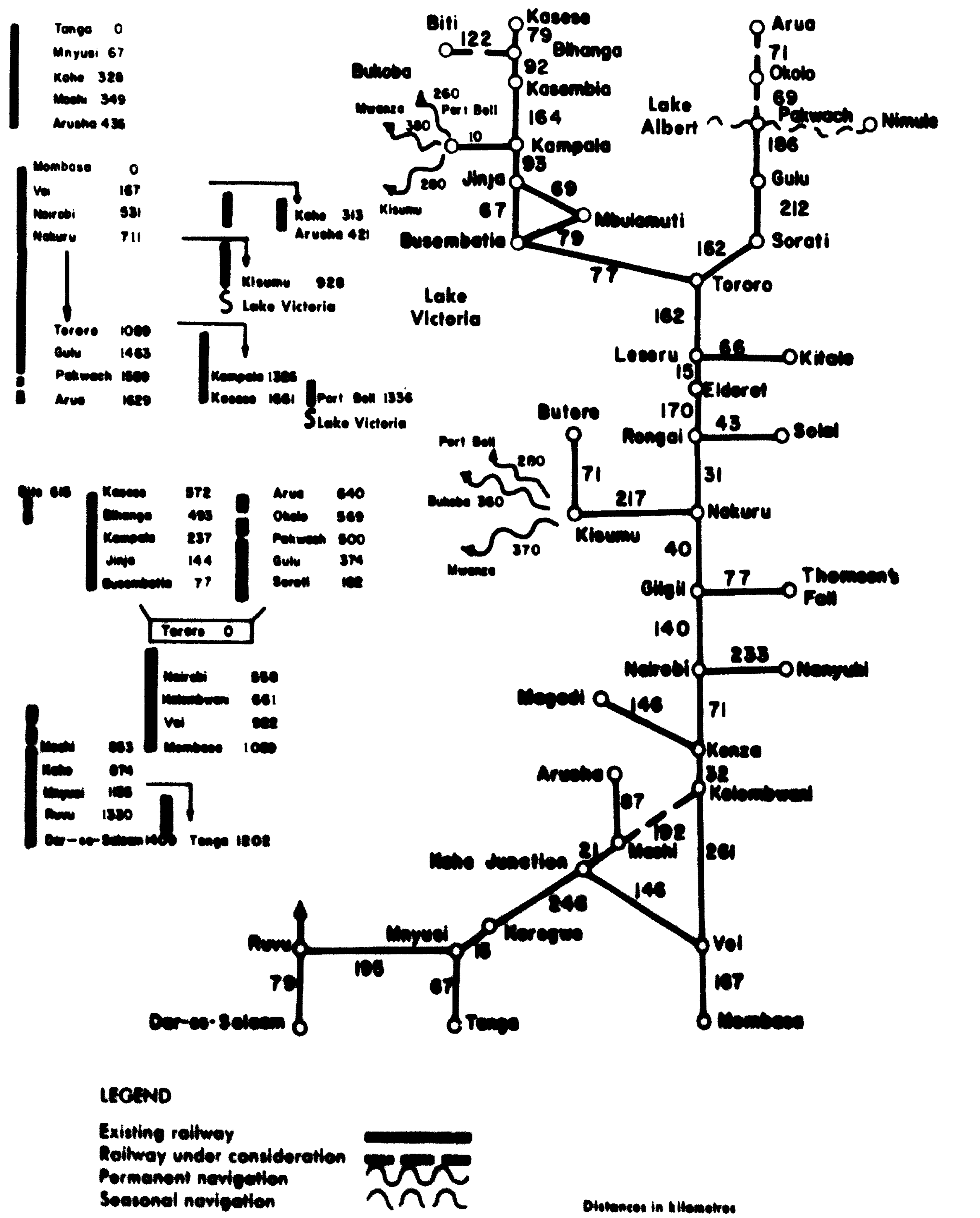
The distinction between these various categories is not absolute, especially in the case of surrounded countries. For instance, in Mali, Southern Rhodesia, Uganda, Upper Volta and Zambia, the railways linking these countries with the ports not only serve as lines of penetration for overseas imports and exports, but are also axes of integration for trade with the coastal country. Lake Tanganyika is a line of penetration for Burundi and an axis of integration between Burundi, the Congo (Democratic Republic of), the United Republic of Tanzania and Zambia.

Failing any adequate axis of integration (Kenya-Ethiopia), products for trade must take the lines of penetration of both countries, which involves transshipment to a maritime line and the drawbacks of two changes, plus those of handling, special maritime backing etc. Maritime transport also has the drawback of directly exposing the African product, *mutatis mutandis*, to competition with the imported product.

B. Lines of penetration into the region of the Great Lakes

The lines of penetration are evident, and their effect may be imagined, on studying the tremendous African region extending from the Sudan to Southern Rhodesia

Map 3. Kenya-Uganda penetration route



II. Raw materials and fuel

The main raw materials required for iron and steel production are iron-ore, scrap, fuel pure limestone (including dolomitic limestone) and water. Raw materials required in smaller quantities are manganese ore and ferro-alloys, and mention must also be made of the need for certain manufactured materials essential for the maintenance of production, notably, furnace refractory blocks and bricks, casting-pit refractories and engineering spares. As a general rule, however, local availability of these secondary raw materials and of the materials needed for maintenance is not of prime importance in the first stages of a developing steel industry because they can be readily imported. Fresh water in large quantities is one of the essential requirements for an iron and steel works, and it is difficult to visualize the construction of such a works in countries where water is currently scarce. This does not mean that such countries would never be able to operate a steel works, but merely that such developments must be delayed until water-supplies can be developed.

The raw iron required will come from ore or scrap, or both. Although ore alone or scrap alone can sustain an iron and steel works, usually both are used. In a country in the early stages of industrial development, little scrap will be available. This follows from the fact that there are few metal-using industries from which scrap can be collected and little equipment in the form of machines, buildings and vehicles available for scrapping. In Southern Rhodesia, which is a relatively well-developed African country, scrap arising from the metal-using industries, including building and construction, i.e., process scrap, currently amounts to 2 kg *per capita*, compared with the current steel consumption of 10 kg *per capita*, but in East and West African countries, 1 kg *per capita* is likely to be the maximum. Scrap (capital scrap) available from obsolete structures, machines and vehicles is calculated from their average life, i.e., about fifty years, twenty-five years and ten years, respectively, and at this time distance it is obvious that there was little installed and therefore little becoming obsolete, while in any case only a proportion of what becomes available is collected. In Rhodesia, apart from the mines, the main sources were from vehicles, including the railways, and from industries, the total amounting to about 3 kg *per capita*, but in less developed countries, it is doubtful whether more than 1 kg *per capita* can be collected.[6] Therefore, not only is the quantity likely to be collected very small in relation to current steel demand, but, moreover, it is likely to be required in part by the existing iron and steel foundries. The iron foundries[7] are likely to be advantageously placed to collect the material, e.g., those making agricultural-machinery equipment will collect scrap from local farms and they are very much less exacting than a steel works in regard to quality. Scrap availability will increase rapidly with economic development, but will be subject to the time lag of about twenty years, as already described, so that while small steel works depending upon scrap will expand, they will provide a steadily decreasing proportion of total steel consumption. On the other hand, of course, they use a local material which might otherwise not be collected at all or simply be exported; they make a useful contribution to steel requirements and, more important, still do this at a low capital cost since none of the heavy capital expenditure involved in iron-making is required; and they give valuable training in steel technology. It is, therefore, important to encourage this activity.

As far as iron-ore is concerned, new deposits are frequently revealed as prospecting proceeds. Numerous iron-ore deposits are available in Africa, but since an integrated works producing a minimum of 500,000 tons of iron a year and using, therefore, 1 million tons of ore is under consideration, interest only attaches to those deposits which, either individually or in close proximity, can sustain such a works. Assuming that in view of the heavy social and industrial investment asociated with a steel works, a life of thirty to fifty years is required. This means a deposit of the order of 30 million to 50 million tons, or the equivalent in adjacent deposits. This assumes that the deposit is high grade, which, for practical purposes, may be taken as containing over 50 per cent of iron. Lower grade deposits containing under 50 per cent can usually be beneficiated to raise their iron content, but this is expensive and the naturally enriched deposits will almost invariably provide the basis for a steel industry. In most cases, these higher grade deposits occur as pockets of enrichment in very much larger masses of lower grade iron-bearing rock of perhaps 30 to 40 per cent iron content. It should also be recognized, however, that not only may new deposits be discovered since it is scarcely worth while to prospect in areas remote from transport facilities, but also that in regard to existing deposits it has not been worth while in many cases to go to the considerable expense of proving the reserves by numerous borings. In many cases, therefore, the actual reserves may be very much greater than those stated for example in "The development of the iron and steel industry in Africa".[8] In particular, the Sukulu deposits in Uganda are now estimated at about 45 million tons; new deposits amounting to between 20 million to 80 million tons have been estimated in the Eritrea province of Ethiopia; and the deposits in Mali have been reassessed. Most African countries have, in fact, adequate iron-ore resources to sustain an integrated iron and steel industry, although their relative advantages for this purpose depend also upon the quality of the reserves, i.e., iron content and presence of impurities, as well as on their accessibility. The major deposits in West and North Africa are connected by railway to the coast for export purposes, but others, e.g., in Gabon, Libya, the United Republic of Tanzania, and Zambia, are not linked to transport facilities at the current time.

Fuel, especially coal, is much less generally available. Coking coal is required for the operation of the classical blast-furnace system and is only available in large quantities in Malawi, South Africa, Southern Rhodesia and Zambia, and in smaller quantities in the Sinai Peninsula. Non-coking coal is more generally available. There are large quantities in Southern Africa and substantial deposits (over 100 million tons) in Algeria,

[6] Estimates are for Cameroon, 1 kg *per capita*; and for Upper Volta, 5 kg *per capita*.

[7] In Southern Rhodesia, iron and steel foundries took about one-half of the available scrap.

[8] United Nations Economic Commission for Africa, E/CN.14/INR/27.

and largely centred on the Great Lakes. There are six of these lines, and almost all imports into the region are carried by one or the other of them.

1. The Sudanese line

The Sudanese railways (see map 2) extend their network very deeply inland from Port Sudan, and complete their service by water transport along the Nile which is run by the same company at identical rates. All the main towns of the country are supplied by this system, which goes as far south as Juba, 2,600 kilometres from Port Sudan.

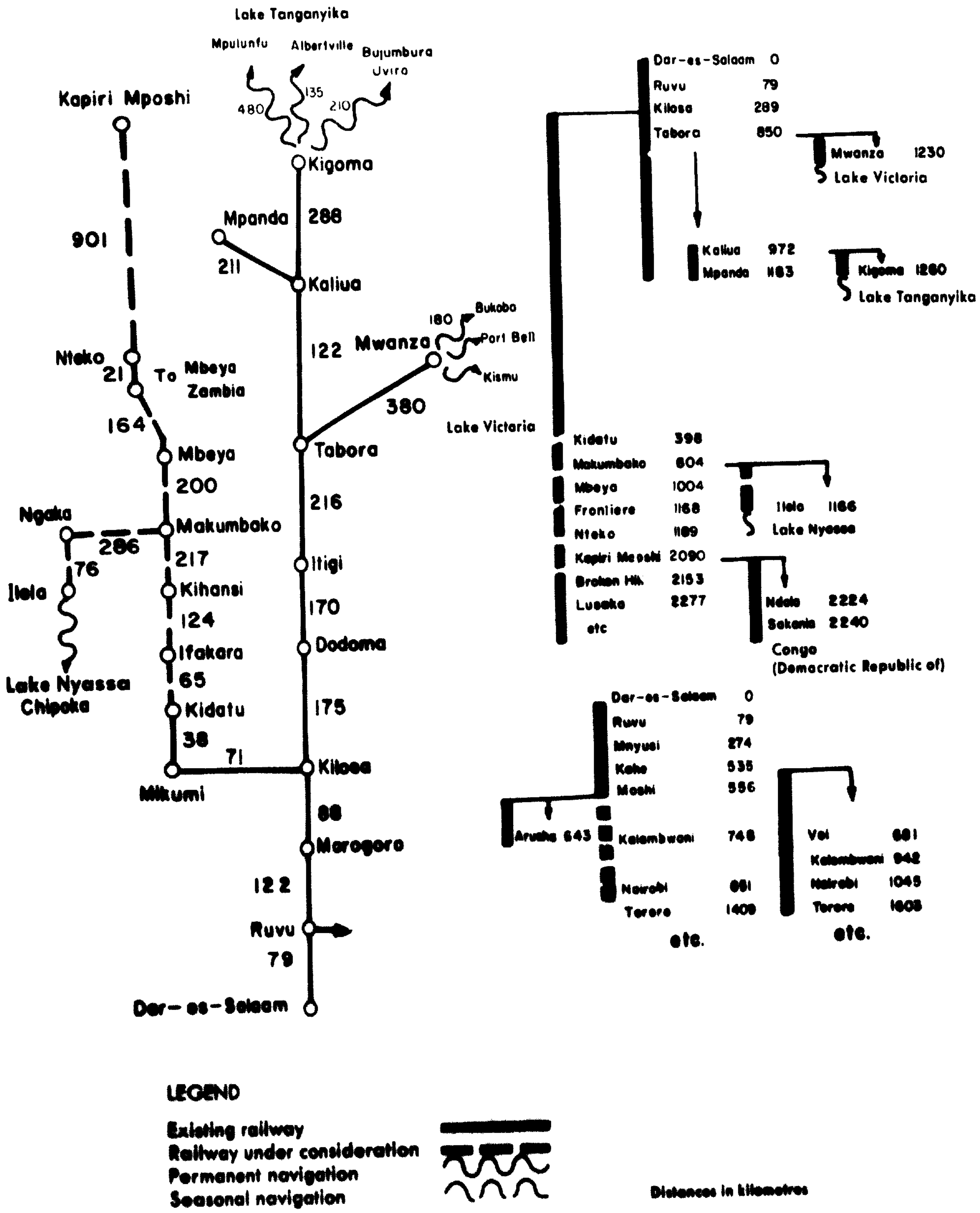
2. The Kenya-Uganda line

East African Railways and Harbours (EAR & H) runs its main line from the port of Mombasa (PK 0) to Tororo (PK 1,089), where it divides in two: one branch goes north and now ends at Pakwach (PK 1,589) on the Nile, pending its extension to Okollo and Arua (PK 1,729) as soon as the Nile bridge has been completed (see map 3). From Tororo (PK 1,089) the southern branch goes to Kampala (PK 1,326) and Kasese (PK 1,661) on the border of the Democratic Republic of the Congo. There are several minor branches of this main line, two of them going to Lake Victoria at Kisumu and Port Bell.

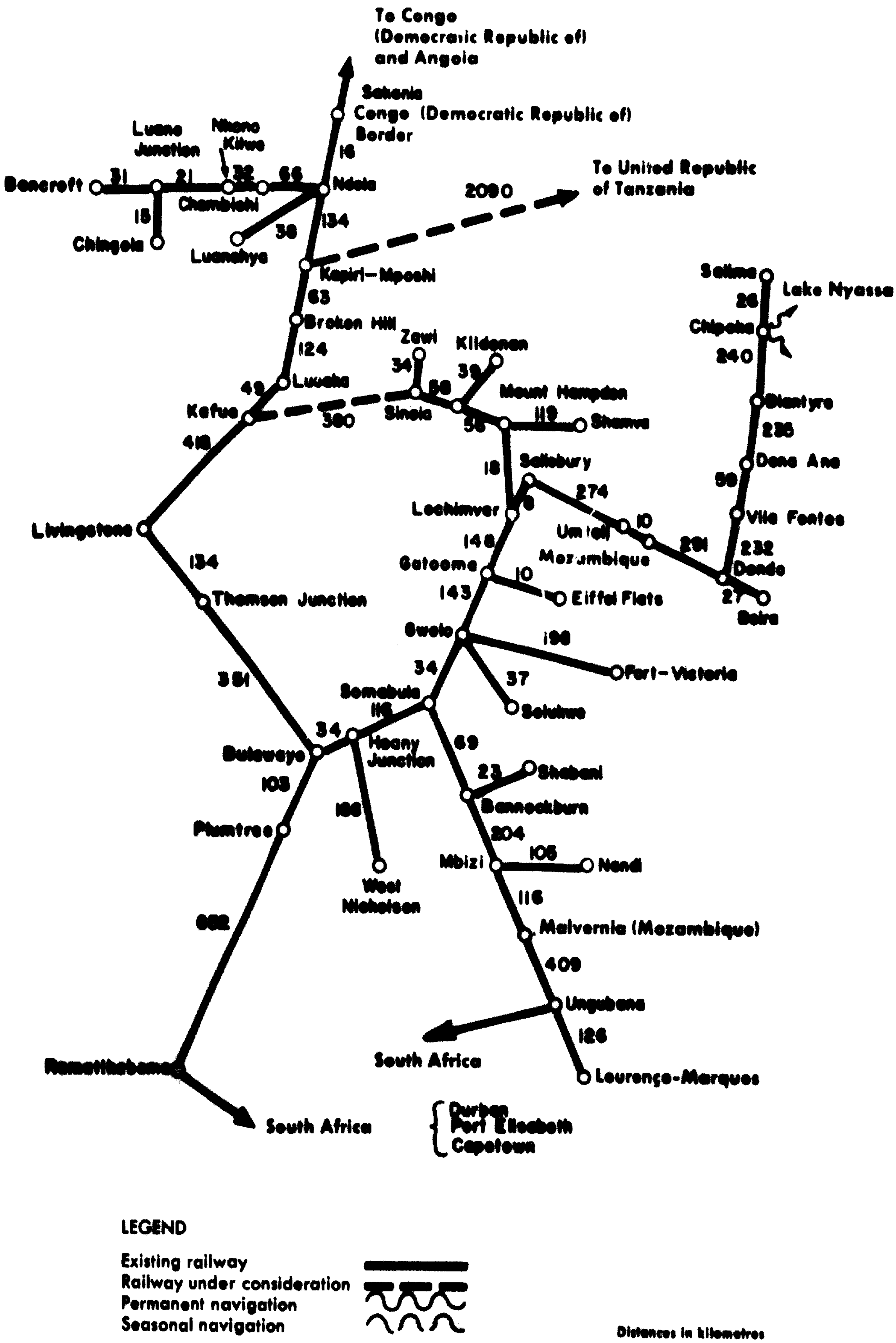
3. The Tanzanian line

This railway (see map 4), also run by the EAR & H, begins at Dar-es-Salaam (PK 0) and goes via Ruvu

Map 4. Tanzanian penetration route



Map 5. Trans-Mozambique penetration route



(PK 79), Kilosa (PK 289) Dodoma (PK 464), Tabora (PK 850) and Kaliua (PK 972), to its terminus at Kigoma (PK 1,260) on the shore of Lake Tanganyika. To the north, a branch line from Tabora goes to Mwanza (PK 1,230) on Lake Victoria, while another runs south from Kilosa towards Zambia: it now reaches Kidatu (PK 398) and will eventually go to Makumbako (PK 804) and Mbeya (PK 1,004), to link up with the Zambian railways at Kapiri Mposhi (PK 2,090). The opening of a branch line from Makumbako to Ilela (PK 1,166), on the borders of Lake Nyassa, is under consideration.

From the port of Tanga (PK 0), another railway line leads to Mnyusi (PK 67), Korogwe (PK 82), Kahe (PK 328), Moshi (PK 249) and Arusha (PK 436).

4. The Trans-Mozambique links

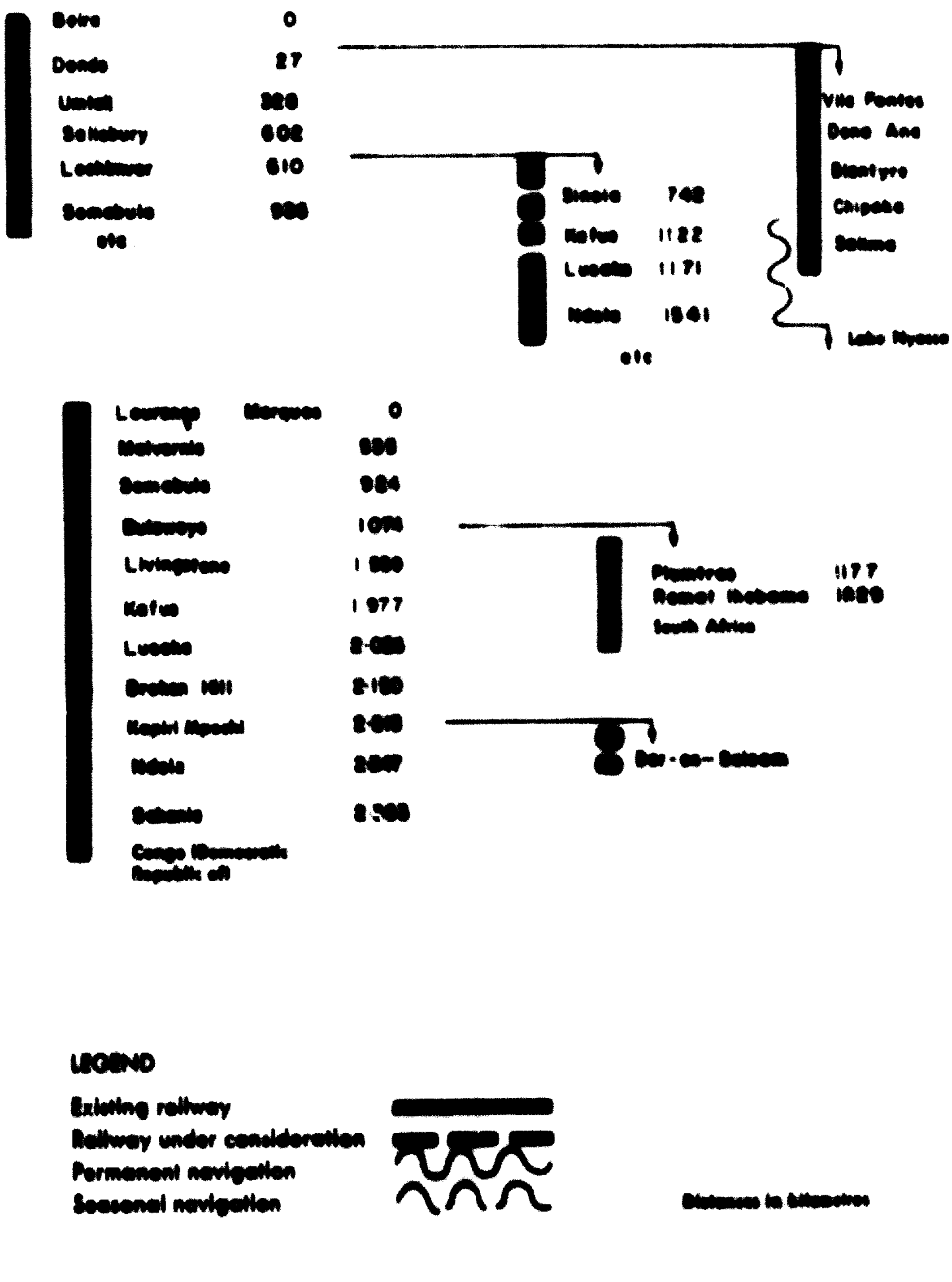
From the port of Beira, the railway goes to Dondo, Salisbury, Lochinvar and Somabula (PK 935) (see map 5 and fig. V). At Dondo a line branches off towards Malawi via Blantyre and Chipoka (PK 793) on Lake Nyassa and ends at Salima (PK 819). From Lochinvar (PK 610), another branch goes to Sinoia (PK 742), 374 km distant from Lusaka by road, and ends at Zawi (PK 776).

From Lourenço Marques (PK 0), a direct line goes to Somabula (PK 924) and continues via Bulawayo (PK 1,074), Livingstone (PK 1,559), Kafue (PK 1,977), Lusaka (PK 2,026), Kapiri Mposhi (PK 2,213) and Ndola (PK 2,347), centre of the Copper Belt, joining the railway network of the Congo (Democratic Republic of) at Sakania (PK 2,363). From Bulawayo, a branch line goes towards South Africa across Bechuanaland, thus giving access to the ports of Durban, Port Elisabeth and Capetown.

Two projects now in abeyance may alter the economy of transport in this region.

(a) Transport along the Zambezi, already studied

Figure V. Trans-Mozambique penetration route



by the Portuguese authorities. According to certain sources of information, the river could be made navigable to the sea in the neighbourhood of the Kariba Dam by means of sluices and locks at Cabora Bassa and the Lupata Gorges.

(*b*) Construction of a link line between Sinoia and Kafue (approximately 380 km) which would shorten the distance from Beira to Lusaka by approximately 850 km, reducing it from *2,026* to about 1,176 km.

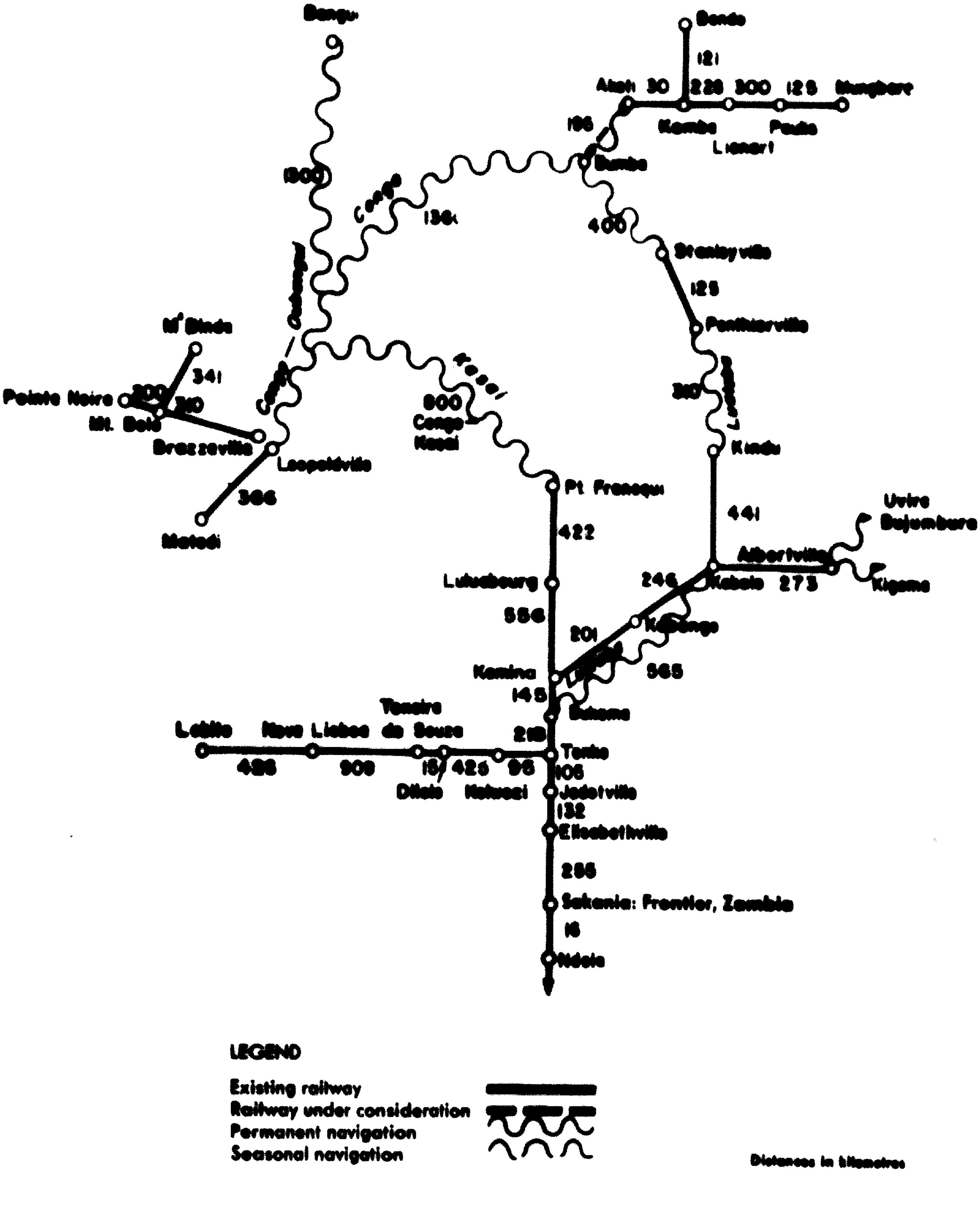
The main project in Zambia is the railway link with the United Republic of Tanzania, between Kapiri Mposhi and Kidatu (approximately *1,692* km), for bringing out copper and developing northern Zambia and the southern part of the United Republic of Tanzania. Ndola, centre of the Copper Belt, is situated as follows in relation to various possible ports of exit:

	Kilometres	Remarks
Via Lobito	2,478	
Via Beira	2,447	At the current time
Via Beira	1,500	Approximate if Sinoia–Kafue line is built
Via Dar es Salaam	2,224	With the projected new line
Via Matadi	2,215	Plus 800 km of navigable waterway

5. Trans-Angolan line

From the port of Lobito (PK 0), the Benguela railway goes through Nova Lisboa (PK 426) and crosses

Map 6. Trans-Angolan penetration route and Congolese system



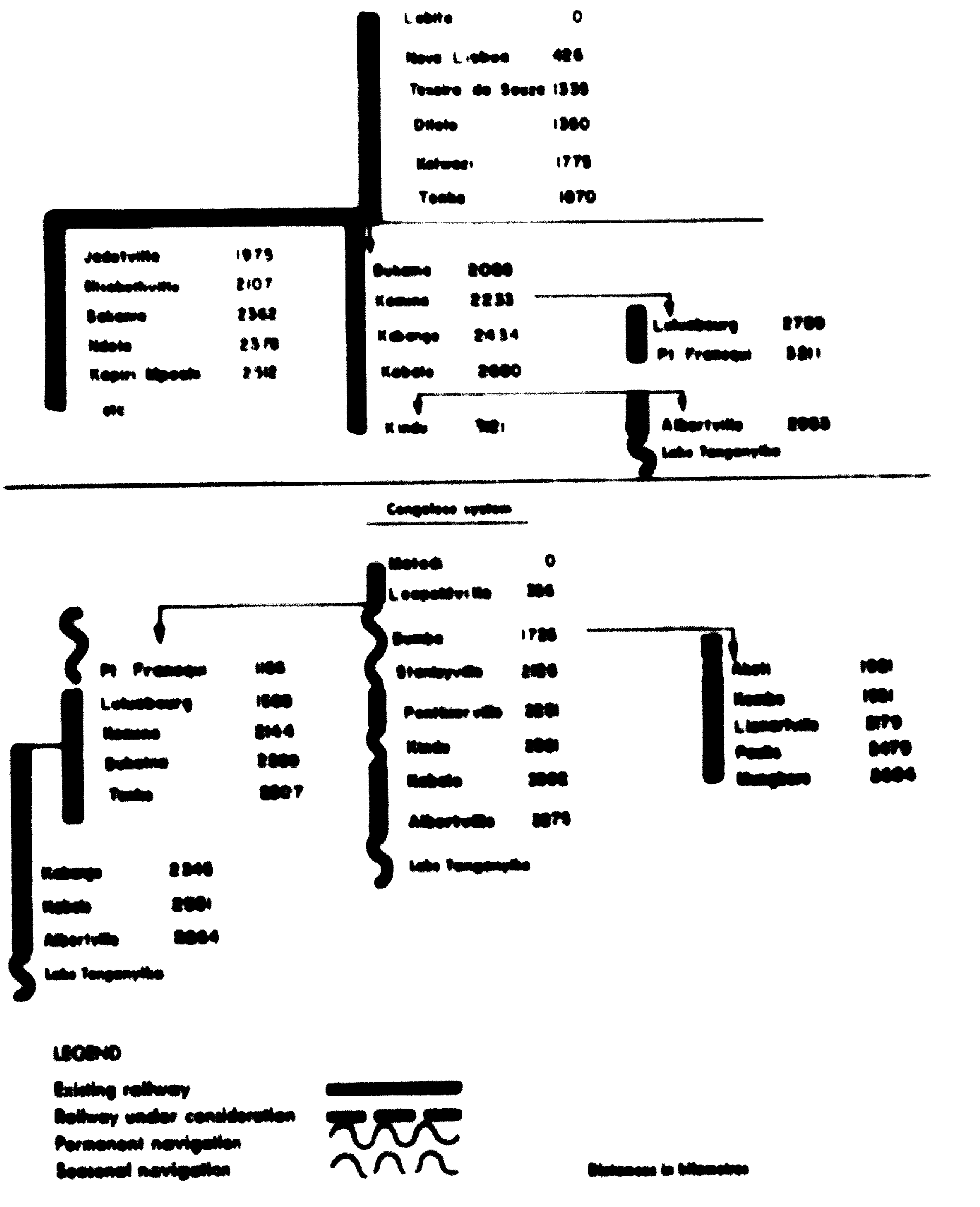
the border of the Democratic Republic of the Congo at Dilolo (PK 1,350) (see map 6 and fig. VI). It then traverses Kilwezi (PK 1,775) and links up with the Congolese system at Tenke (PK 1,870). This line gives access to Ndola in Zambia etc. or north to Kamina (PK 2,233), Kabolo (PK 2,680) and Albertville (PK 2,953) on the shore of Lake Tanganyika, all by rail.

6. The Congolese system

The Congolese system comprises, first of all, a common trunk line, which is the railway from Matadi (PK 0) to Leopoldville (Democratic Republic of the Congo) (PK 366), run by the Office d'exploitation du transport au Congo (OTRACO). It then divides into three branches (see map 6 and fig. VI) as follows:

(a) To the east, navigation on the Congo gives access to Stanleyville (PK 2,120), where the river ceases to be navigable because of the rapids. This reach is duplicated by a railway line from Stanleyville to Ponthierville (PK 2,245), where navigation is resumed on the Lualaba as far as Kindu (PK 2,555). From there onwards, the Congolese railway network gives access to Kabalo (PK 2,906) and Albertville

Figure VI. Trans-Angolan penetration route and Congolese system



(PK 3,209) on Lake Tanganyika. From Kabalo, a link line connects with the rest of the Congolese railway at Kamina.

(*b*) To the north-east, there is navigation up-river on the Congo as far as Bumba (PK 1,723) and then on the Itimbiri, which leads to Aketi, head of the line for the Congo district railways (VICICONGO). An extension of the latter as far as Bumba (185 km) is under consideration because of the difficulties involved in navigating the Itimbiri. From Aketi (PK 1,908), this line gives access to Isenart (PK 2,166), Paulis (PK 2,466) and Mungbere (PK 2,591).

(*c*) To the south-east, the Congo, and later the Kasai are navigable up to Port-Francqui (PK 1,166), the beginning point for the railway line to Luluabourg (PK 1,588), Kamina (PK 2,144), Tenke (PK 2,507), Jadotville (PK 2,612), Elisabethville (PK 2,744) and Zambia, at Sakania (PK 2,144). The Kamina-Kabalo link line (447 km) joins with the eastern line at Kabalo (PK 2,591), and the latter continues to Albertville (PK 2,864).

All these lines of penetration converge in the region of the Great Lakes, which is densely populated, highly mineralized and very fertile, and has vast reserves of hydraulic power. A straight line drawn on the map from Juba to Albertville will show how, bearing in mind the VICICONGO extension project from Mungbere to Kilo, the six great lines of penetration come within 50 km of the perpendicular.

In addition to the great lines of penetration, there are others, which are only of national or lesser importance at the current time.

7. Ethiopian lines

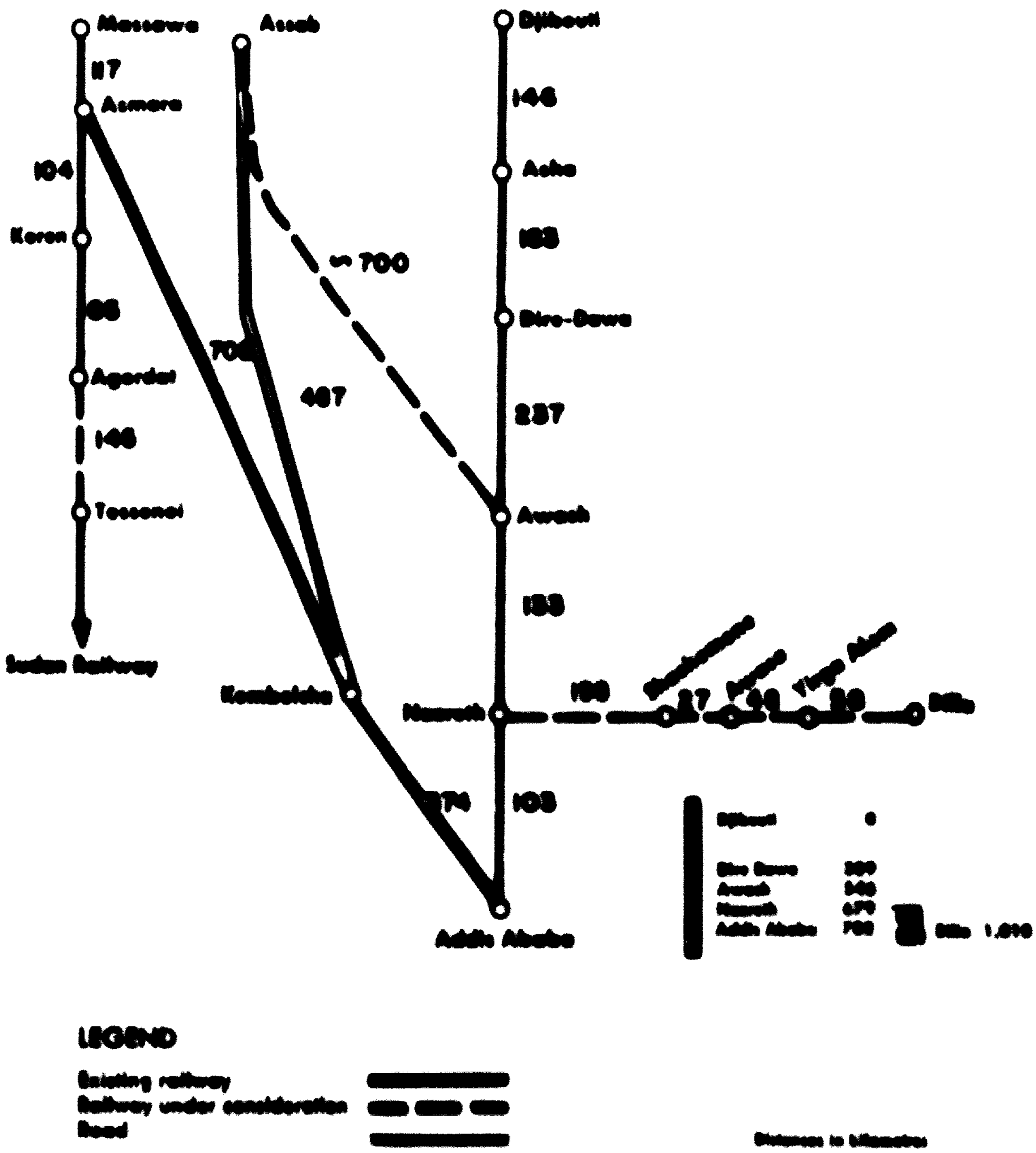
The Ethiopian lines of penetration (see map 7) include the following:

(*a*) The Franco-Ethiopian Railway: Djibouti (PK 0), Nazareth (PK 679) and Addis Ababa (PK 782), with an extension project towards Sidamo;

(*b*) Province: Nazareth–Dilla (PK 1,010);

(*c*) The railway from Massawa (PK 0) to Asmara

Map 7. Ethiopian penetration route



(PK 111) — the terminus at Agordat (PK 300) being approximately 150 km from Tessenei on the Sudan railway line.

(d) The road from Assab to Addis Ababa (901 km).

C. Axes of integration in the region of the Great Lakes

The position here is much more complicated than in the case of the lines of penetration. A distinction will be drawn between railways, navigable waterways and roads.

1. Railways

The interconnected railway system of Angola, Congo (Democratic Republic of), Zambia, Southern Rhodesia, Mozambique, Malawi, Swaziland, Bechuanaland, South Africa and South West Africa provides in theory for railway traffic in this zone but it often involves lengthy deviations. Between Lusaka and Salisbury, for instance, a good two-lane asphalt road covers the 491 km separating the two cities, whereas the journey by rail is about three times as long, involving a detour via Livingstone and Bulawayo, a distance of 1,435 km.

Similarly, between Salisbury and Blantyre the partly improved road via Tête covers 619 km, whereas by rail the detour via Dondo means a total distance of 1,101 km, or approximately twice as long.

From Lusaka to Blantyre the road covers 1,110 km, whether via Fort James and Lilongwe or via Salisbury, while the rail journey covers 2,536 km, more than twice the distance.

The link-line between Kafue and Sinoia would reduce the distance by rail from Lusaka to Salisbury from the current figure of 1,435 km by approximately 570 km.

The Kenya, Uganda and Tanzanian lines of penetration are interconnected by 602 km of link line between Voi, Kahe, Korogwe, Muyuni and Ruvu and completed by two branch lines, Mnyusi-Tanga, and Kahe-Moshi-Arusha. All are run by E.A.R. & H. Through the railway system which is common to Kenya, Uganda and the United Republic of Tanzania, Nairobi is 1,045 km from Dar es Salaam and 795 km from Kampala. When the projected link line between Moshi and Kalembwani (192 km) is built, the distance from Nairobi to Dar es Salaam will be shortened by 194 km, reducing it to 851 km.

The construction of the Dar es Salaam-Kapiri Mposhi interconnexion will permit railway traffic and trade between the two interconnected systems mentioned in the preceding paragraph. The distances from Kampala to the main centres will then be as follows:

	Kilometres		Kilometres
Kampala	0	Makumbako	2,[illegible]*
Nairobi	795	Mbeya	2,[illegible]*
Ruvu	1,367*	Kapiri Mposhi	3,370*
Kilosa	1,777*	Lusaka	3,[illegible]*
Kidatu	1,8[illegible]*	Salisbury	4,[illegible]*

* With the projected Kalembwani-Moshi link-line, 11 not add 194 kilometres.

* With the Sinoia-Kafue link-line.

In Ethiopia, a team of experts[10] recommended, inter alia, an Assab-Addis Ababa railway to be prolonged to Gambela and the Sudan together with secondary lines from Addis Ababa serving the rich provinces of Wollega, Illubabor and Kaffa, that is to say, the south-western area of Ethiopia.

2. Navigable waterways

(a) The Lower Nile

Until recent years the Nile was navigable and was exploited from Wadi Halfa, terminus of the Sudan railways on the border of the United Arab Republic, as far as Shelal, 340 km distant, near Aswan.

The building of the Aswan Dam and the formation of the artificial lake, spreading over 500 km, will alter the former conditions of navigation both up-river and down-river through flow control.[11]

There appears to be no provision for a sluice or lock to permit ships to pass from the upper to the lower reaches. But Aswan is to have a port served by the Egyptian railways.

When this work is finished, and the railway and port installations at Wadi Halfa are once more in place, the Aswan artificial lake will permit transit of goods between the Egyptian and Sudanese railways.

(b) The Nile, the Sobat and the Baro

There is seasonal navigation now between Malakal in the Sudan and Gambela in Ethiopia, first going up the Nile for 23 km, then along the Sobat for 348 km and finally along the Baro for 201 km. Gambela is thus 572 km distant from Malakal. Traffic fell from 2,000 tons in 1958 to 900 tons in 1961 and 157 tons in 1963 (including 141 tons of coffee).

(c) The Nile and Lake Albert

Because of the rapids, the Nile is not navigable between Juba and Nimule. After Nimule, however, the Nile and Lake Albert form 400 km of waterway serving the ports of Kasenyi, Butiaba, Mahagi, Pakwach, Camp Rhino and Nimule, located in three countries: Uganda, Sudan and Congo (Democratic Republic of). The EAR&H exploited this reach until 1964, but has stopped since the improvement of land transport in that area and also because of difficulties due to irregularities of depth. Only one local traffic still continues, and it does not seem that this sector can be of much interest for large-scale international transport.

(d) Lake Victoria

Covering an area of 67,000 square kilometres, Lake Victoria is common to Kenya, Uganda, and the United Republic of Tanzania and is the hood of important navigation exploited by the EAR&H. Traffic is between 200,000 to 300,000 tons per annum between the six main ports, which are indicated in table 1.

[10] See *Ethiopian Herald*, Vol VI, No. 184 (5 August 1965).

[11] See A. Lederer, "Le bassin hydrographique du Nil et son équipement fluvial", *Bulletin des Séances de l'Académie Royale des Sciences d'Outre-Mer de Belgique*, Vol VII, No. 4 (1961), p. 648 et seq.

Table 3. Distances between main ports of Lake Victoria
(Kilometres)

	Kisumu	Port Bell	Bukakata	Bukoba	Mwanza	Musoma
Kisumu* Kenya		278	133	360	367	233
Port Bell* Uganda			103	256	383	256
Bukakata Uganda				137	283	253
Bukoba United Republic of Tanzania					180	227
Mwanza* United Republic of Tanzania						198
Musoma United Republic of Tanzania						

* Ports served by the EAR&H railway network

(e) *Lake Tanganyika*

Lake Tanganyika is more than 700 km in length and borders on four nations: Burundi, the Congo (Democratic Republic of), the United Republic of Tanzania and Zambia. It can, therefore, form an excellent axis of integration from north to south. Two of its ports, Albertville and Kigoma, are served by the railway.

Up to the current time, it has been mainly used as a line of penetration by Burundi, the Congo (Democratic Republic of) and the United Republic of Tanzania. Until 1964, the Lake Railway (CFL) was the only one linking the northern part with the ports of Kigoma, Rumonge, Baraka, Bujumbura, Kalundu and Kabimba. The distances between these ports is indicated in table 4.

In 1958, 220,000 tons were handled at Albertville and also 220,000 at Bujumbura. In the same year, traffic on the Congo (Democratic Republic of) line from Rwanda and Burundi *via* the United Republic of Tanzania amounted to 89,000 tons, all of which therefore passed through Kigoma.

Table 4. Distances between ports of Lake Tanganyika
(Kilometres)

	Albertville	*Kabimba*	*Kigoma*	*Rumonge*	*Baraka*	*Bujumbura*	*Kalundu*
Albertville* (Congo (Democratic Republic of))		57	135	258	309	345	345
Kabimba (Congo (Democratic Republic of))	—	—	84	207	258	294	294
Kigoma (United Republic of Tanzania)	—	—	—	123	174	210	210
Rumonge (Burundi)	—	—	—	—	51	87	87
Baraka (Congo (Democratic Republic of))	—	—	—	—	—	102	102
Bujumbura (Burundi)	—	—	—	—	—	—	24
Kalundu (Congo (Democratic Republic of))	—	—	—	—	—	—	—

* Also served by railway

The south-western shore of the Lake is likewise exploited by CFL, from Albertville (PK 0) to Kataki (PK 10), Tembwe (PK 70), Moba-Baudouinville (PK 135), Zongwe (PK 190) and Lunangwa (PK 320).

On the south-western shore, the EAR & H ensures transport between Kigoma and Mpulungu (480 km), serving *en route* Lagossa, Kibweza, Karema, Kirando, Kipili, Wapembe, Kala and Kassanga. Total traffic is around 12,000 tons per annum.

(f) *Lake Nyassa*

About 480 km in length, Lake Nyassa is bordered by Malawi, Mozambique and the United Republic of Tanzania. Two railways now reach its shores at Chipoka in Malawi and Metangula in Mozambique. In the United Republic of Tanzania, a branch line from Makumbako to Ilela is under consideration. At the current time, there is little traffic on the Malawi shore, between the ports of Monkey Bay, Chipoka, Kota Kota, Nkata Bay, Deep Bay, Kambwe, Itungi and Moamba Bay. In view of its great length, Lake Nyassa could be used for long-distance international transport.

(g) *The small lakes*

The other international lakes—Lake Edward, Uganda—the Congo (Democratic Republic of); Lake Kivu, Rwanda—the Congo (Democratic Republic of); and Lake Moero, Zambia—the Congo (Democratic Republic of)—are used for navigation of local interest, but they are, apparently, too small to incorporate into an international transport system. Lake Rudolph (Ethiopia-Kenya-Sudan), does not seem to be used at all.

(h) *The Zambezi River*

At the current time, the Zambezi is not suitable for navigation, except up-river from Livingstone and down-river from Marromeu. The Portuguese plan to work on the river at Cahora-Bassa and in the Lupata Gorges might in the future make it a waterway for trade between Southern Rhodesia and Zambia, on the one hand, and Mozambique and perhaps Malawi on the other.

(i) *The Congo and Ubangi Rivers*

The Congolese system also serves as a line of penetration for the Congo (Brazzaville) and the Central African Republic. The railway which goes from Pointe Noire to Brazzaville (510 km) beyond the Congo, and then to the Ubangi, gives access as far as Banqui in all seasons. Seasonal navigation exists up-river as far as Ouango. On the right bank of the Congo, the Sangha, one of its tributaries, gives access to Salo in the Central African Republic and Port Soufflay (by means of a minor confluent, the N'Goko) as far as the borders of Cameroon and the Congo (Brazzaville). This network also serves as an axis of integration between the Central African Republic, the Congo (Brazzaville) and the Congo (Democratic Republic of).

3. Roads

Apart from air travel, the road network is the sole means of transport between the various countries. It consists roughly of the following:

(a) *One feed-road*: Matadi-Beira (4,640 km). With a length of 4,640 km, asphalted from Matadi to Kengo (650 km) and from Kolwezi to Beira (1,900 km), this road goes to Loulnabourg, Kamina, Elisabethville, Lusaka and Salisbury;

(b) *Five north-south roads*: These five roads (plus one variant), fed by the above mentioned road, consist of the following:

(i) *The great north-south axis (4,840 km)*: beginning in Asmara (PK 0), this road goes *via* Addis Ababa (PK 1,066), Nairobi (PK 2,549) and Dodoma (PK 3,256), to Tunduma (PK 4,023), and rejoins the feed-road at Kapiri-Mposhi (PK 4,840). Approximately 700 km are asphalted, but between Ethiopia and Kenya, the road is just a track, accessible only to four-wheel-drive vehicles;

(ii) *The Lakes axis (2,540 km)*: from Juba (PK 0), this road goes to Kampala (PK 671), Uvimza (PK 1,534) and Abercorn (PK 2,162), and rejoins the great north-south axis at Mpika (PK 2,546).

(iii) *The east Congolese axis (2,820 km)*: from Juba (PK 0), this road runs west of the Lakes to Bunia (PK 657), Goma (PK 1,230), Bukavu (PK 1,438) and Albertville (PK 1,944), to rejoin the feed-road at Elisabethville (PK 2,823);

(iv) *The central Congolese axis (2,800 km)*: from Bangassou (PK 0), it goes *via* Stanleyville (PK 725), Kindu (PK 1,327) and Kamina (PK 2,363), and ends at Guba (PK 2,797), on the feeder, near Jadotville;

(v) *The Malawi axis (1,980 km)*: from Mpulungu (PK 0), this road intersects the great north-south axis at Tunduma (PK 236), serves Fort Hill (PK 329), Lilongwe (PK 396), Blantyre (PK 1,355) and Tête (PK 1,581), and ends at Salisbury (PK 1,975);

(vi) *Lake Tanganyika variant (900 km)*: an alternative lake axis route from Kampala (PK 0) goes to Rwanda and Burundi *via* Kigali (PK 584) and Bujumbura (PK 880), to its terminus at Kalundu (PK 903).

(c) *Transversal roads*: there are excellent roads to duplicate the lines of penetration, but this paper is concerned only with those giving access from one country to another. They are mainly as follows:

(i) Bangui-Bangassou-Bambouti-Juba: 2,073 km;

(ii) Stanleyville-Paulis-Juba: 1,186 km;

(iii) Stanleyville-Bunia-Pakwach-Gulu: 1,074 km;

(iv) Stanleyville-Bukavu-Gitegax: 1,104 km;

(v) Stanleyville-Gema-Kampala: 1,444 km;

(vi) Stanleyville-Kasese-Fort Portal-Kampala: 1,236 km;

(vii) Stanleyville-Kasese-Mbarara-Kampala: 1,220 km;

(viii) Lusaka-Fort Jameson-Lilongwe: 752 km.

On the whole, these roads, which do permit or have permitted trade between the various countries in the region of the Great Lakes, are mediocre, and the charges are, in practice, very high in comparison with those obtaining on the lines of penetration.

D. Transport costs

1. Road expenses and charges

The road transport sector has certain rather characteristic features. The cost of fully loaded operation (supply per ton per km) varies according to the features of the itinerary (width, length, layout, road level, type of surface and density of traffic), the type of vehicle used (petrol or diesel engine, lorries, semi-trailers, or 5-, 10- or 25-ton lorries and trailers), the competency of personnel employed and the levels of wages and prices. Once these factors are determined, costs are in proportion to the volume of transport: to transport 5, 25 or 100 times the quantity requires 5, 25 or 100 times more vehicles. The advantages of a large undertaking (discount from suppliers, repair shops etc.) are offset by an increase in general expenses (bureaucratization) and the initiative of small carriers. The road transport sector is therefore a highly competitive one, run for profit, with large and small undertakings existing side by side.

On to these technical factors of expenditure will be grafted the trade factors, which will determine the very variable prices, the degree of competition, the coefficient of loading, the probability of return freight, delays at either end, the distance carried, long-term contract security, etc. As the road carrier can do little about the technical factors, he will try to use the trade factors to his best advantage by choosing the most favourable itineraries: lengthy journeys carrying a full load in both directions without delay at either end. Road and regulations permitting, the ideal thing is transport between a large town and the port serving it. Port Sudan-Khartoum, Assab-Addis Ababa, Mombasa-Nairobi, Pointe Noire-Brazzaville, Douala-Yaoundé etc. It will then be the natural policy of the road carriers, joined together in a pressure group and backed by powerful private interests, to try to wrest from the public authorities the means of competing with the railways along the lines of penetration (improving the roads running parallel to the railway, relaxing the regulations, etc).

Several studies have been undertaken concerning the cost of supply per ton and per kilometre. They *all tend to prove* that in average trade conditions the price per ton per kilometre can rarely be less than 4 cents, sometimes 3 cents, with a transport organization (operation Hirondelle, Dahomey-Niger), but never below, 2 cents (for large carriers, fully-laden), except as compensation between different types of merchandise (Addis Ababa-Assab). In point of fact, high competition and ignorance of the rules of accountancy and of estimating prime costs leads some carriers to offer below-cost prices regardless of amortization, provision for major repairs, insurances etc., which explains some of the prices currently quoted.

In Senegal, prices varied from 11.9 cents per ton per km on the Tambacounda-Kegougou road to 1.80 cents per ton per km on the Dakar–Kolack road, a good asphalt road on which competition is very high.[12]

In Nigeria, prices ranged from 7 cents per ton per km to 2.8 cents per ton per km,[13] the latter being a rate regarded as exceptional, possible only in the case of long term contracts with return freight.

Tariffs on the EAR&H road services in the United Republic of Tanzania (1963) vary from 3.4 to 6.4 cents per ton per km, according to the type of goods carried.

In Uganda, the rate for road transport between Kampala and Biti (330 km) is 5.6 cents per ton per km.[14] It is estimated, however, that if the branch line is built, this figure may be reduced by about one third which would bring it to 3.7 cents per ton per km.

Again in Uganda, E. K. Hawkins mentioned the case of a call for offers to carry goods in bulk daily over 50 km, fully loaded, without return freight, on a stabilized dirt road.[15] Twenty-eight offers were received, as shown in table 5.

Table 5. Uganda: rates offered for one-way transport of bulk goods over 50 kilometres*

(Cents per ton per kilometre)

Number of offers	*Transport rate*
2	3.4–4.2
8	4.3–5.1
10	5.2–5.9
4	6.0–6.8
2	6.9–7.6
1	7.7–8.5
1	over 8.5

* No return freight.

Tariffs on the Central African Road, Ltd. between Nairobi and some towns in Southern Rhodesia and Zambia vary according to the type of goods (from 3 to 5.6 cents per ton per km) and according to the weight carried (less than 1 ton, from 1 to 5 tons and over 5 tons).

The Southern Rhodesian railways use a scale of charges for their road services varying from 5.32 to 12.57 cents per ton per km, according to the type of goods. These rates also vary slightly according to distance (up to 320 km).

In 1959, the tariffs in force on the road junction from Bujumbura to Astrida and Kigali (Burundi and Rwanda) were as follows:

(*a*) Bujumbura-Astrida (166 km): $14 per ton, or 8.4 cents per ton per km;

(*b*) Bujumbura-Kigali (299 km): $22 per ton, or 7.3 cents per ton per km;

(*c*) Astrida-Bujumbura (166 km): $11 per ton, or 6.6 cents per ton per km;

(*d*) Kigali-Bujumbura (299 km): $17 per ton, or 5.7 cents per ton per km.

The lowest rates in Africa on a per-ton-and-kilometre basis are probably those obtaining in Ethiopia, on the road axis Addis Ababa to Assab (560 km). This road, which connects a large city in the interior with one of the ports that serve it, is used by lorries with trailers (25 ton load) plying fully loaded in both directions without any considerable delay at either end. The tariffs are fixed by the Government according to the type of goods carried and the direction taken, within the limits shown in table 6.

Table 6. Tariffs fixed by Government of Ethiopia for road axis, Addis Ababa–Assab

(Cents per ton per kilometre)

Addis Ababa–Assab		*Assab–Addis Ababa*	
Hides and skins	3.00	Cars, pick-up vans	4.65
Coffee	1.74	Beverages, tires	1.02
Cereals, oil cake	1.16	Sacks, steel pipes	2.09
		Salt	1.86

Again in Ethiopia, a call for offers in June 1965 for fully loaded (10 tons) transport both ways on a two-lane asphalt road from Nazareth to Awassa gave the results shown in table 7.

Table 7. Rate offers for two-way fully loaded transport Nazareth–Awassa, Ethiopia

Course	*Distance (kilometres)*	Offer No. 1	Offer No. 2	Offer No. 3
		(Cents per ton per kilometre)		
Nazareth–Awassa	234	2.99	2.22	5.62
Modjo–Awassa	305	2.64	2.13	5.60
Awassa–Nazareth	234	1.97	2.99	5.62
Awassa–Modjo	305	1.95	2.34	5.60

In Ethiopia a call was also made for offers to carry 30,000 tons of cement over 25 km without return freight at the rate of 2,500 tons a month (unloading only at carrier's expense), with the results shown in table 8.

Table 8. Ethiopia: rate offers for one-way transport of 30,000 tons of cement over 25 kilometres*

Offer No.	*Transport rate (dollars per ton)*	*Transport rate (cents per ton per kilometre)*
1	0.66	2.64
2	0.78	3.12
3	1.00	4.00
4	1.28	5.12
5	1.50	6.00
6	1.63	6.52
7	1.94	7.76
8	2.00	8.00

* No return freight.

In the Sudan, the through-booking arrangements between the Sudanese and East African railways for carrying goods by road between Juba and Nimule (197 km) specify a rate of 45 Sudanese millimes per 10 kg, or 4.5 Sudanese pounds, or $12.91 per ton. This corresponds to a mean rate of 6.5 cents per ton per km.

2. COSTS AND TARIFFS BY WATERWAY

Few studies are available concerning the costs of

[12] Compagnie d'Etudes Industrielles et d'Aménagement du Territoire, (CINAM), *Le flux des Transports dans la République du Sénégal* (Paris, June 1961).

[13] *Transportation: A Guide to Current Costs in Nigeria* (June 1964).

[14] Uganda, Study of the Bihanga-Biti Railway Extension.

[15] E. K. Hawkins, *Roads and Road Transport in an Underdeveloped Country: A Case Study of Uganda* (London, Her Majesty's Stationery Office, 1962), p. 97.

the Congo (Democratic Republic of), Morocco, Nigeria and the United Republic of Tanzania. Charcoal made from timber is a substitute for coking coal, within limits, in the blast furnace system, and adequate supplies exist, for example, in East Africa, where coal supplies are both limited and inaccessible. Oil and natural gas can be used to reduce coke requirements by injection into the blast furnace or by direct reduction of iron-ore, and these materials are available in large quantities in North Africa, West Africa and Central Africa. Hydroelectric possibilities in Africa are probably unparalleled and could be used for electric smelting, especially in the Central African and East African subregions.

III. Economics of the industry

Two key economic issues arise in considering the establishment of an iron and steel industry in developing countries. The first is that of securing economies of scale, which are very large in metallurgical operations and which, in fact, usually necessitate a market greater than that provided by any single country. At the same time, the market area to be served cannot be spread too widely; otherwise, transport costs become prohibitive. The problem is, therefore, one of balancing increasing of economies of scale against rising transport costs. It is unlikely, for example, that an iron and steel plant established in one of the African subregions would be able to compete in other subregions with local plants, and this is one of the main reasons for considering industrial development in Africa on a subregional basis at first. Without detailed analysis, however, it is not possible to say whether one or two or even three plants could supply a particular subregion most efficiently.

The second issue is that of choosing the lowest cost location for a plant, having regard for the cost of assembling raw materials for the manufacture of steel and the cost of distributing the finished product. Once more, it is only by detailed consideration of the location of markets that this issue can be decided.

Both these problems have been examined in some detail in the East African and West African subregions in the course of discussions on the development of the iron and steel industry, and the conclusions reached are discussed in the next chapter. The present chapter is concerned with the more general aspects of economies of scale and location.

As far as economies of scale are concerned, it may be expected that metallurgical operations would broadly conform to what is sometimes called the 0.6 rule, i.e., that increasing the capacity of a plant by 10 per cent will increase capital investment by only 6 per cent and, therefore, reduce capital costs per unit of output by about 4 per cent.[9] Doubling the capacity of works will accordingly reduce unit costs by about one-fourth, and halving the capacity will increase them by about one-third. The different operations carried out in iron and steel manufacture vary, however, in regard to both the extent of economies of scale and the level of output at which these economies become critical. Moreover, since total costs also include the cost of fuel, labour and raw materials, some of which are constant, economies of scale, as far as total costs are concerned, are considerably less than those indicated by the above mentioned rule.

Fairly detailed investigations are included in a paper prepared for the United Nations Economic Commission for Africa (ECA) Conference on the Harmonization of Industrial Development Programmes in East Africa;[10] they are summarized below.

Open cast mining of iron-ore or coal can be efficiently conducted on a scale of about 1 million tons per annum with little further reduction of costs for increasing scale of operations, but with costs increasing by about one-quarter if the scale of operations is halved.

Costs of iron production by the classical blast-furnace method conform reasonably well to the 0.6 rule if raw material costs are excluded, but the total cost of manufacturing iron per unit increases by about 17 per cent for a reduction in the scale of operations from 800,000 tons per annum to 400,000 tons per annum and would decline by 6 per cent for an increase of scale of operations from 800,000 to 1.6 million tons per annum. Corresponding changes in unit costs in relation to scale for other iron-making processes, e.g., kiln processes, are approximately 12 and 2 per cent, respectively, so that such processes tend to compete with the classical blast-furnace at lower levels of output. These processes are used, however, mainly for other reasons, e.g., kiln processes where non-coking coal is available and charcoal blast-furnaces where only wood is available.

Similarly, electric-smelting processes can be efficiently carried out at a lower scale of output, so that while, from a thermal point of view, electricity must be very cheap to compete with coal, electricity at 0.2 cents per unit equals coal at $15.60 per ton; when capital costs are also taken into account, the competitive price for coal is reduced to $5.40 per ton at low scales of output.

Steel-making by the Lenz-Donhai processes conforms fairly well to the 0.6 rule, but electric steel-making gives only small economies of scale and can be efficiently carried out on a small scale.

The rolling of sections and flat products also conforms to the 0.6 rule, except that in regard to bar and rod it is possible, by reducing the number of stands, to secure efficient operations at an output below 200,000 tons per annum. There are, of course, several scrap-melting and bar-rolling mills in Africa operating at about 10,000 tons per annum. These mills are, however, high-cost producers and are competitive mainly because they have the advantage of using cheap local scrap.

Total unit costs for an integrated works producing bar and rod would fall by about $14 per ton if the scale of operation were increased from 400,000 to 800,000 tons per annum, and in the case of flat products, by about $17 per ton. Taking transport charges by rail as consisting of $4 for terminal charges and 2 cents per ton per mile for running charges, such an increase in scale of operations would be justified if the additional market, in the case of bar and rod, were within 1,000

[9] "The development of the iron and steel industry in Africa" (E/CN.14/INR/27).

[10] "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87).

river or lake transport in Africa.[10] Many factors intervene, as noted below.

The width of the navigable channel and the minimum bend radius dictate the size of the convoy, adaptation of the convoy pushed rigidly to the bends and facilities for passing and overtaking. Large convoys pushed along the Congo can measure up to 240 metres, whereas nothing over 110 metres can negotiate the narrow bends of the Itimbiri.

The capacity of the means of transport employed is limited by considerations of depth. V barges of 1,200 tons (76 metres by 11.50 metres) on the Congo with a 2 metre draught. V barges of 50 tons (24 metres by 3.50 metres) on the Itimbiri with a draught of 0.90 metres (57 ton capacity if built of light alloy).

Permanency of depth throughout the year is a condition for making best use of equipment. The capacity of V barges on the Congo is reduced in the conditions shown in table 9, according to how low they lie in the water.

Table 9. Capacity of V barges on Congo River, by their depth in water

Depth in water (metres)	Capacity (tons)	Percentage maximum
1.80	1,444	
1.70	1,005	88
1.50	805	70
1.20	570	50
1.00	414	36

The problem of lack of depth was discussed in one report as follows:

"Lack of depth causes increased resistance to the forward movement, and therefore requires greater effort on the part of the tug. This often entails division of the convoy.

"It limits the power of the tugboats, because if a draught of 1.50 instead of 1.20 metres were available for k-type tugs, for instance, propellers of 1.80 metres in diameter could be adapted and made to absorb a power of 625 hp instead of 330 hp at 330 revolutions a minute. With an additional 30 cm of draught, the power of a tugboat of this type could therefore be almost doubled."[11]

Navigation by night is possible through night-buoying, which permits better use of equipment. In studying navigation on the Nile, a duration of 4,000 hours of navigation per annum is estimated without the use of night-buoys, as compared with 6,000 hours per annum with night-buoying and two crews.

The inadequate size of locks involves a division of convoys and consequently a loss of time. The usable measurements of the locks at Nag Hammadi, Assiut and Esna are 70 × 15 metres. The five locks following the old Aswan Dam measure 80 × 9.50 metres. Modernization of the locks would mean that shipping could go through more rapidly. At the current time, the hand-manipulated locks at Esna, Assiut and Nag Hammadi require about an hour for each operation.

River works may also constitute an impediment to navigation. The width between the buttresses of the Nag Hammadi bridge is only 16 metres, which is not enough to accommodate convoys 15 metres wide.

The technique used — the type of propulsion and method of tugging — also has a great bearing on the cost. The method of propelling two or more barges at a time is giving way to that of pushing and of using integrated two-boats which reduce the resistance to forward movement and can be operated with fewer hands.

For instance, the figures given in table 10 were drawn up by A. Lederer for transporting timber along the Congo between Dongo and Leopoldville, a distance of 1,050 km, with a convoy of four 500-ton barges and one 500 hp pusher, with night navigation. The duration of rote, twenty-two days, comprises the following: four days down river and six days up, seven days unloading and five unloading. The value of the tug is $240,000 and it is assumed to be in use 240 days per annum; the value of one barge is $60,000, assumed to be in use 300 days per annum. On the basis of the foregoing information transport costs are as shown in table 10.

Table 10. Cost of transporting timber along Congo River between Dongo and Leopoldville

(Dollars)

Daily cost of pusher	
Repairs, upkeep, amortization, interest	120.00
Fuel and lubricants	120.00
Wages of crew (2 × 7)	24.80
General expenses (crew)	18.60
	283.40
Daily cost of barges	
Repairs, upkeep, amortization, interest	24.00
Cost of transport	
Tug for ten days	2,834.00
Four barges for twenty-two days	2,112.00
Cost of one trip	4,946.00
Prime cost per ton (return empty)	2.473
Prime cost per ton per kilometre	0.236

The relative values of the incidence of various factors (draught, navigation by night, return cargo, equipment used) on the cost were assessed by A. Lederer in his study of transport on the Nile. He arrived at the results given in table 11, in which the figures indicate the cost per ton per kilometre on the basis of 100.

[10] See A. Lederer, "Transport sur le Nil en aval d'Assuan", Communications à l'Académie Royale des Sciences d'Outre-Mer de Belgique, *Bulletin des Séances*, Vol. VII, No. 4 (1960); "Transport de bois sur le Congo", *Bulletin des Séances*, Vol. VIII, No. 6 (1962).

[11] Conseil du Gouvernement du Congo Belge, Session budgétaire, 1958, *Notes documentaires*, annex II, p. A30.

Table 11. Relative values of incidence of various factors on cost of transport on Nile River

	M			P		T	
	[illegible] hp [illegible] tons	[illegible] hp [illegible] tons + PB [illegible] tons	[illegible] hp [illegible] tons + TB [illegible] tons	[illegible] hp + PB [illegible] tons	[illegible] hp + TB [illegible] tons	[illegible] hp + PB [illegible] tons	[illegible] hp + PB [illegible] tons
Convoy load (tons)	470	970	970	1,000	1,000	2,000	4,200
Draught below 1.80 metres without night navigation							
Without return cargo	116	87	97	81	100	75	69
With return cargo (50%)	87	62	66	56	69	52	47
With night navigation							
Without return cargo	100	74	80	69	84	62	55
With return cargo (50%)	76	55	59	47	58	43	38
Permanent draught of 1.80 metres without night navigation							
Without return cargo	92	68	72	64	79	60	55
With return cargo (50%)	67	49	52	44	55	41	37
With night navigation							
Without return cargo	82	58	62	54	65	49	43
With return cargo (50%)	60	43	46	37	46	34	29

NOTE. M = Motorized (200 or 40 CV). P = Pusher (400, 800 or 1,500 CV). T = Tug (450 CV). PB = Pushed barge (500 or 1,050 tons). TB = Tugged barge (500 tons).

These few figures show that the price can be low if a good waterway is available. This is the case with the Congo, the Kasai, the Nile (at least from Khartoum to Malakal) and the Great Lakes. That is why the Democratic Republic of the Congo decided to extend the railway from Aketi to Bumba; the distance is shorter, of course, but also there are navigational difficulties on the Itimbiri.

Generally speaking, the waterways — both river and lake — are exploited by the same companies as the railways, and at the same rates, as follows:

(*a*) The Sudan Railways exploit the navigable reaches of the Nile at the same rates as the railway;

(*b*) EAR&H exploits Lake Victoria and Lake Tanganyika at the same rates as the railway, allowing for expenses of load transference;

(*c*) CFL exploits the Lualaba and Lake Tanganyika at two-thirds of the railway tariff plus transfer expenses and harbour dues (1959);

(*d*) OTRACO exploits the Congo, the Kasai and the Matadi-Léopoldville railway. No data are available concerning the rates charged;

(*e*) All the Congo carriers — OTRACO, CFL, Chemin de fer du Bas Congo au Katanga (BCK) and VICICONGO — grouped together in the Congo Carriers Committee (COMITRA), apply a concerted policy with the tariffs and allow for goods carried on associated networks in applying the provisions concerning lower rates for longer distances.

As the great lines of penetration are managed by a single company or group of companies, the tariff policy is the same as that of the railways.

3. RAILWAY COSTS AND TARIFFS

The business of rail transport has a number of special characteristics. At the economic level, expenditure on construction and financing is high, whereas expenditure on operations is low. Income increases with volume of traffic, and mean expenditure decreases. Therefore, the only justification for a railway is that there should be considerable traffic.

In so far as accounting methods permit of analysis by airing and correctly assessing expenses, the actual costs vary around this mean average in relation to the distance carried (incidence of terminal loads) and the volume of load (small quantities, full trucks, whole trainloads), all other things being equal.

The concept of public service is usually preponderant in railways, which are of general interest. The public authorities require them to carry at certain rates (approved rates) and within certain time-limits. For passenger service, they are likewise required to ensure minimum regular connexions. The concept of profit in private enterprise gives place to that of public service. The railway is not required to make a profit, but to cover its expenses by receipts and to do its best to help develop the economy.

The public authorities exercise close supervision over the railway and, by way of compensation, allow it certain advantages (power of expropriation and of drawing up regulation); they protect it (control of road competition along routes parallel to the railway line) and help it to comply with the required conditions (traffic papers etc.). The most remarkable characteristic of the railway, however, is undoubtedly the economic policy it enables the State to follow in connexion with the scale of charges, owing to its monopolistic position.

Several factors come into play in fixing the mean cost — layout and contour of the line; bracing of the track; spacing of railway-stations; degree of modernization (electric, diesel, welded rails, heavy trains, automatic coupling, etc.); wage-levels, skill, conscience and productivity of personnel, competency of management, volume, type, structure and balance of traffic, distance of transport, group charges, loan conditions, so that the mean cost depends upon local conditions, and it is not possible to transpose from one network to another. Only one factor is common to all: cost decreases with the rising volume of traffic.

This is explained first of all by the considerable financial expenditure involved. The cost of a railway line varies between $50,000 per km (Uganda, Kenya) and $100,000 per km (Cameroon). At 7 per cent per annum this means $3,500 to $7,000 per km. For a traffic of 100,000 tons per annum this expenditure is between 3.5 and 7 cents per ton per km. For a traffic of 500,000 tons per annum it falls to between 0.7 and 1.4 cents per ton per km. In practice, events (devaluation, payment of loans) have often eliminated them, and in new constructions they are reduced by favourable financial conditions (grants, long-term loans at a low rate of interest).

Structural expenses (upkeep of track, premises and telecommunications, station personnel etc.) are almost independent of the volume of traffic, at least within certain limits. In the study for the Trans-Cameroon railway they are assessed at $1,640 per km. For the Bihanga-Biti extension in Uganda they are estimated at $1,480 per km and on the Moshi-Kiu link line (Uganda–United Republic of Tanzania), at $1,400 per km.

Operational costs, on the other hand, are very low: 86 cents per ton per km for the Bihanga-Biti extension, 69 cents per ton per km for the Kilombero Valley Project, 36 cents per ton per km offered for the Trans-Cameroon, and 25 cents per ton per km offered for the Moshi-Kiu link line.

The incidence of this various expenditure on the mean cost per ton per km is indicated in table 12, with figures taken from the Kiu-Moshi link (see also figures VII and VIII).

Table 12. Incidence of various expenditures on mean cost per ton per kilometre, Kiu-Moshi link-line

(Cents per ton per kilometre)

Volume of traffic (thousands of tons per annum)	*Exp. on operation (4)*	*Structural Exp. (3)*	(4) + (3)	*Renewal annuity (2)*	(4) + (3) + (2)	*Exp. on finance (1)*	(4) + (3) + (2) + (1)
100	0.25	1.40	1.65	0.30	1.95	3.15	5.10
200	0.25	0.70	0.95	0.15	1.10	1.57	2.67
300	0.25	0.46	0.71	0.10	0.81	1.05	1.86
400	0.25	0.35	0.60	0.075	0.67	0.78	1.455
500	0.25	0.28	0.53	0.06	0.59	0.63	1.22
600	0.25	0.23	0.48	0.05	0.53	0.52	1.05
700	0.25	0.20	0.45	0.043	0.49	0.45	0.94
800	0.25	0.17	0.42	0.037	0.46	0.39	0.85
900	0.25	0.155	0.405	0.033	0.438	0.35	0.788
1,000	0.25	0.14	0.39	0.030	0.42	0.315	0.735
1,100	0.25	0.127	0.377	0.027	0.404	0.286	0.69
1,200	0.25	0.116	0.366	0.025	0.391	0.262	0.653
1,300	0.25	0.108	0.358	0.023	0.381	0.242	0.623
1,400	0.25	0.100	0.35	0.021	0.371	0.225	0.596
1,500	0.25	0.093	0.343	0.020	0.363	0.210	0.573

In any case, once a given traffic level is reached, the cost of rail transport is lower than that of road transport. This level varies with local conditions and is around 150,000 to 300,000 tons per km per annum.

In the region of the Great Lakes, all the railways reach or even greatly exceed this level. In 1962/1963, the average density of traffic on the Sudan Railways was over 500,000 tons. On the EAR&H it was 525,000 tons per km (including transport in service in 1964). The average traffic on the network in Southern Rhodesia and Zambia is around 1.6 million tons per km. It was about 1,710,000 tons per km in 1958 on the Matadi-Léopoldville Railway, 700,000 on the BCK and 190,000 on the CFL, but only 52,000 on the VICICONGO. On the Angola Railway, the average density of traffic was 1,050,000 tons per km in 1960. Nearly all the railways thus have low prime costs, which permit them to follow a tariff policy.[18]

For a network, the mean cost varies according to the line in relation to the volume of traffic it carries, since structural expenditure would be distributed on a *pro rata* basis in proportion to such traffic. Structural expenditure per ton per km is lower on the Mombasa-Nairobi or Port Sudan-Khartoum line, where traffic exceeds 200,000 tons per annum, than on the Kalina-Mpandu or Babanousa-Wau line, where it has not yet reached 100,000 tons per annum. A single tariff based on distance and regardless of line is, therefore, an initial compensation with a view to the general interest.

Discriminatory rates based on the type of goods carried are a second compensation. To carry a truckload of whisky or of fertilizer costs the railways about the same amount, but the tariffs are very different. The following figures are for 500 km:

	Railway line		
	Southern Rhodesia	*EAR&H*	*Sudan*
		(dollars per ton)	
Whisky	37.00	16.00	36.00
Fertilizer	2.90	3.30	3.70

If the mean cost is 1.5 cents per ton per km, or $7.50 per ton for 500 km, carrying 1 ton of whisky for 500 km in the Sudan gives a profit of $28.50, which permits 7.5 tons of fertilizer to be carried 500 km at the reduced rate of $3.70 per ton.

[18] See annex II, figures XII-XX for data on tariffs of various African railways.

Figure VII. Rail transport costs

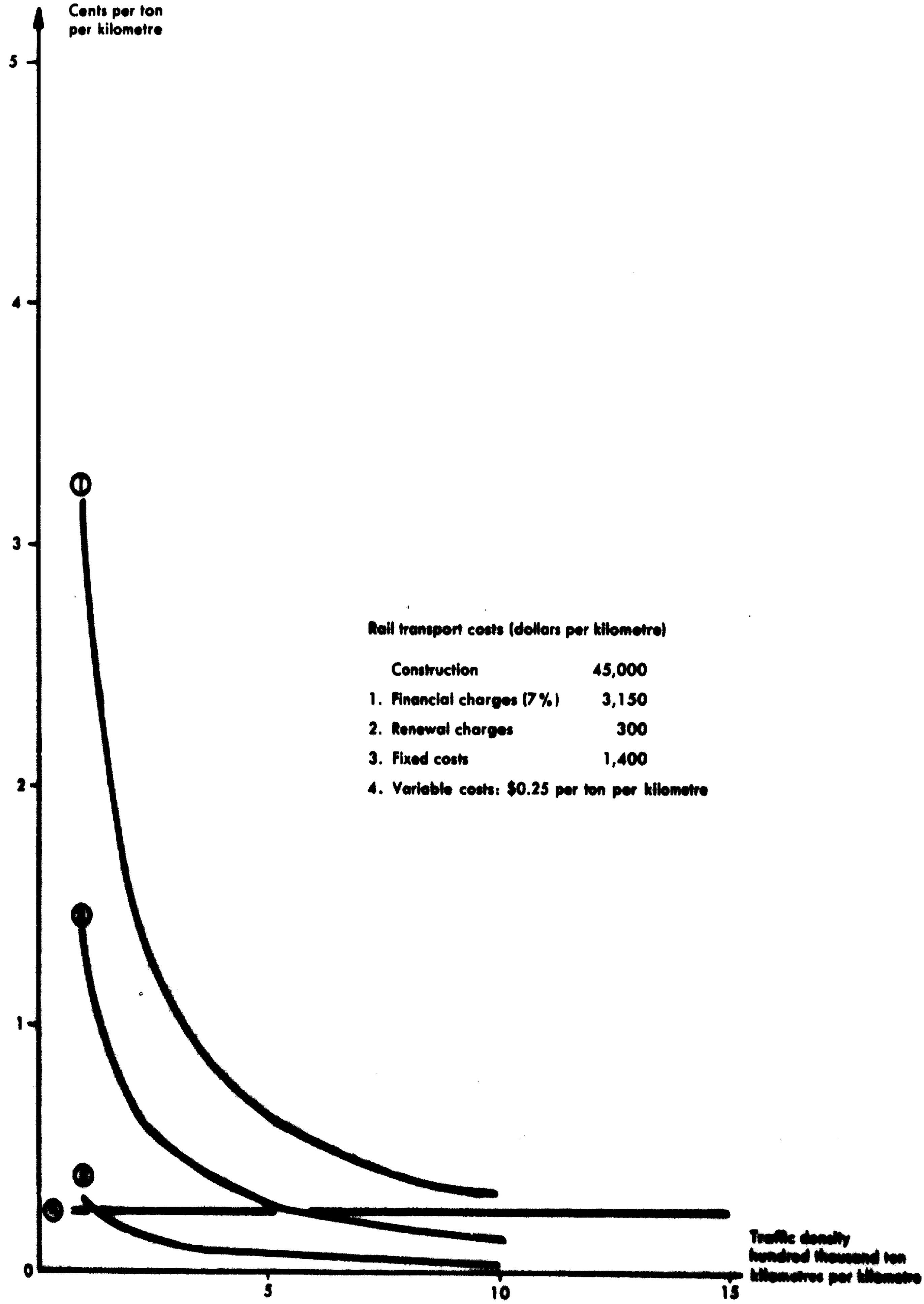


Figure VIII. Combined rail transport costs

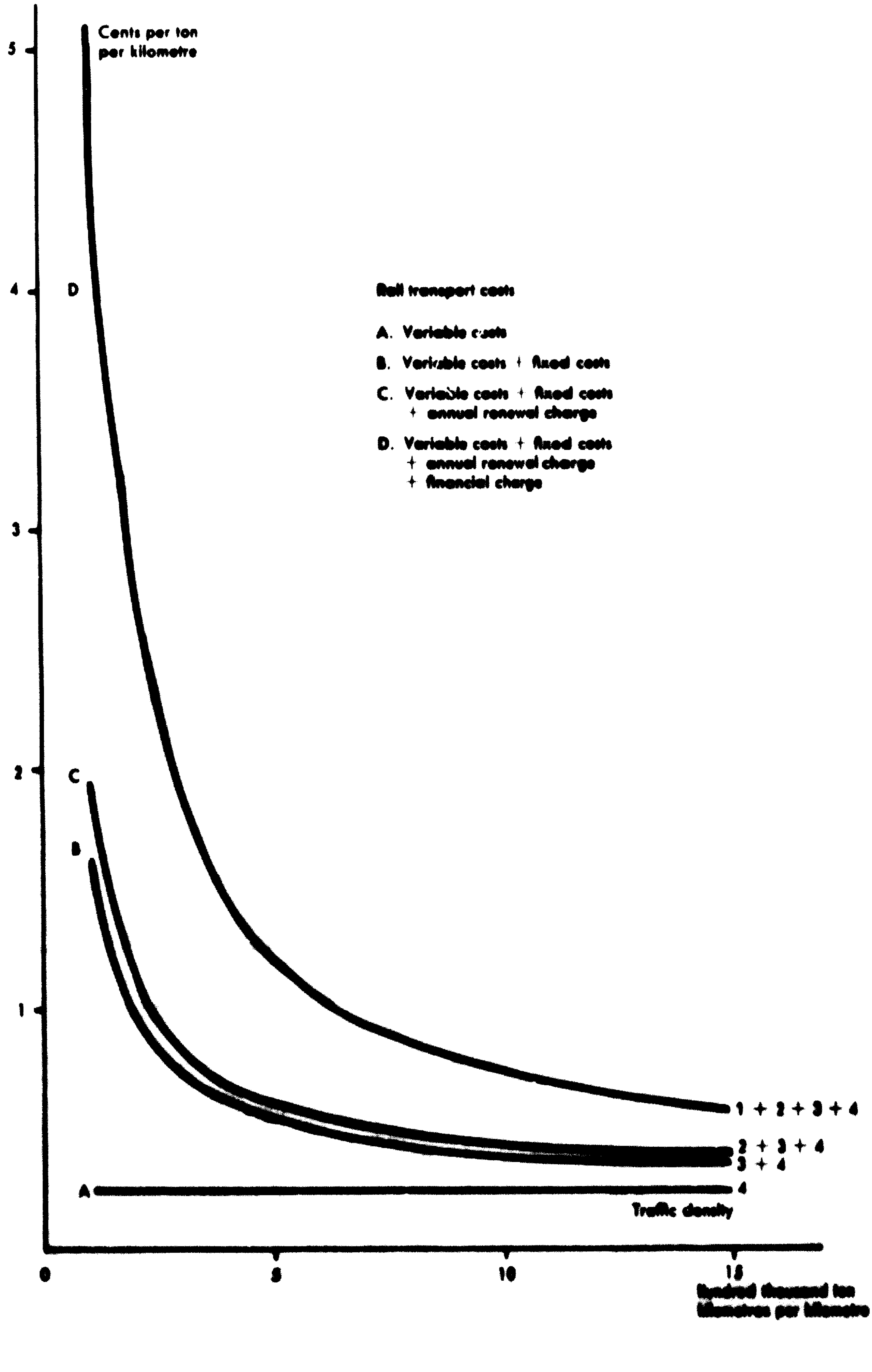
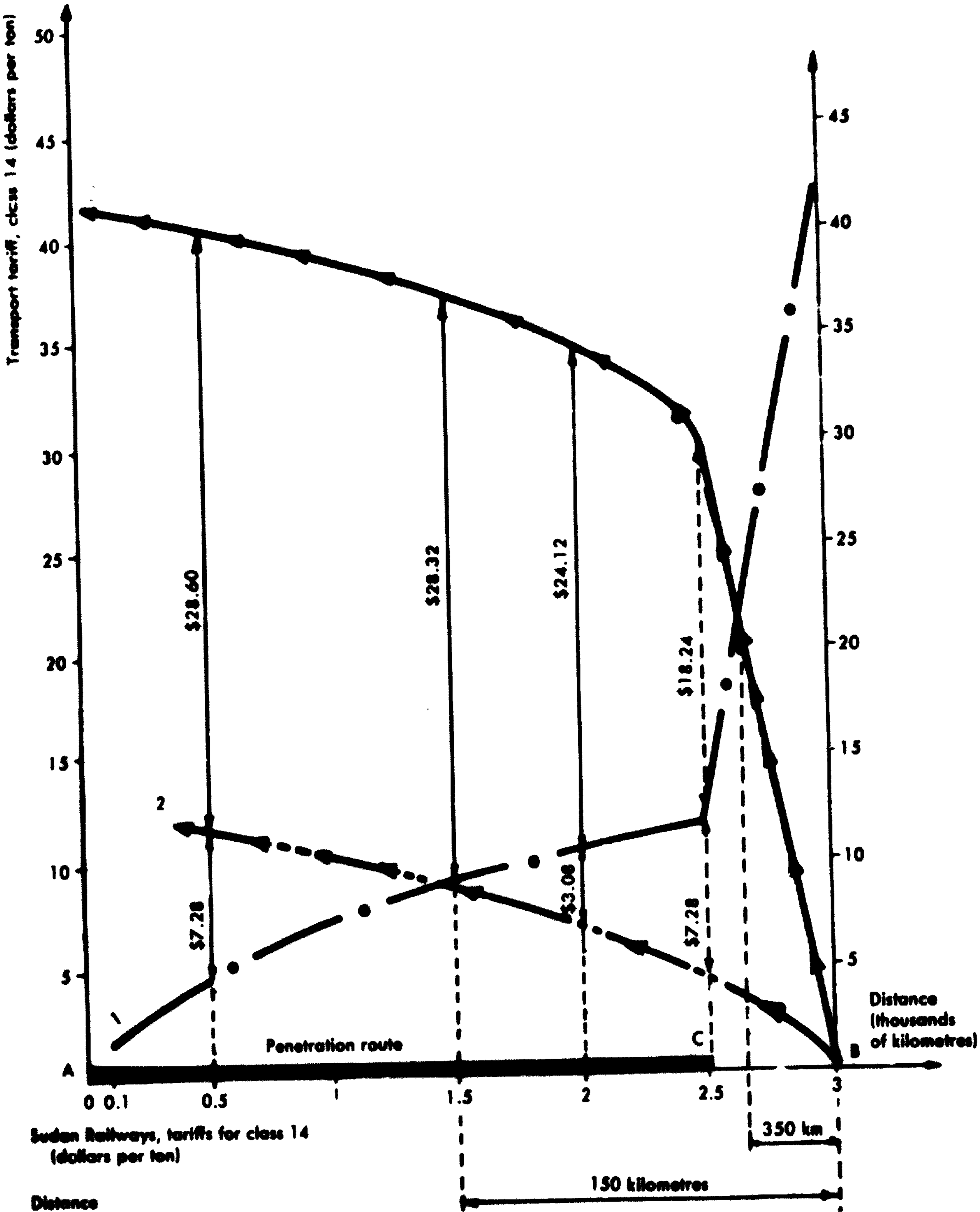


Figure IX. The effect of unequal transport rates in disintegrating the African market



Sudan Railways, tariffs for class 14 (dollars per ton)

Distance (kilometres)	Tariff
100	1.68
500	4.48
1,000	7.28
1,500	8.96
2,000	10.36
2,500	11.76

Road: $0.06 per ton per kilometre
$30 for 500 kilometres

Transport charge

Competing imported product

African product

Current transport system

Improved transport system

The discrimination of rates and the economic policy thus permitted explain the reserved attitudes towards projects for major routes parallel to the railway (Mombasa-Nairobi, Port Sudan-Khartoum etc.). On these axes the road carriers would be in a position to charge around 2.5 to 3 cents per ton per km (long distance, fully loaded in both directions, with large carrier lorries and without any appreciable delay at either end), thus depriving the railway of all the profitable traffic which permits it to practice a transport policy, or else forcing it to lower its tariffs. In both cases, this would lead to a decrease in compensation possibilities and, therefore, to an increase in privileged tariffs (fertilizers, foodstuffs, exports etc.).

Diminishing rates according to distance is a third form of compensation, in so far as it does not reflect the exact decrease in costs, but rather amplifies it.[19] The diminution is very marked, as may be seen from the figures for the Southern Rhodesian railways in category 10, for example (coffee, steel).

Table 13. Southern Rhodesian railways: tariffs for goods in category 10

	Tariff	
Distance (kilometres)	*Dollars per ton*	*Cents per ton per kilometre*
100	6.17	6.17
500	10.80	2.16
1,000	15.12	1.51
1,500	19.44	1.30
2,000	22.22	1.11
2,500	24.68	0.98

Discrimination according to type of goods carried and diminishing rates according to distance are the rule on the great lines of penetration in the region of the Great Lakes: Sudanese Railways, Southern Rhodesian railways, EAR&H (see annex II, figures XII - XX).

This policy is likewise followed by the Congolese system with an added compensation organized between the various Congolese carriers for interregional tariffs,[20] based on six principles, as follows:

(*a*) Expensive products pay for inexpensive products;

(*b*) No product should pay more than it can afford;

(*c*) No product should normally pay more in internal transport than it would pay in export;

(*d*) Tariffs should correspond to transport allowances;

(*e*) The general tariff should apply equally to all customers;

(*f*) Profits from tariffs, as a whole, should provide carriers with whatever resources they require.

Lastly, the tariff policy is also used to favour African industrialization and African products: in Nigeria, cement from Nkalagu and Abese; in East Africa, fibrocement at Tororo, iron and steel from Jinja etc.

For the products regarded as most indispensable for the economy of the country, this policy allows extremely low tariffs on the lines of penetration — frequently lower than 1 cent per ton per km over long distances and as little as 0.5 cents per ton per km for such products as fertilizers over a distance of some 2,500 km.

On the other hand, tariffs are high (around 6 cents per ton per km) on the axes of integration, which consist mainly of mediocre roads. Even if the roads are improved, tariffs cannot in practice be lower than 3 cents per ton per km.

This difference in tariffs between lines of penetration and axes of integration involves a real breakdown of the African market in favour of imports and to the detriment of the African products. It is an obstacle to economic co-operation, thus paralysing industrialization.

E. Fragmentation of the African market

The fragmentation of the African market is very evident on all the axes and lines. Take, for instance, the Sudanese line, where it is most striking (see fig. IX). In the case of an imported product listed in category 14 (cement), for instance, the rate for carriage along the line of penetration from Port Sudan to Juba (2,500 km) is $11.76 per ton. From there on, it must be sent by road at 6 cents per ton per km. Over a total distance of 3,000 km, the cost of transport is $41.76 per ton, of which $30.00 per ton is in respect of the last 500 km (see fig. IX, graph 1).

At the end of this itinerary (Uganda), if the intention is to make and sell cement in the Sudan, the African product will be heavily penalized. It will have to travel 500 km by road at 6 cents per ton per km, thus adding $30.00 per ton to the carrying costs at the very outset. Then it will take the Sudanese line in the opposite direction, paying the same rate as imported cement (see fig. IX, graph 2).

The diagram shows that, for the same outlay on transport, the African product travels only 350 km, while the imported product can travel 2,650 km, or almost eight times the distance. Half-way, the African product is therefore penalized at the rate of $28.32 per ton. Although the c.i.f. cost of the important is the same as the *ex*-factory price of the African product, the market for the latter is only 350 km distant.

Assuming that an improved transport system and a tariff policy allow of equal transport rates in both directions, then the African product (given equality of c.i.f. and *ex*-factory prices) could compete with the imported product up to half-way, or 1,500 km (see fig. IX, graph 3). With a Customs protection of $7.28 per ton, the African product could be sold at a distance of 2,500 km from the place of manufacture, but with the current system of transport, it would need a protection of $28.60 + $7.20, i.e., $35.80 per ton.

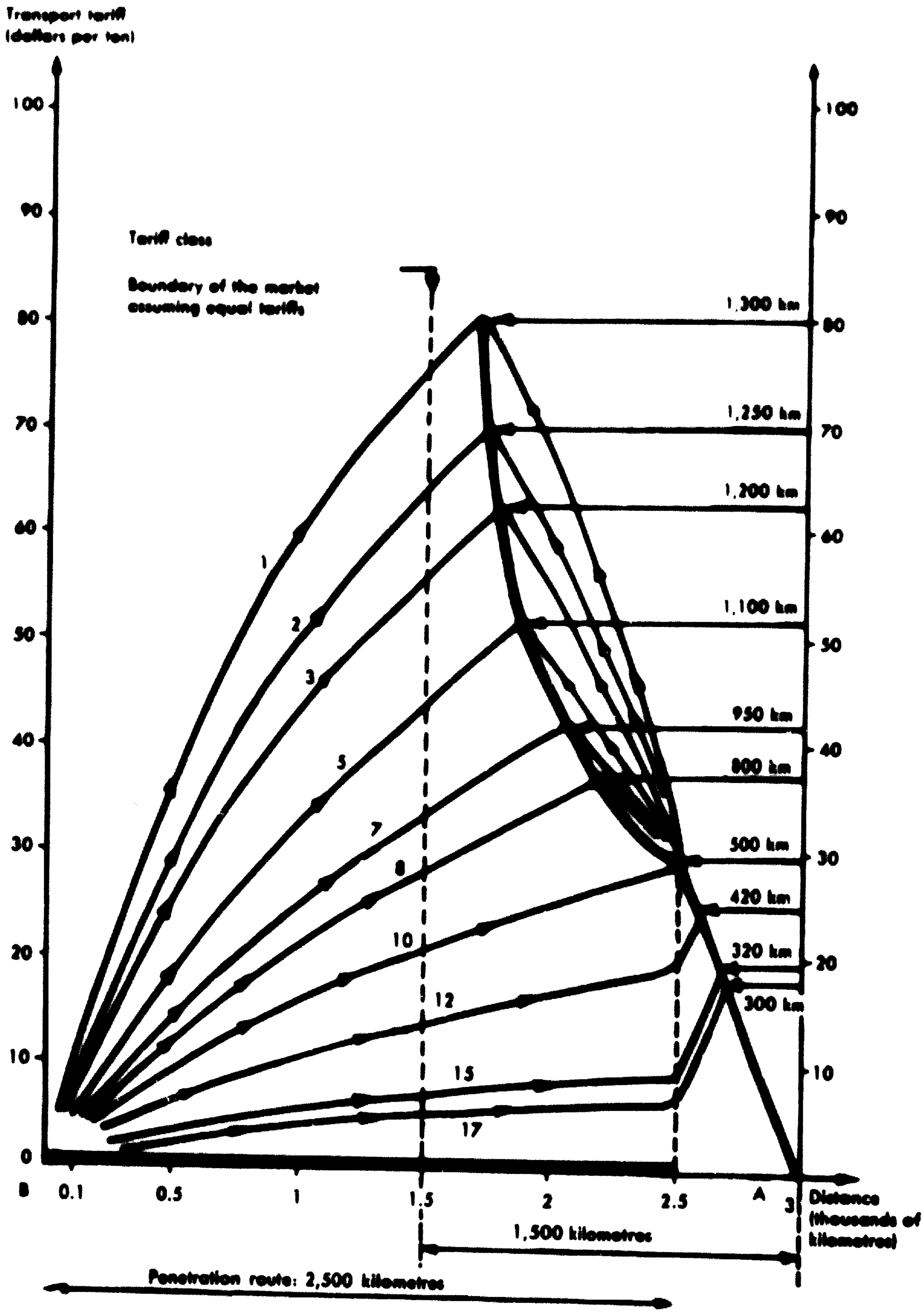
A change from the current rates to equal rates in both directions would increase the sales radius from 350 to 1,500 km. For a continent where consumption would be in proportion to the sales radius (same density of population, same tastes, same income brackets etc.), this would multiply by eighteen the size of the market available to African enterprise.

The fragmentation of the market varies with tariffs and, therefore, with the category of goods transported (see figure X). Categories for which the tariffs are highest are only lightly penalized (a sales radius of 1,300 km for category 1), whereas for category 17, the radius is only 300 km. For category 10 (steel produced in Uganda), the sales radius would be approximately 500 km.

[19] See A. Hazlewood, *Road and Rail in East Africa* (Oxford, Basil Blackwell, 1964).

[20] See *Transport in the Belgian Congo* (1959), chapter X, "Tariff policy".

Figure X. The disintegrating effect of penetration route tariffs on the African market

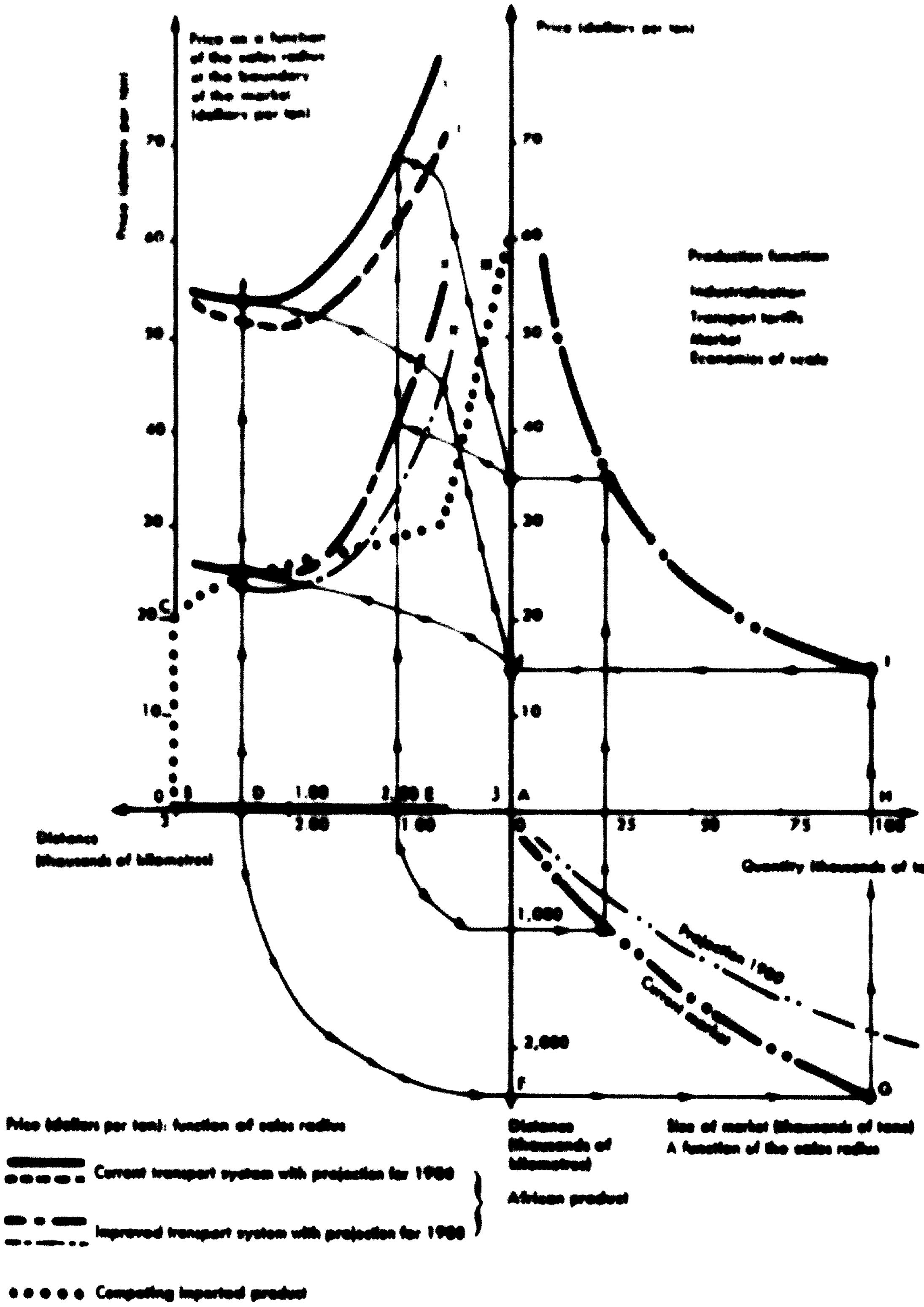


By reducing the natural sales radius, the current system paralyses industrialization, for some types of industry which cannot exist under the current system would become possible as a result to sizable economies in a built-up market.

1. Fragmentation of the market and economies of scale

It is presumed in figure XI that an African product, the productive operation of which is shown in the

Figure XI. Africa: domestic versus imported product, effect of transport tariffs upon the market



north-east quadrant, is in competition with an import costing $20 per ton c.i.f. The price of the import (c.i.f. plus transport) is shown in the northwest quadrant, graph III.

For a given localization of African enterprise it is possible to determine consumption in the various trade centres (actual or estimated consumption) and to draw a graph showing the size of the market in relation to the sales radius (south-east quadrant).

These graphs and hypotheses regarding transport tariffs enable one to determine the feasibility of establishing a new industry, as is discussed below.

Beginning from D, 2,400 km distant from the site of the proposed industry, the south-east quadrant gives a bearing on the size of the market: (DFG), i.e., 100,000 tons, which leads to a price of $54 per ton (point L) *ex*-factory, 2,400 km distant. An improved transport system would lower the price to $25 per ton.

Repeating this operation for the various sales areas and joining all points obtained with the current transport system (point L), one comes to graph I, showing the price at the market limits with the existing transport system.

Repeating it again for an improved transport system (point K), one has graph II, which gives the market-limit price with the improved transport system.

Assessing consumption, one obtains graphs I′ and II′, based on the current transport system and the improved transport system.

The relative positions of graphs I, II, I′ and II′, and of graph III indicate the possibilities of industrialization. These relative positions depend upon the market, production operations, transport tariffs and the c.i.f. cost of the competing import. Graphs I, II, and I′, and II′ begin to decrease with the distance from the proposed centre of production (economies of scale are greater than increased carrying costs) down to a minimum, and then rise as optimum production approaches (economies of scale weaken and increases due to transport costs become preponderant).

It is easy to interpret figure XI. Graph I does not cut across graph III: the industry cannot be established because in any case the African product is more expensive than the imported product. Industrialization cannot be contemplated without the help of strong customs protection.

Graph I′ does not cut across graph III either. Even by estimating consumption, it is not possible to forecast the date on which industrialization could be contemplated without recourse to customs protection.

Graph II intersects graph III. If a better transport system were available, the new industry could be considered at once. The African product could naturally compete with the imported product up to approximately 2,200 kilometres. Graph II′ confirms the possibility of industrialization.

The diagram cannot be applied in cases where several lines of penetration lead to the neighbourhood of a projected centre of production (for instance, Uganda has the Sudanese, Kenya-Uganda, Trans-Angola and Congolese lines), because it presupposes the following conditions:

(*a*) That the c.i.f. price of the competing product is identical in all sorts commanding the lines of penetration;

(*b*) That the lines of penetration and the axes of integration linking them to the proposed production centre are the same length;

(*c*) That the tariffs in force there are the same.

These hypotheses, however, may easily be counteracted by making use of the isoline theory, with global production and transport costs. It is best to retain the previous diagram, the presentation being less intuitive in this case.

The causes of the fragmentation of the African market may then be summed up as follows:

(*a*) On the axes of integration, high cost of transport: road transport on mediocre roads;

(*b*) On the lines of penetration, low tariffs due to various causes:

(i) The existence of good navigable waterways;

(ii) The use of technique: the railway, which, through an economic factor of dense traffic, permits low average costs;

(iii) The application of a tariff policy (discrimination according to type of merchandise and reduction for distance), which permits a lowering of tariffs for the most useful products.

How can the African market be built up to facilitate economic co-operation? There are many obstacles to be encountered.

II. Building up the African market: obstacles to economic co-operation

To try to build up the African market, some way must be found to obtain the same tariffs on the axes of integration as on the lines of penetration.

One way would be to increase the tariffs on the lines of penetration to the same level as those obtaining on the axes of integration. From the political and social standpoints, however, this is not practicable. It would be curing the disease by killing the patient.

The solution, therefore, would be to reduce tariffs on the axes of integration, so that African products could compete with imported products on an equal footing.

A road solution is apparently not enough. Considerable improvement of the existing roads would mean, at best, an average rate of 3 cents per ton per km, whereas the tariff policy in force on the lines of penetration permits, in some cases, a figure as low as 0.5 cents per ton per km.

A waterway solution seems to be ruled out, because such enormous investments would be required. At the current time, it is not possible to consider seriously making the Nile navigable from Juba to Lake Victoria, or digging canals between the lakes and over the mountains at a cost of hundreds of millions of dollars.

The only workable hypothesis that remains is to interconnect the various railway networks.[21] But this is not a miracle solution. Indeed, it has been shown how high structural expenditure prevents the railway from offering low-cost transport unless there is enough traffic. Otherwise, the cost per ton per kilometre would be higher than that of road transport. This solution, therefore is not suitable unless a certain minimum volume of traffic is assured — say, approximately 200,000 to 300,000 tons per annum.

It is perhaps possible to make this condition a little more elastic. An interconnexion between networks consists of extensions which are marginal, as compared with each individual network. General expenses are not the same as for an independent new line. Furthermore, the same compensation which comes into play between existing lines could also apply to the extension, subject to slight changes in the tariffs as a whole. This possibility should, therefore, be studied in detail. In any case, it is not without its limitations and harks back to the fundamental condition of a traffic minimum. Everyone agrees that transport facilities are the bottle-neck

[21] This hypothesis encounters certain technical difficulties due to the various characteristics of the African networks: gauge of tracks, coupling system, braking system etc. As the secretariat of the United Nations Economic Commission for Africa has undertaken a study of ways and means of overcoming such difficulties, they will not be considered in the present text.

miles of the plant or 1,500 miles, in the case of flat products. If only road transport is available, then these figures would be reduced to about 800 to 1,100 miles, respectively, while the availability of sea transport would widen the market to about 1,600 and 2,600 miles. In general, therefore, and within the African subregions, economies of scale are likely to outweigh transport costs, and one large integrated plant is likely to be a cheaper means of supplying steel to a subregion than two or more smaller plants.

Location analysis involves the evaluation at various possible sites of the total cost of assembling raw materials, of manufacturing steel and of distributing the finished product. The manufacturing cost will vary with the process used, the quality of the available raw materials and with labour rates, etc., and must be evaluated in each case.

The cost of assembling raw materials relates essentially to transport costs on iron-ore, fuel and limestone. Of these, iron-ore is easily the most important since even with high-quality ore, 2 tons are required for each ton of finished steel produced, whereas under certain circumstances, e.g., with careful preparation of the ore and the use of oil and natural-gas injection, coke requirements can be reduced to about .5 ton per ton of finished steel. The quantity of limestone required depends upon the quality of the iron-ore, but would not normally exceed .5 ton. An inland iron and steel plant is, therefore, normally located close to iron-ore deposits, and a coastal plant near a port which has a railway link with the iron-ore deposits and, at the same time, has the advantage of cheap sea transport for importing other materials, e.g., coke and limestone, and for distributing finished steel.

With improved bulk-handling facilities, the cost of transporting raw materials per ton-mile has been reduced to about one-third of that for finished steel, so that the total transport cost per ton-mile on the raw materials required for steel manufacture is now about the same as that on the finished product. Nevertheless, iron and steel plants are located near the source of raw materials rather than the market, mainly because the market is not one particular location, but consists of several centres so that, in most cases, moving nearer to one centre is moving away from another.

The precise calculation of the most suitable location requires an estimate of consumption at the various market centres and of the transport costs to each. As is described in the following chapter, these calculations have been made for the East and West African subregions. There are, however, certain general principles applicable to all location calculations. First of all, it is reasonable to establish re-rolling works in the main centres of consumption, based on billets from the suitably located integrated works. This is because distribution costs are reduced to the extent that the cost of transporting billets to the centre for re-rolling is less than that of transporting finished steel, and there is also less damage in transport. This saving is usually, however, insufficient to offset entirely the loss in economies of scale which results from dividing output even at the rolling stage and even of the simpler products, such as bar and rod, and the main justification for doing so is to spread employment and income, and to widen experience in metallurgical operations. Secondly, it is possible to measure the extra cost involved in having two integrated plants instead of one, the loss in economies of scale being partly offset by the reduction in transport charges secured by each plant delivering within its own area. It should be noted, however, that while the extra unit cost of having two plants instead of one may be small, the total investment may be considerably greater, e.g., if investment follows the 0.6 rule, it would be nearly one-third higher.

As far as specialization on different types of finished steel is concerned, the economies of scale even on flat products are only about $6 a ton when production is increased from 400,000 to 800,000 tons per annum, and it would only pay, therefore, to achieve this specialization if this gain were not lost in increasing transport charges, i.e., if the extra transport involved were within 200 to 300 miles. With the low level of consumption in African countries, it is, therefore, doubtful whether the stage has yet been reached when specialization is an economic proposition, and, in general, each integrated works will tend to make as many products as practicable so as to achieve economies of scale at the iron- and steel-making stages.

In all the cases so far examined in detail, it has been shown that it is possible to produce iron and steel in Africa at costs well below those obtaining in Europe. In the case of West Africa, the estimated cost of producing re-inforcing bar in an integrated works with a capacity of 450,000 tons per annum at Buchanan, after allowing 15 per cent on the investment, is $98 per ton and at an 800,000-ton capacity, $81. The corresponding figure for a new plant installed in the United Kingdom of Great Britain and Northern Ireland is $116.

In East Africa, it was estimated that an integrated works selling at prices equal to those of imported steel would make a gross return of 40 per cent on capital, while two integrated works would make a return of 33 per cent.

IV. Future development

In discussing the future development of the iron and steel industry in Africa, it is convenient to proceed by considering, for each of the subregions in turn, the current facilities available for iron and steel production, the extensions now in course of installation and, lastly, longer term possibilities. Finally, some consideration may be given to the relationship between development in the various subregions and in the region as a whole.

A. North Africa

Algeria has a small steel works in operation, rolling reinforcing bars and small sections, and based on melting scrap in an open-hearth furnace. The furnace has a capacity of 30,000 tons per annum, and the rolling mill, 35,000-40,000 tons per annum. A major project for the erection at Bone of an integrated iron for African development,[22] but, in point of fact, economic justifications are lacking because of a series of vicious circles, contradictions and constraints.

A. Long-term planning compared with short-term problems

In the first place, studies on industrialization and economic co-operation are on a long-term basis. In the documents submitted to the Conference on the Harmonization of Industrial Development Programmes in East Africa (Lusaka, 26 October - 6 November 1965), the target year was 1975, or even 1980. Governments and those in charge of day-to-day administration are, however, faced with short-term problems. Hence, there is a conflict in which "sweet" and "sour" words are easily bandied — utopianism and realism; broad views and down-to-earth considerations.

Non-industrialized and dominated by systems handed down from colonial times, states must, first of all, export raw materials and import equipment goods. National development plans are based on non-African, foreign trade. Most of the traffic that can be forecast is concentrated on the lines of penetration, more especially on the sectors nearest to the ports. In making improvements, it is normal to give priority to these sectors — thus strengthening the lines of penetration.

National planners and foreign experts are inevitably drawn towards the same attitude. Nearly all the plans advocate improving the supply network and lines of penetration, and overlook the axes of integration. The reason for this is simple: at the current time, traffic is negligible on all these axes, and there is no means of foretelling what it will become in the future. To apply even a 10 per cent trend to traffic in the neighbourhood of 2,000 to 3,000 tons per annum does not lead to proposals for any considerable changes.

The outlook for trade in agricultural products is not very encouraging, because economies are frequently in competition and trade in industrial products is unpredictable, as it depends upon an inter-State agreement on economic co-operation and the location of undertakings and markets. In the absence of such agreement, plans to improve the axes of integration have no foundation.

The authorities responsible for national transport systems, faced with the daily difficulties of operating and of achieving financial equilibrium, are not anxious to overload their networks with lines which might create further liabilities through lack of traffic. Multilateral and bilateral organizations decline to finance infra-structure which is not justified by traffic, because they are afraid of burdening the budget of the States with maintenance expenses, or of seeing equipment deteriorate through lack of upkeep.

So far as transport is concerned, therefore, the economists find it impossible to propose any appreciable change in the current system and to justify it from an economic standpoint.

B. Predetermined framework of subregions

Secondly, industrial planners appointed to study industrialization and economic co-operation are obviously hampered by the predetermined framework of the subregions and by the fact that the current system of transport is not adapted to circumstances. The documents of the Lusaka Conference are convincing in this respect.

The paper on the chemical industries (E/CN.14/INR/83) submitted to the Conference deals with the transport system and accepts the existing framework, but, reading between the lines, regards it as ill-adapted.

Another paper submitted to the Conference, "Electrotechnical engineering industries in the East African subregion" (E/CN.14/INR/89), goes even further:

"From the market point of view and considering transport difficulties, it would be well to treat the Subregion in three sections (see map):

"(i) The north, covering Ethiopia, French Somaliland and Somalia, which have better communications with neighbouring countries to the north than with those to the south.

"(ii) The centre, comprising Kenya, Uganda, Tanzania, Burundi and Rwanda. These countries have considerable ties with the Democratic Republic of the Congo to the west.

"(iii) The south, comprising Malawi, Zambia and Rhodesia. These have ties with Mozambique to the east and Angola to the west.

"Malagasy, Mauritius and Reunion could join either the central or the southern sections."

In still another paper submitted to the Lusaka Conference — "Development of the iron and steel industry in East and Central Africa" (E/CN.14/INR/87) — special attention is given to projects for transport infra-structure which might change the picture: rail communications between the United Republic of Tanzania and Zambia; a link-line from Sinoia to Kafue; navigability of the Zambezi. Regarding the projected metal products industry at Tororo, it makes a discreet appeal for the markets of the upper Congo and equatorial Sudan to be taken into consideration.

Yet none of these planners, taken individually, is able to propose any change in the framework or in the current system of transport. The quantities of finished products to be distributed by each country are insufficient to justify any appreciable change. The predetermined framework and the current transport system inevitably tend to mask some of the possibilities and, perhaps, to lead to an underestimation of the true possibilities.

The result is, therefore, a vicious circle:

(*a*) Industrialization is impossible, because the market is not large enough;

(*b*) To build up the market by improving the lines of communication is not economically justifiable because, through lack of industrialization, there is no trading to be done.

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[22] See interview with P. Moussa, former Director for Africa of the International Bank for Reconstruction and Development, *Le Figaro* (19 May 1964):

Question: "Which categories of investment are most productive and desirable?

Answer: "Infra-structure, in some cases: roads, railways, ports, canals, dams, power-stations — these are the most desirable investments. After her Liberation, it was clear that the first priority in devastated France was to rebuild lines of communication. Similarly, they constitute the most serious bottleneck in Africa, the one which must be got rid of first. French aid has long given very clear priority to infra-structure.

"In the case of industry, Africa is facing a serious difficulty because of her extremely restricted national markets. Of 35 independent countries in Africa, only two — Nigeria and Egypt — have more than 20 million inhabitants. Twenty-six of the 35 countries in question have less than 10 million, and 22 of them less than five million. Eight independent African countries have even less than two million inhabitants."

C. Conflict between financial and economic concepts

Moreover, improving the transport system is complicated by conflicts of doctrines between the financial and the economic concepts. This is obvious in the case of the railways, as evidenced by such slogans as "The railway must pay for itself", "The roads bring wealth", "Transport is not an end in itself".

It has been seen that the railway costs include (*a*) an initial investment on track and premises, and (*b*) annual operational expenses, i.e. running expenses, structural expenses and renewals.

According to the financial concept, the railway regarded as a private enterprise must bear the amortization of the initial loan. Such expenditure has a marked effect on average cost. In the case of figures VII and VIII (pp. 136 and 137), these financial commitments amount to 1.6 cents per ton per km for a traffic of 200,000 tons per annum, whereas the total amount for other commitments is 1.1 cents per ton per km. To obtain a mean cost of 1.22 cents per ton per km, the traffic world has to reach 500,000 tons per annum. The financial conditions of the loan are of overriding importance.

According to the economic concept, the initial investment is separated from annual operational expenses. The investment (building of infra-structure) leads to low transport costs: 1.10 cents per ton per km for a traffic figure of 200,000 tons per annum. This low rate favours economic growth and, therefore, increased national production. The soundness of the operation is then judged by the relationship between the increasing national production and the amount of the investment. If the project is not considered economically sound, financial problems are solved by whatever means are available: grants; long-term, low-interest loans; financing from the state budget with maximum limitation of commitments incurred by the railway.

Two conditions must be fulfilled in applying this concept:

(*a*) A traffic minimum to allow a low mean cost. This minimum, however, is lower than in the case of the financial concept because amortization of the initial loan is excluded. In the hypotheses considered in figures VII and VIII (pp. 136 and 137), this minimum is approximately 200,000 tons per annum instead of 500,000 tons per annum, to obtain a mean cost of approximately 1.15 cents per ton per km;

(*b*) Economic soundness through economic growth made possible by the low mean cost. This growth, by forward and backward linkage effects and through the multiplier, gives added value to the gross domestic product, which, in theory, is partly recoverable through fiscal channels and thus facilitates loan repayments.

This economic concept was applied in studying the Trans-Cameroon railway.

The economic concept tends to regard industrialization and the building up of the market through improved lines of communication as an indivisible whole composed of factors which justify one another.

The beginning point is the current position in which the fragmented market makes it impossible to set up important industries because of the high tariffs charged on the axes of integration.

At the cost of a large investment, a railway interconnexion is built between two or more lines of penetration. If there is enough traffic, the low mean cost on this interconnexion will help to build up the market.

This low mean cost, by building up the market, will permit African undertakings A, B, and C to be established on a sound financial basis, which heretofore would have been impossible. Forward and backward linkage effects plus wage distribution and their multiplying effects will give added value to the gross domestic product (see example given for Cameroon in the introduction to the present text).

If these undertakings are financially sound, that is to say, if they reward capital outlay by making a profit, no further attention should be made on such an outlay, which lays no burden on the community. Indeed, the community profits by the value added to the gross domestic product to compensate for its sacrifice in making the large initial investment.

The conditions must then be confirmed, as follows:

(*a*) The volume of traffic caused by supplying raw materials to factories A, B, C, etc., and distributing their finished products must reach a certain minimum, to justify a low tariff and to permit the effective rebuilding of the market.

(*b*) The value added for these factories must be sufficient to justify the considerable investment on the part of the community.

Some approximate amounts may be estimated on the basis of the figures given above (see introduction) for studies on the industrialization of Cameroon, as follows: capital investment for ten factories, $14 million; annual turn-over, $8.9 million; total increase in domestic product, $10 million.

For example, one may assume that a railway interconnexion for rebuilding the market would cost about $200 million and involve annual financial commitments of $14 million (at 7 per cent).

Rebuilding the market would permit the establishment of various industries (steel and metal products, fertilizers etc.) involving a volume of international transport amounting to 300,000 tons and giving a total value added of $280 million. The 300,000 tons would permit a low mean cost of transport. Moreover, it can be estimated that 5 per cent of the value added (or $14 million) would be recoverable through fiscal channels to amortize the construction of the interconnexion.

It is clear, therefore, that from the economic standpoint, industrialization, transport and economic co-operation are inextricably linked. They are different aspects of one and the same objective, and cannot be solved independently of one another. But these links make it possible to suggest an approach which would tackle each problem in turn, solving them one by one. The Great Lakes region of Africa seems appropriate for such procedure.

III. Hypothesis of work for rebuilding the African market in the Great Lakes region

It has been seen in connexion with the lines of penetration that six of them, operating at very low tariffs, arrive close to the perpendicular of a straight line drawn from Juba to Albertville (1,250 km). If it is possible to interconnect the six lines and to obtain the same tariffs as on one line of penetration, then the market will be strengthened throughout and industrialization and economic co-operation will appear in a different light.

The method of work would consist in providing the various industrial experts with a rebuilding hypothesis (politically acceptable to the States), that is to say, an interconnexion with a tariff to be confirmed *a posteriori* based on proposals put forward by the experts if the hypothesis were held to be economically justified.

A. Hypothesis of layout

The principle is the interconnexion of the lines of penetration. Several layouts may be considered, but the final choice can be determined only by field studies, economic studies and negotiation between the States. The layout indicated below in table 14 is merely an example, and distances are approximate (see also map 8).

Table 14. Africa: hypothetical interconnexion of lines of penetration, including branch lines

(Approximate distances in kilometres)

Juba — Gulu	100
Gulu — Kasambia	370
Kasambia — Bugene	280
Bugene — Kigali	140
Kigali — Bukavu	220
Bukavu — Uvira	130
Uvira — Bujumbura	30
	1,470
Branch lines	
Mungbere — Okollo	380
Bukavu — Kongolo	410
Bugene — Bukoba	100
Bugene — Kalius	420
	1,310

Such sectors as Bugene-Bukoba or Bugene-Kalius might not, perhaps, be indispensable. It might be well to link Kasene and Stanleyville, rather than Mungbere and Okollo. All this would be considered in detail in the studies.

The layout comprises some 2,800 km of railway. The existing African network consists of 80,000 km built over a century at an average rate of 800 km per annum. An interconnexion of 2,800 km built over a half dozen years to promote economic co-operation does not therefore seem too Utopian.

B. Approximate costs

Several extensions now planned in East Africa are estimated at about $50,000 per km. In West Africa, the Trans-Cameroon line will cost roughly $1,000 per km. As some Sectors of the interconnexion would have to be built in difficult mountainous country, the investment figure may be estimated at $200 million to $300 million. This sum does not seem excessive when compared with other investments.

Assistance to the developing countries amounts to $8,000 million per annum. Over a period of five years, this work would account for about 0.75 per cent of that amount.

The investment programme in the transport sector of seven Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Peru and Venezuela), over an average seven-year period, amounts to over $9,000 million.[23]

The cost of work on the Aswan High Dam, with the power-station and the power transport network, is in the region of $1,000 million. Each of the large African dams (Akosombo, Kainji and Kariba), together with the work related thereto, represents an investment in excess of $200 million.

Investment estimates for industrial co-ordination in East Africa total $4,000 million for the period from the current time to 1975-1980.[24] The same source indicates that the steel and metal products industry planned for Tororo around 1975 (annual production of 460,000 tons, $35 million), represents an investment of $114 million and would create a value added of $23 million.[25]

[23] United Nations, *El Transporte en América Latina* (United Nations publication, Sales No.: 65.II.G.7).

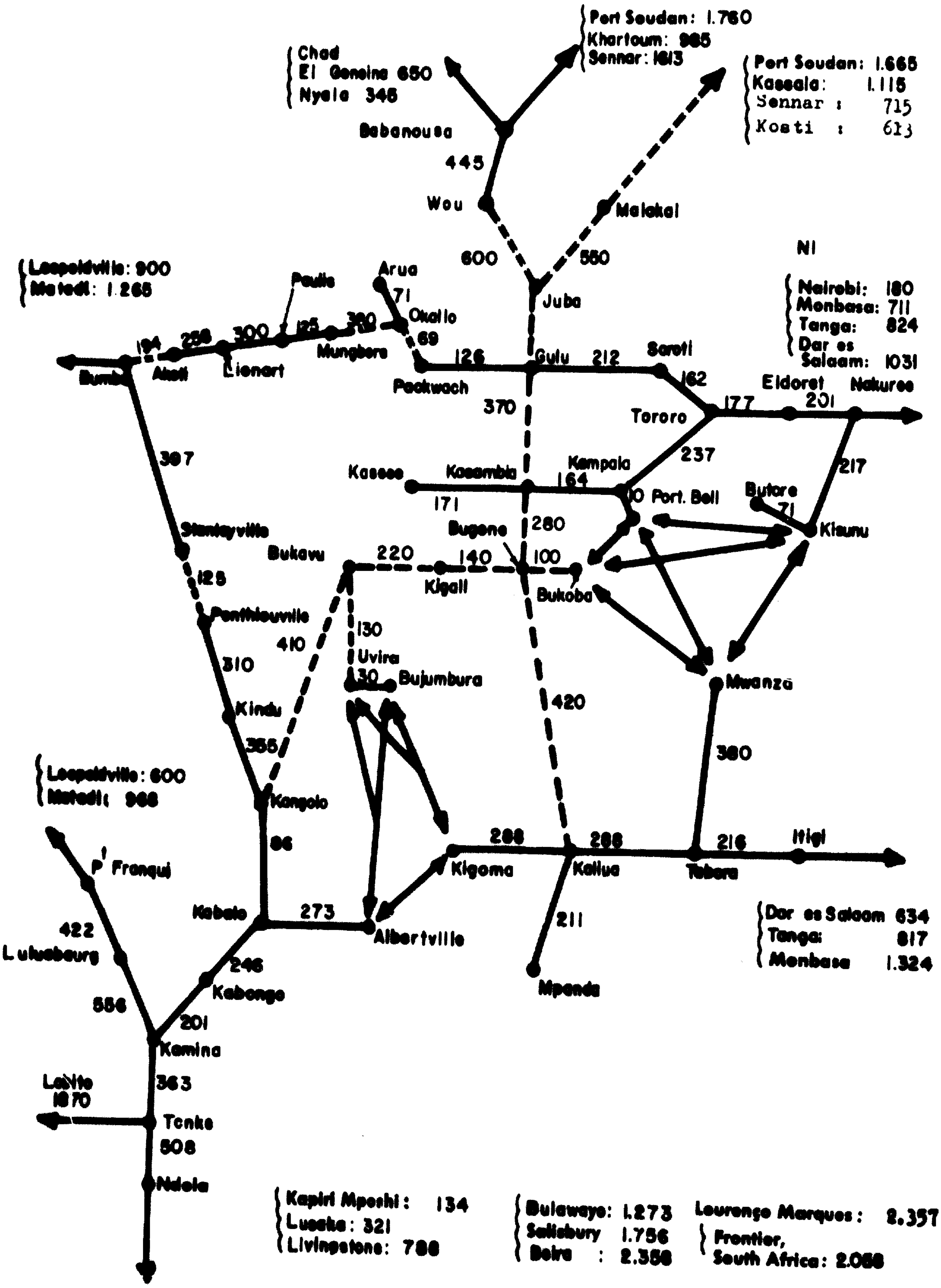
[24] United Nations Economic Commission for Africa, "Industrial co-ordination in East Africa: a quantitative approach to first approximations" (E/CN.14/INR/102), paper presented to the Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October — 6 November 1965.

[25] In this document (E/CN.14/INR/102), the concept of value added does not take account of forward and backward linkage effects, or of the multiplier.

IV. The Great Lakes region

The Great Lakes region can be considered merely by taking the Congo (Democratic Republic of) and the Sudan into account in studies on East Africa. The current population of the Democratic Republic of the Congo is 15 million and that of the Sudan, around 13 million, or 28 million in all, representing some 40 per cent of the population of continental East Africa.

Covering about 1,200 km, the proposed interconnexion axis concerns seven countries (Burundi, the Congo (Democratic Republic of), Kenya, Rwanda, the Sudan, Uganda and the United Republic of Tanzania), hence the possibility of creating an international development axis to distribute industries between several countries in the area.



Port Soudan: 1.760
Khartoum: 985
Sennar: 1613
Chad
El Geneina 650
Nyala 345
Port Soudan: 1.665
Kassala: 1.115
Sennar : 715
Kosti : 613
Babanousa
445
Wou
Malakal
600
550
Juba
Leopoldville: 900
Matadi: 1.265
Paulis
Arua
71
Okallo
69
Mungbere
126
Gulu
212
Soroti
162
Bumba
Aketi
Lienart
Packwach
300
125
390
NI
Nairobi: 180
Monbasa: 711
Tanga: 824
Dar es Salaam: 1031
Eldoret
Nakuru
177
201
Tororo
370
397
237
217
Kasese
Kasambia
Kampala
164
171
Port. Bell
Butare
71
Kisumu
Bugene
280
Stanleyville
Bukavu
220
140
100
Kigali
Bukoba
125
Ponthierville
130
410
Uvira
310
Bujumbura
Kindu
Mwanza
420
355
380
Leopoldville: 600
Matadi: 965
Kongolo
86
288
288
216
Itigi
Kigoma
Kaliua
Tabora
P' Francqui
422
Luluabourg
Kabalo
273
Albertville
211
Dar es Salaam 634
Tanga: 817
Monbasa 1.324
246
Kabongo
556
201
Kamina
Mpanda
363
Lobito 1870
Tenke
508
Ndola
Kapiri Mposhi: 134
Lusaka: 321
Livingstone: 788
Bulawayo: 1.273
Salisbury 1.756
Beira : 2.358
Lourenço Marques: 2.357
Frontier, South Africa: 2.058

All the extremities of the axis are far from the sea. The cost of overland transport is, therefore, a natural protection against competition from imports. The interconnexion, by opening Africa to itself, gives the landlocked countries a chance, as well as the areas which are far from the seaboard.

The Great Lakes region appears suitable for industrial activities. It has an important accessible market, dense population (and, therefore, abundant manpower), plentiful natural resources, vast reserves of hydraulic power etc.

The market could be extended as follows. To the north-east, Ethiopia, by improving communications with southern Sudan and Uganda, will naturally be called upon to form part of this market when the Ethiopian railway network is developed. It would then be shorter to send steel from Tororo to Addis Ababa *via* the interior than along the lines of penetration with maritime transport.

To the south, the development of navigation on Lake Tanganyika and improved communications between Mpulungu and the rest of Zambia would lead to the inclusion of Zambia in the market. This leads to the concept of an industrial axis from north to south, in the heart of Africa, centred on the Great Lakes and of interest to at least nine countries.

A. Extending the market

A study might be undertaken, for instance, on the limitations of the market for an undertaking located at Tororo (near the Kenya-Uganda border).

On the assumption that the steel and metal products industry at Tororo could sell at Mombasa (1,089 km from Tororo) and at Dar-es-Salaam (at least 1,400 km from Tororo), this would mean that in competing with imported products, the steel and metal products industry would have an advantage equivalent to transport over 1,100 km or 1,400 km (either through lower cost or through customs protection).

With the interconnexion, Tororo would be roughly 670 km from Juba, 1,720 km from Babanoussa (1,780 km distant from Port Sudan) and 2,100 km from Khartoum (800 km distant from Port Sudan). Assuming the *ex*-factory cost of the African product to be the same as the c.i.f. cost of the imported product, an African product manufactured at Tororo could go beyond Babanoussa and be sold as far away as Chad in the Abeché area. With a protection equivalent to 1,400 km, it could compete with the imported product as far as Khartoum, which means that it could capture practically nine-tenths of the Sudanese market. To the west, a product manufactured at Tororo could reach Kamina in Katanga at a distance of approximately 2,050 km, whereas Kamina is 2,140 km from Matadi on the Kasai and 2,230 km from Lobito. With a protection equivalent to only 400 or 500 km, the Tororo market would extend to all the eastern area of the Democratic Republic of the Congo: Kivu, Katanga and the eastern province.

Conversely, a Sudanese undertaking could market its products throughout the whole of Uganda and even further away, and the same would apply to an undertaking located at Stanleyville.

B. Consequences of extending the market

Studies on the steel and metal products industry at Tororo were based on the consumption estimates given in table 15.

Table 15. Projections of steel and metal products industry at Tororo

	Projections[a]			Projections[b]			
	Current	*1970*	*1980*	*Direct consumption*	*Existing factories*	*Proposed factories*	*Total*
Kenya	71	93	165	98	38	160	296
Uganda	26	34	60	53	11	39	103
United Republic of Tanzania	45	56	100	89	20	194	303
Burundi and Rwanda	1	2	3	1	1	1	3
TOTAL	143	185	328	241	70	394	705
Ethiopia	29	37	66	39	14	27	80
Madagascar	34	44	79	53	13	22	88
Malawi	4	5	8	4	2	1	7
Mauritius	20	26	46	33	7	1	41
Somalia	5	6	11	6	2	—	8
Southern Rhodesia	168	220	395	200	93	168	461
Zambia	54	70	125	100	22	120	242
TOTAL	457	593	1,058	676	223	732	1,362

[a] Projections of W. S. Atkins and Partners.
[b] Projections of United Nations Economic Commission for Africa, 1980.

There are, therefore, both a weak hypothesis (328,000 tons in 1980) and a strong hypothesis (705,000 tons in 1980) for Burundi, Kenya, Rwanda, Uganda and the United Republic of Tanzania. The adoption of the latter led to the projection of a steel and metal products industry at Tororo around 1975 with a capacity of approximately 450,000 tons.

The statistics for steel imports into the Democratic Republic of the Congo are as follows (metals and metallurgical articles):

Year	Tons	Year	Tons
1953	213,000	1957	244,000
1954	211,000	1958	141,000
1955	?	1959	117,000
1956	230,000		

The 1962 statistics for Sudan are as follows:

	Tons
Cast-iron and iron-alloys	50,000
Plates and sheets	20,000
Strips	3,000
Rails-railway equipment	28,000
Iron and steel wire	1,000
Tubes and pipes	7,000
TOTAL	109,000

The market in the Democratic Republic of the Congo shows very considerable variation. Assuming that, in normal circumstances, it currently amounts to 200,000 tons per annum, and that the Sudan market amounts to 100,000 tons per annum, the total for both is 300,000 tons per annum, or twice the current market of Burundi, Kenya, Rwanda, Uganda and the United Republic of Tanzania. If only half the Congolese market and three-quarters of the Sudanese market are within range of the Tororo factory, this will mean a further 175,000 tons per annum, or more than the current consumption of Burundi, Kenya, Rwanda, Uganda and the United Republic of Tanzania.

In the case of the strong hypothesis, the interconnexion would permit a larger factory to be built at Tororo, or would permit it to be built sooner. In the case of the weak hypothesis, assuming the same rate of growth of consumption in the Democratic Republic of the Congo and in the Sudan as in the other countries, it could, in any event, be built around the year 1975. The interconnexion would, therefore, have a traffic of some 100,000 tons per annum northwards and slightly more southwards, which would be a partial justification.

As another example, the Sudan imported approximately 110,000 tons of sugar in 1962, of which 60,000 tons came from developed countries. Uganda is an exporter of sugar (5,000 tons in 1963). It would, perhaps, be possible to develop this production in Uganda for sale in the Sudan, which would lead to a not inconsiderable traffic on the interconnexion.

Furthermore, the soil and climate of East Africa are apparently unsuitable for growing hevea. Advance planning in the rubber industry forecasts a consumption of some 15,000 tons per annum around 1975. The soil and climate of the Democratic Republic of the Congo are more suitable. In Kivu, in the eastern province, 13,900 hectares were under hevea cultivation in 1959, and produced 8,500 tons of rubber. Perhaps rubber from the Democratic Republic of the Congo might be used in East Africa. That would mean traffic on the interconnexion.

These few figures tend to show that re-traffic in the region of from 200,000 to 300,000 tons per annum may be possible in ten years or so, provided agreement is reached on economic co-operation, alignment of plans and location of enterprise.

Economic co-operation could then be concentrated on the concept of building up the market. As regards transport, studies should make a point of systematic research on the possible flux of traffic:

(*a*) Imports from and exports to the outside world for sectors of the interconnexion to be used as lines of penetration, as in the case of Rwanda;

(*b*) Development of agricultural activities within the framework of the built-up market in order to bring possible complementary factors into play;

(*c*) Research on new industrial activities made possible by the extended built-up market.

This leads to consideration of the practical method of organizing and constructing an over-all study of this nature. As an example one might take the organization of a committee appointed by the United Nations Economic Commission for Asia and the Far East (ECAFE) for the co-ordination of investigations on the Lower Mekong Basin in South-East Asia.

C. The Committee for Co-ordination of Studies on the Lower Mekong Basin

The Mekong is a major international river in South-East Asia which is being co-operatively developed by four States: Cambodia, Laos, the Republic of Viet-Nam and Thailand.

The aim is to develop the hydraulic resources of the Lower Mekong Basin, both on the main river and on its tributaries, for the production of hydroelectric power, and for purposes of irrigation, water control, drainage, improved navigation, development of the watersheds, water supply and other related fields, for the benefit of all peoples of the Basin, regardless of nationality or politics. Roughly speaking, the work is divided as follows:

(*a*) Planning: pre-investments, including collection of basic data, general development programme for the Basin, planning of various improvements on the main river and its tributaries, planning of improved navigational facilities and related projects;

(*b*) Construction;

(*c*) Financing;

(*d*) Management.[90]

This project, which covers a very wide field (cartography, hydrology, dam projects, transport studies, pilot farms, mining prospection, studies on the power market, studies on industries, legal, administrative and customs problems, professional training, agricultural planning as a whole, food etc.) is supervised by a Committee of the four States. The statutes and rules of procedure of the Committee are annexed to the present paper (see annex I). The Committee appointed an Advisory Board of Experts of world-wide renown. In 1964, there were six of these experts.

The United Nations provides technical assistance and co-operates with the Committee through its various branches and specialized agencies: ECAFE, the United Nations Special Fund, the International Labour Organisation, the Food and Agriculture Organization, the United Nations Educational, Scientific and Cultural Organization, the International Bank for Reconstruction and Development, the World Health Organization, the World Meteorological Organization, the International Atomic Energy Agency and the World Food Programme.

[90] See United Nations Economic Commission for Asia and the Far East, "Report of the Committee for Co-ordination of Studies on the Lower Mekong Basin" (E/CN.11/670).

The following countries assist the Committee through the Colombo Plan: Australia, Canada, India, Japan, New Zealand, Pakistan, United Kingdom of Great Britain and Northern Ireland and United States of America. Other countries assisting the Committee are: Belgium, China (Taiwan), Denmark, Federal Republic of Germany, Finland, France, Iran, Israel, Italy, Netherlands, Norway, the Philippines and Sweden.

The Asia Foundation, the Ford Foundation and Resources for the Future, Inc. also assist the Committee.

In addition to all these, four private companies have made direct offers of assistance which the Committee has accepted. They are: Gestetner Eastern Ltd., Price Waterhouse Co., Shell Oil Co. and Sycip, Gorres, Velayo and Co.

Each of the programmes for the development of the Mekong Basin[17] operates within the framework of a plan of operation, project agreement, or exchange of letters signed by: (a) A representative of a co-operation programme; and (b) the Committee, a representative of the Committee or a country which is a member of the Committee, each of these programmes being part and parcel of the Mekong project as a whole. Within the framework of each of these programmes, and after drawing up the plan of work, supervision devolves, to a large extent, upon the country or co-operating body which submitted the programme in question. Each of these countries or co-operating bodies reports to the Committee on progress of work or on problems arising, and, from time to time, requests assistance and advice from the Committee and its secretariat, but remains largely responsible, together with the counterpart personnel collaborating with it, for achieving the objectives approved by the Committee.

As of 11 January 1965, the total amounts paid in or pledged to the Mekong project were as shown in table 16.

[17] See E/CN.11/679, p. 120, French text.

Table 16. Amounts paid in or pledged to Lower Mekong Basin project, 11 January 1965

(Dollars)

Studies, pre-investment and plans		
Bilateral contribution from certain States		11,396,000
From United Nations and its specialized agencies		
Economic Commission for Asia and the Far East	485,000	
Special Fund	6,513,000	
Bureau of Technical Assistance Operations	363,000	
International Labour Organisation	12,000	
Food and Agriculture Organization	134,000	
United Nations Educational, Scientific and Cultural Organization	17,000	
World Health Organization	5,000	
World Meteorological Organization	15,000	
International Atomic Energy Agency	55,000	
World Food Programme	126,000	
TOTAL	7,756,000	7,756,000
Counterpart from States to Committee		7,991,000
TOTAL		27,143,000
Investments for construction		40,623,000

According to the method followed by the Mekong Committee, the States in question can themselves organize and supervise their assistance. Assistance from the States comes within the general framework, and thus the donors are assured that their contribution forms part of a co-ordinated whole.

D. Procedure for studying methods of building up the market in the Great Lakes region

The following procedure might be used to study the method of building up the market by means of a railway interconnexion in the Great Lakes region, coupled with industrialization and economic co-operation:

(a) The ECA secretariat might be asked to test the hypothesis roughly, that is to say, to determine if the minimum traffic condition (200,000 to 300,000 tons per annum) is within the realm of possibilities or if it is Utopian. The secretariat might also be asked to study the various implications and consequences of the project (duration: a few months);

(b) If the results are favourable, a conference of the States concerned could be convened, and the files submitted to it. In the event of agreement, the United Nations Special Fund could be asked to undertake a study for the purpose of:

(i) Providing exact data: brief outline of layout, construction costs, possible tariff, possible trade; etc.;

(ii) Determining the methods to be used, as studies should be co-ordinated and would doubtless call for such techniques as operational research;

(iii) Defining the later stage of research: duration, cost, nature, etc.;

(c) The States might meet again to make final arrangements for appointing a Committee to supervise operations.

ANNEX I

Statutes of the Committee for the Co-ordination of Studies on the Lower Mekong Basin

COMMITTEE FOR THE CO-ORDINATION OF STUDIES ON THE LOWER MEKONG BASIN

Statutes (E/CN.11/478)

[Adopted by the Preparatory Committee of the four Governments at its meeting of 17 September 1957, amended on 31 October 1957 at the first session, and approved by the participating Governments.]

SECTION I — ESTABLISHMENT OF THE COMMITTEE

The Committee for the co-ordination of studies on the lower Mekong Basin hereinafter called "the Committee" is hereby established by the Governments of Cambodia, Laos, Thailand and the Republic of Viet-Nam (hereinafter called "the participating Governments"), further to the decision taken at its third session by the United Nations Economic Commission for Asia and the Far East (hereinafter called "the Commission"). By this decision, recorded in paragraph 277 of the annual report of the Commission for the period 15 February 1956 to 28 March 1957, the Commission endorsed the wish expressed by the participating Governments that studies devoted by the secretariat to the development of the lower Mekong basin, that is to say, that portion of the hydrographic basin of the Mekong situated on the territory of the participating Governments, should be carried out in conjunction with the aforesaid Governments. The participating Governments hereby establish a Committee whose terms of reference are set forth in the present Statutes.

SECTION II — ORGANIZATION

Article 1

1. The Committee shall consist of four members.

2. Each of the participating Governments shall appoint one full plenipotentiary member, together with such deputies, experts and advisers it may wish to appoint.

Article 2

The Committee shall be presided over by each of its members in succession according to alphabetical order of member countries. Each member shall assume the duties of Chairman for a period of one year.

SECTION III — CO-OPERATION WITH THE SECRETARIAT OF THE COMMISSION

Article 3

In conformity with the decision taken by the Commission at its third session, the secretariat of the Commission shall co-operate with the Committee in the performance of duties devolving upon the Committee.

SECTION IV — TERMS OF REFERENCE

Article 4

The Committee shall encourage, co-ordinate, direct and supervise planning and studies in respect of operations for developing hydraulic resources in the lower Mekong basin. For this purpose it shall:

(*a*) Prepare and submit to the participating Governments plans for co-ordinating research, studies and field operations;

(*b*) On behalf of the participating Governments, request special financial and technical assistance and receive and administer autonomously any financial and technical assistance which may be forthcoming within the framework of the United Nations Technical Assistance Programme, or from the specialized agencies or friendly Governments;[1]

(*c*) Submit or recommend to the participating Governments any proposals concerning the utilization of the main course of the river for the development of hydraulic resources.

SECTION V — SESSIONS

Article 5

1. Subject to the provisions of the present Statutes, the Committee shall adopt its Rules of Procedure.

2. Meetings of the Committee shall take place with the participation of all member countries.

3. Decisions of the Committee shall be taken unanimously.

4. At each meeting, the Executive Secretary of the Commission or his representative shall submit oral or written statements on matters under consideration.

[1] It is understood that the provisions of this sub-paragraph shall enter into force as soon as each of the four participating Governments shall have individually notified the Chairman of the Technical Assistance Board that it has expressly authorized the Committee to request technical assistance on its behalf for developing the lower basin of the Mekong.

SECTION VI — GENERAL PROVISIONS

Article 6

The Committee shall submit reports to the participating Governments as well as annual reports to the Commission. On its recommendation, such reports or summaries thereof may be communicated to other Governments or international organizations.

Article 7

The Committee may invite representatives of Governments or specialized agencies to attend meetings in the capacity of observers.

Article 8

1. It is understood that although the Governments shall take action through the Committee on all technical matters coming within the terms of reference of the Committee, the provisions of the present Statutes shall not affect, replace or in any way modify agreements in respect of the Mekong which are at present in force or which may later be concluded between the Governments concerned.

2. Amendments to the present Statute may be proposed by any of the participating States. They shall be studied by the Committee and shall take effect as soon they have been approved by all the participating Governments.

Rules of Procedure (E/CN.11/478)

(*Adopted at its first session by the Committee for the Co-ordination of Studies on the Lower Mekong Basin*[2])

SECTION I — SESSIONS

Rule 1

The Committee shall meet regularly three times a year in ordinary session.

In addition, the Committee may be convened in special session at any time at the request of one or more of its members, or at the request of the Executive Secretary of the Commission.

Rule 2

At least four weeks before the beginning of a session, the Executive Secretary of the Commission shall send out notification of the date of the session, together with the provisional agenda and the relevant basic documents.

Rule 3

Unless the Committee decides otherwise all meetings shall be in private.

SECTION II — CO-OPERATION WITH THE SECRETARIAT OF THE COMMISSION

Rule 4

The Committee may ask the Executive Secretary of the Commission to make the necessary arrangements with a view to consultation, and in particular to prepare documents, organize meetings and draft minutes.

SECTION III — GENERAL PROVISIONS

Rule 5

In respect of any eventuality for which no provision is made in the present Rules of Procedure, the appropriate provisions of the Rules of Procedure of the Economic Commission for Asia and the Far East shall apply, in so far as they may be deemed suitable for the purposes of the Committee.

[2] Based on a draft drawn up at the meeting of the Preparatory Committee of the Four Governments held on 17 September 1957.

ANNEX II

Tariffs of various African railways: figures XII-XX

Figure XII. Southern Rhodesian railway tariffs: classes 1-10

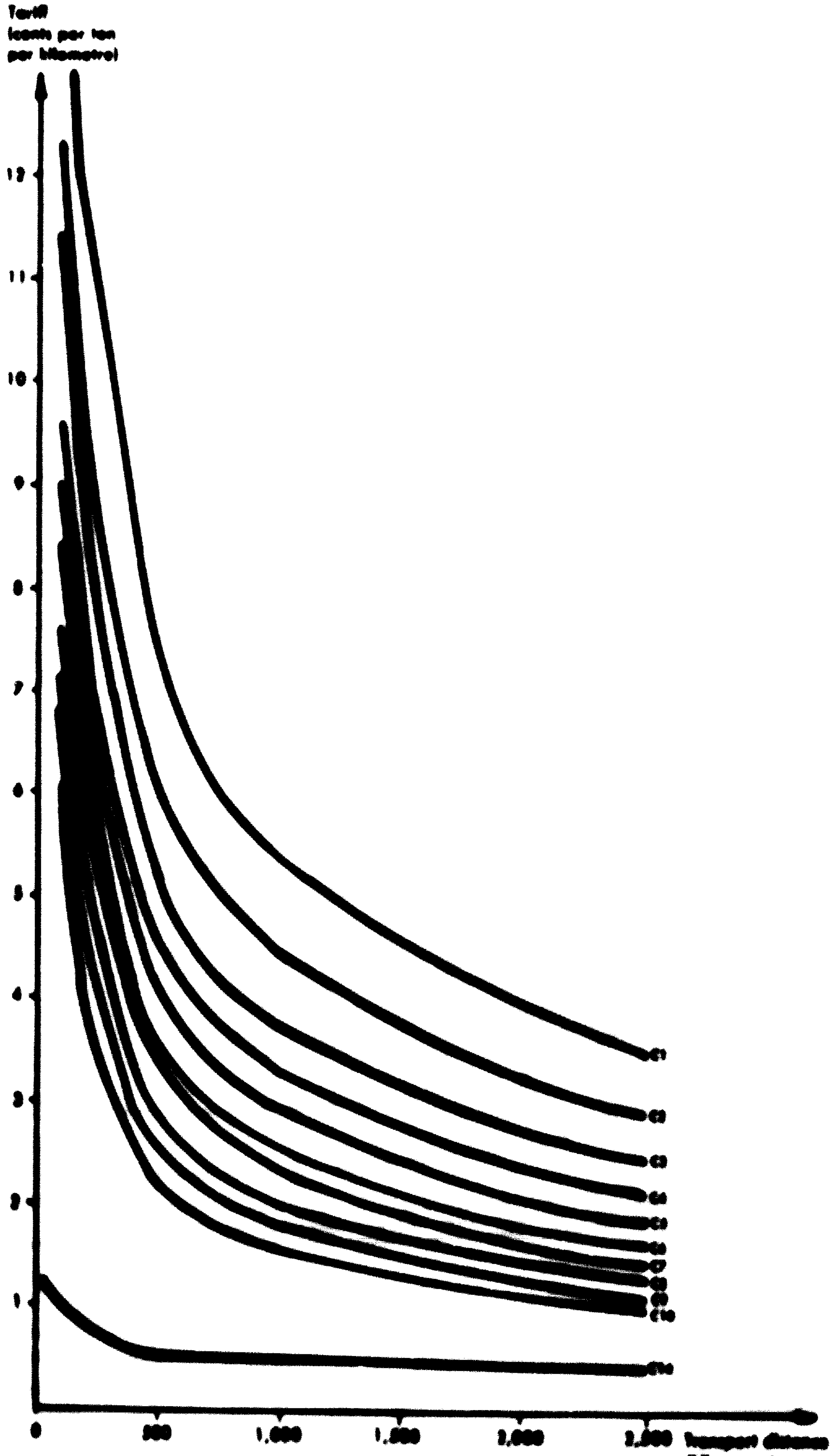
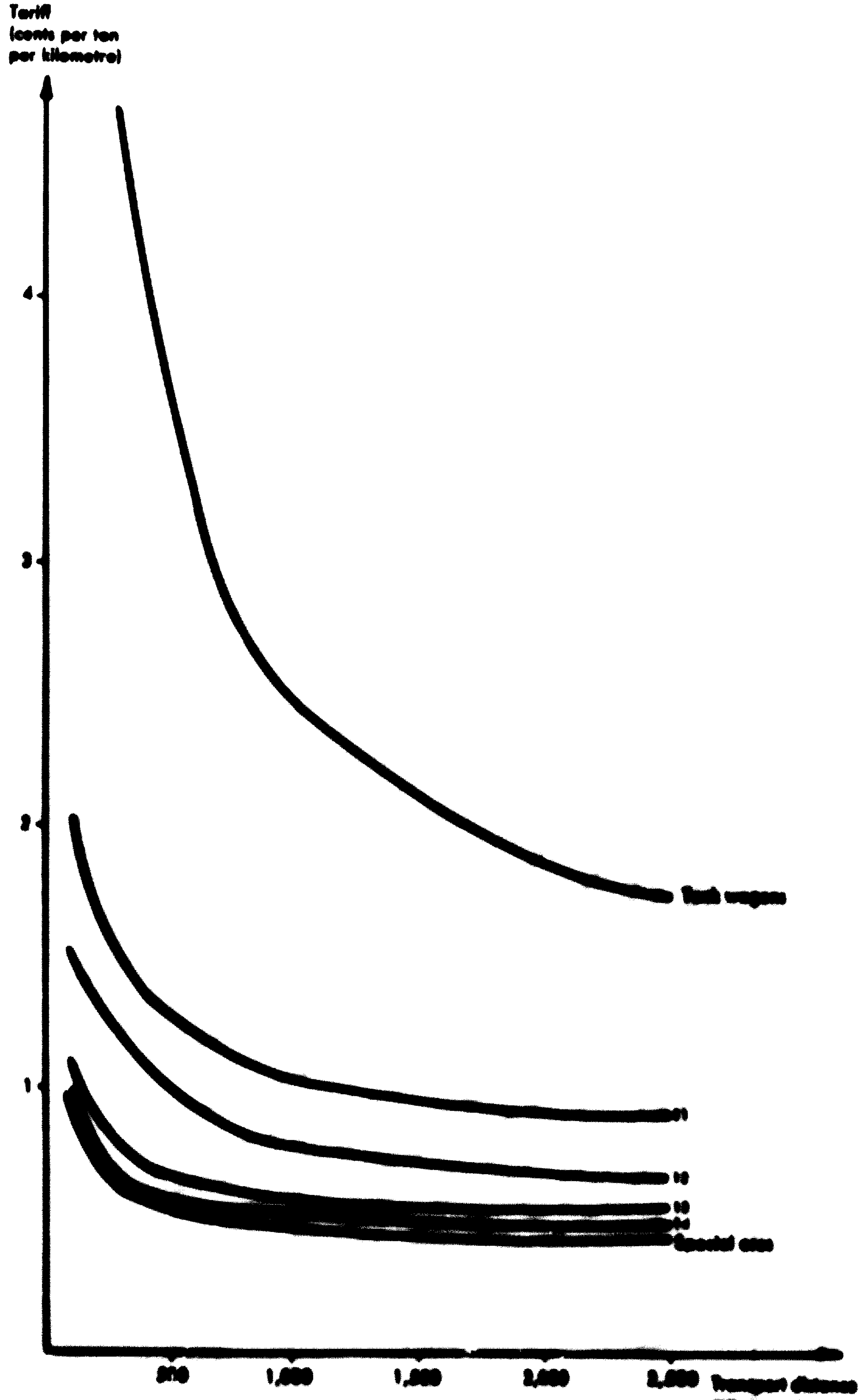


Figure XIII. Southern Rhodesian railway tariffs: classes 11-14, special ores and tank wagons



and steel works with a capacity of 380,000 tons and producing 300,000 tons per annum of flat product is in course of execution and is expected to come into operation by the end of 1966. It is based on domestic ore and imported coke. The plant will have sintering facilities and oil injection, resulting in a low coke rate, and the blast furnace will have a capacity of 400,000 tons per annum. Steel will be made by the Lenz-Donhau process.

Tunisia has virtually completed the erection of a small integrated iron and steel works in the Menzel-Bourgiba region. This plant has a steel-capacity of 80,000 tons per annum, and production is expected to begin by the end of 1965 or early 1966. It is based upon domestic ores and imported coke. The blast-furnace has a capacity of 100,000 tons per annum and the Lenz-Donhau converter, of 80,000 tons per annum. There is continuous casting of billets, and the rolling mill (reinforcing bars and small sections) has a capacity of 70,000 tons per annum.

Morocco has no steel-making facilities at the current time but a re-rolling unit with a capacity of 120,000 tons per annum is envisaged by 1967 at Casablanca. This may be based on billets from the Algerian works, and from 1970 onwards, on billets from an integrated plant with a capacity of 300,000 tons per annum, which may be established at Nador, based on domestic ore and coal. Alternatively, the Casablanca works may be based on scrap melting. No iron and steel facilities currently exist in Libya or in the Sudan.

Iron- and steel-making facilities in the United Arab Republic are relatively advanced. The main unit is the integrated works at Helwan with a finished steel capacity of 200,000 tons per annum, producing flat products as well as light and medium sections. Other units include three semi-integrated plants with a capacity of 180,000 tons per annum in round bars. It is proposed to expand the capacity of the Helwan works to 1.5 million tons of ingot steel per annum and to include a strip mill (already under construction) with an ultimate capacity of 700,000 tons of finished products per annum. The plant will use oxygen steel-making and continuous casting. The establishment of a second integrated plant is contemplated at Aswan, with a capacity of 400,000 tons per annum in round bars and comprising electric reduction, oxygen steel-making, continuous casting and a fully continuous bar mill. A wide-plate mill with a capacity of 200,000 tons per annum, based on slabs from Helwan, is under study and might form the nucleus of a third integrated works. The existing semi-integrated plants intend to double their capacity, and one of them will specialize in special alloy steels.

B. West Africa

The only steel-making facilities in West Africa at the current time are those of the scrap-melting plants in Nigeria (near Enugu) and in Ghana (Tema), both with a current output of about 12,000 tons per annum. In the case of the Tema works, the capacity is about 30,000 tons per annum.

The future development of the steel industry in the subregion on a co-ordinated basis has been considered at a number of conferences,[11] beginning from the stand-point (subsequently modified to allow for an inland plant as well as a coastal one) that the market was only large enough to permit the operation of one integrated plant of an economical size and that this should accordingly be located at the site which would give the lowest over-all cost, including cost of manufacture and cost of distribution. The calculations establishing this location in the case of a coastal plant were made by SETEC[12] and resulted in the choice of Lower Buchanan (Liberia), as compared with alternative sites in Gabon, Ghana and Nigeria. A subsequent investigation showed that the Buchanan site was also of a much lower cost than an alternative site in Mauritania. This report, together with one prepared on the site of an inland steel works, was submitted to the Conference on Industrial Co-ordination in West Africa, held in Bamako in October 1964. The Conference, which also took note of the intention of the Nigerian Government to proceed with a steel industry project on which they had already incurred considerable expense, accepted the necessity of setting up an iron and steel works in the interior, namely at Gouina, together with the recommendations of the consultants in regard to the site for a coastal plant, namely, at Lower Buchanan.

The initiative then passed to the Government of Liberia which, in August 1965, called a consultative meeting on iron and steel in Monrovia (WAC/IRON/5) to consider a possible approach to co-operation in the establishment and development of an iron and steel industry in the subregion, particularly with respect to the erection of an integrated plant at Lower Buchanan. Documents were available showing the possible iron and steel units which could be established in a subregion and stating the intentions of the Government of Liberia in regard to the proposed Buchanan plant. Discussions took place mainly on the need for establishing machinery to co-ordinate industrial development throughout the subregion and on certain problems which the establishment of an integrated plant serving the whole subregion would create. It was decided to appoint an interim committee of experts to pursue these matters further and to report as soon as possible to an appropriate intergovernmental body. The terms of reference of the Committee were laid down and included a request to report first of all on the constitution, functions and powers of an iron and steel authority to be established for the purpose of programming and harmonizing the development of the iron and steel industry in West Africa, and, secondly, on various problems involved in the establishment and operation of the industry, namely, the type, size and location of re-rolling works which might be established in co-operation with the integrated works, the price policy to be pursued, the possibility of removing tariffs, means of payment for the imports of steel, and financial participation in the project by the various West African Governments. The first meeting of the committee was held in Abidjan in October 1965 (WAC/IRON/10) and reviewed the various documents prepared on the above mentioned subjects. Resolutions were passed asking for detailed statements from the various Governments on their immediate intentions in regard to iron and steel development in their respective countries and

[11] See, for example, United Nations Economic Commission for Africa, "Summary of iron and steel investigation in West Africa" (E/CN.14/IS/3), paper prepared for West African Meeting on Iron and Steel, Monrovia, 2-7 August 1965.

[12] "Sidérurgie et première étape de transformation" (E/CN.14/INR/72, 2 vol.), paper prepared for the United Nations Economic Commission for Africa Conference on Industrial Co-ordination in West Africa, Bamako, 5-15 October 1964.

Figure XIV. East African Railways and Harbours: tariffs for classes 4-10

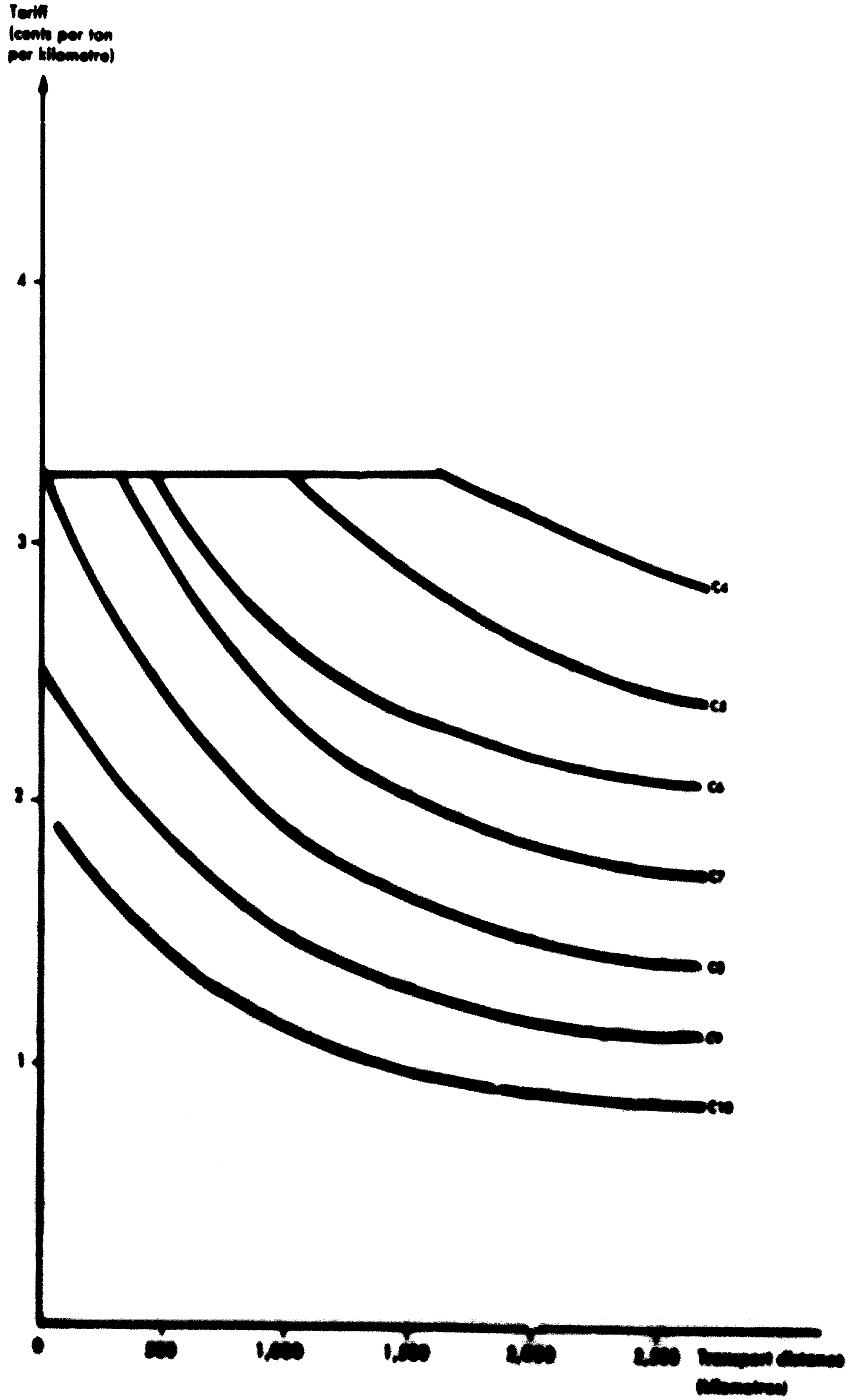


Figure XV. East African Railways and Harbours: special tariffs for hydrocarbons — special tariffs A, B, C, D

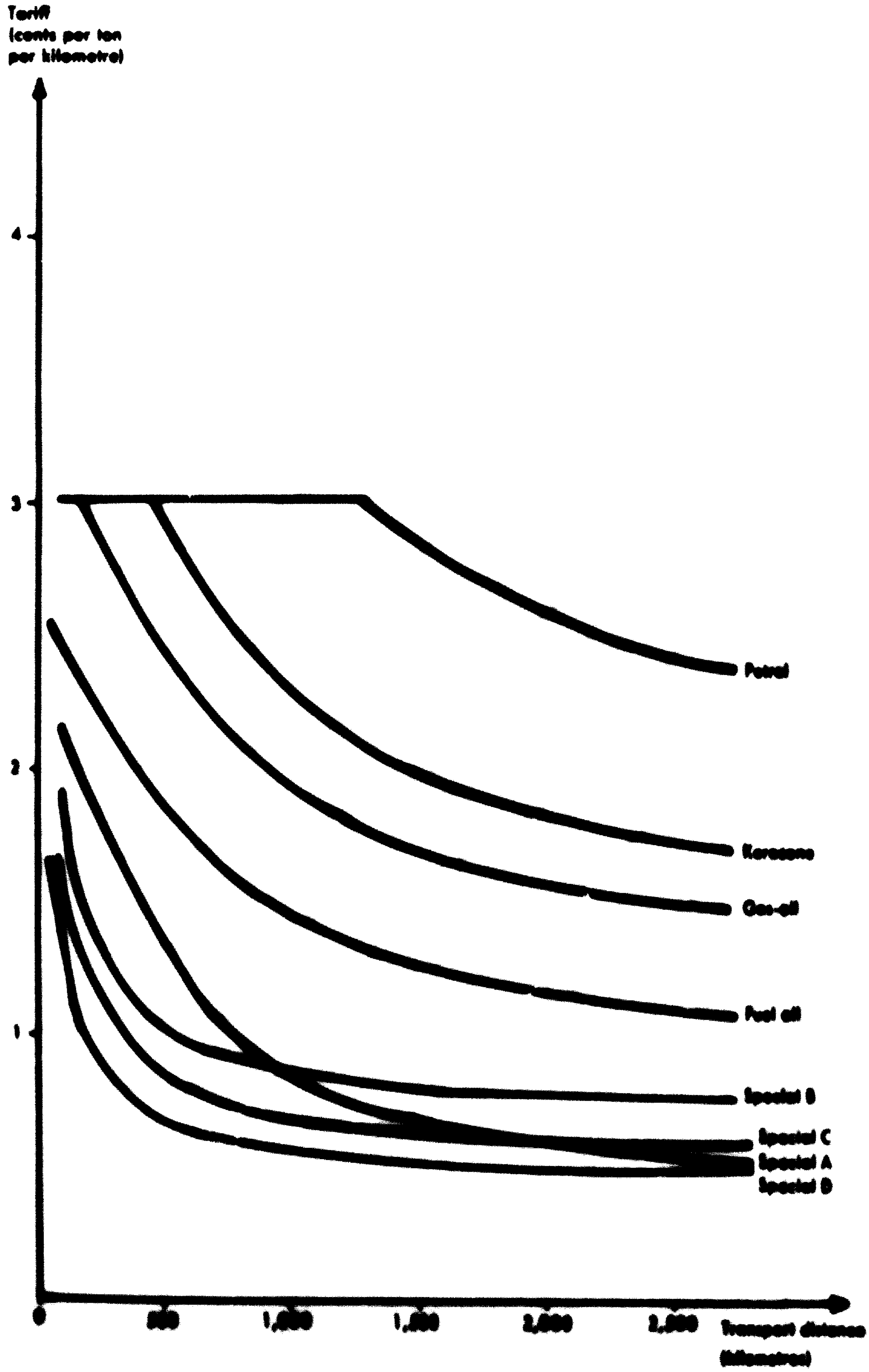


Figure XVI. East African Railways and Harbours: transport tariffs, 1963

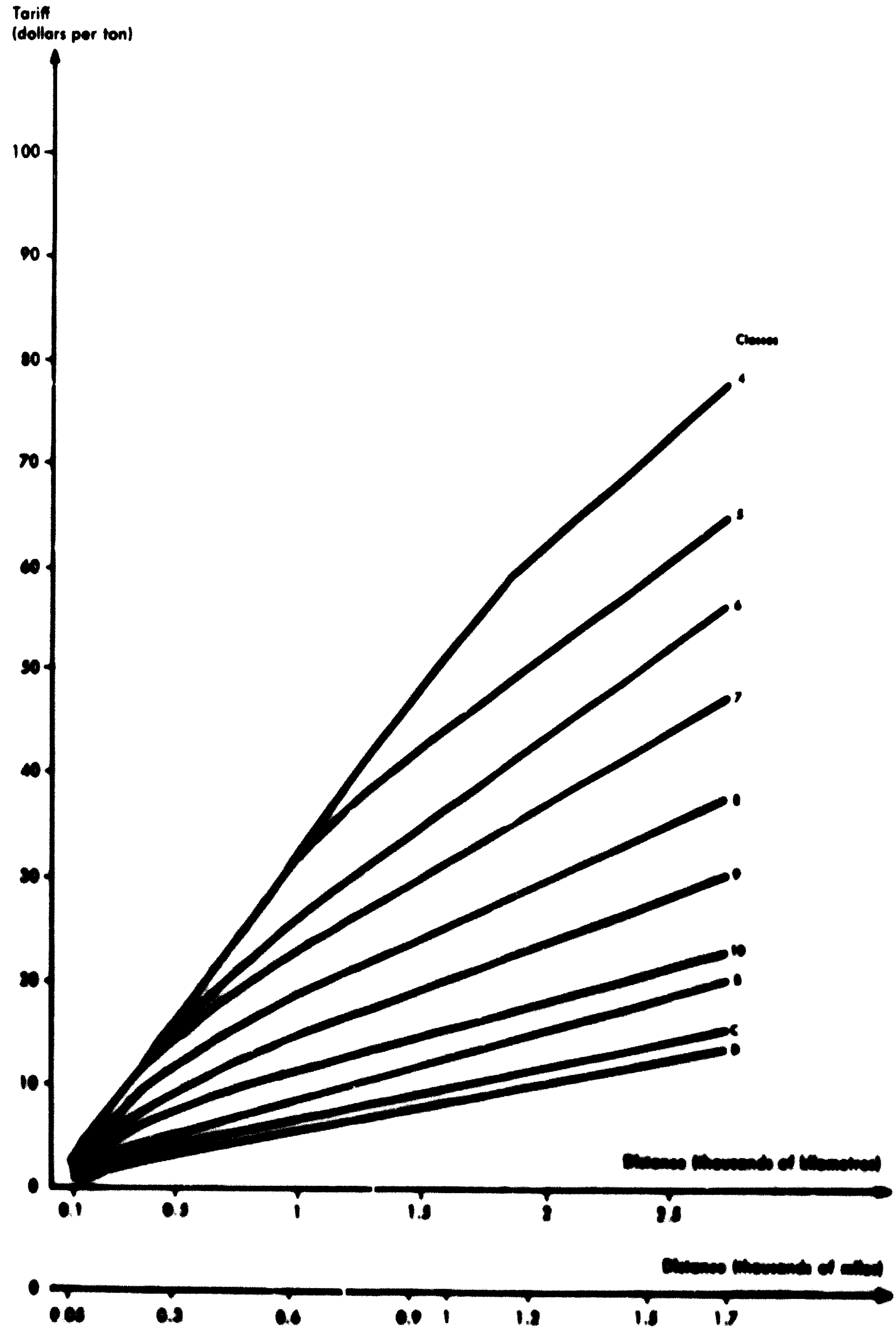


Figure XVII. Sudan Railways: tariffs for classes 1-10

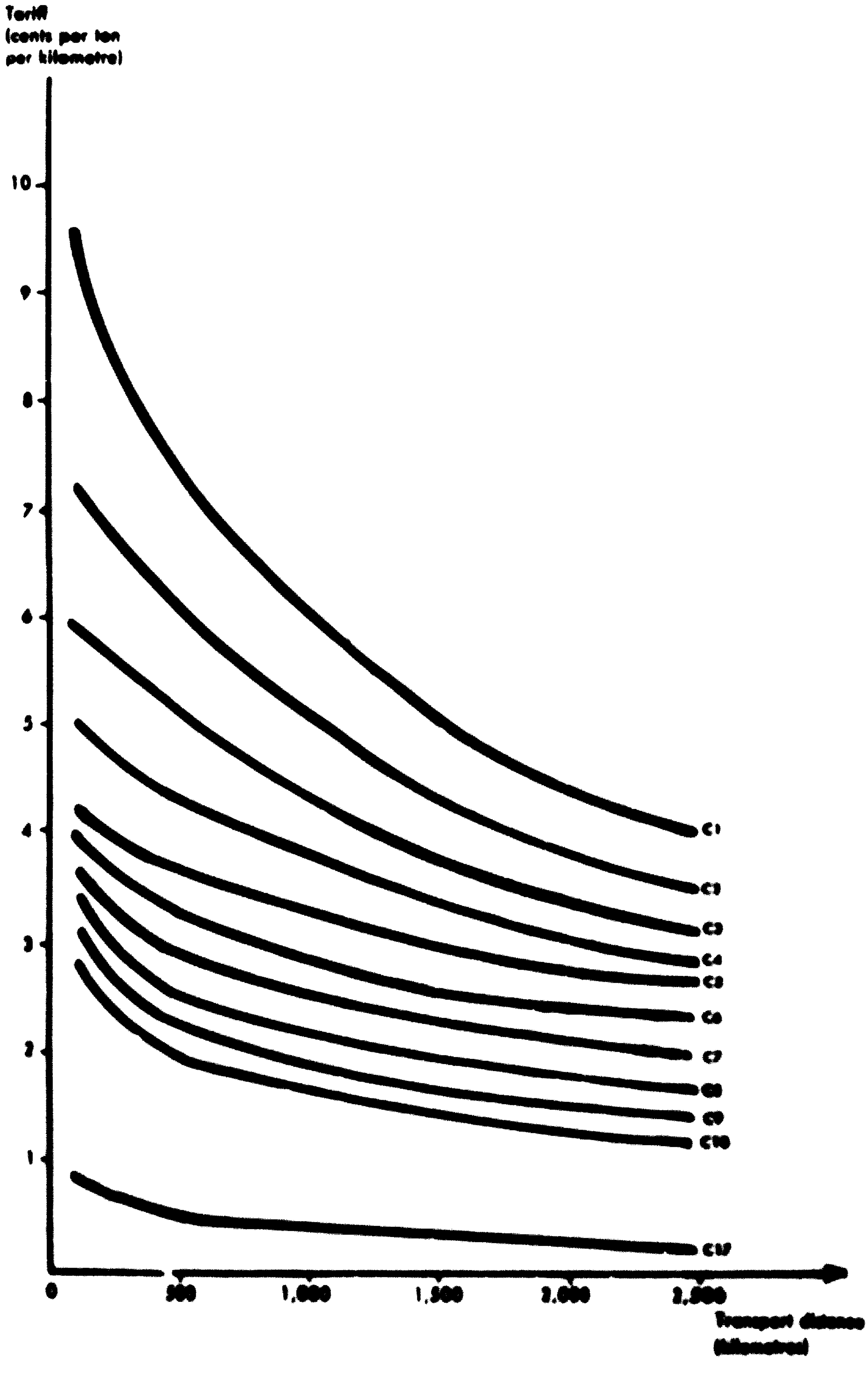


Figure XVIII. Sudan Railways: tariffs for classes 11-17

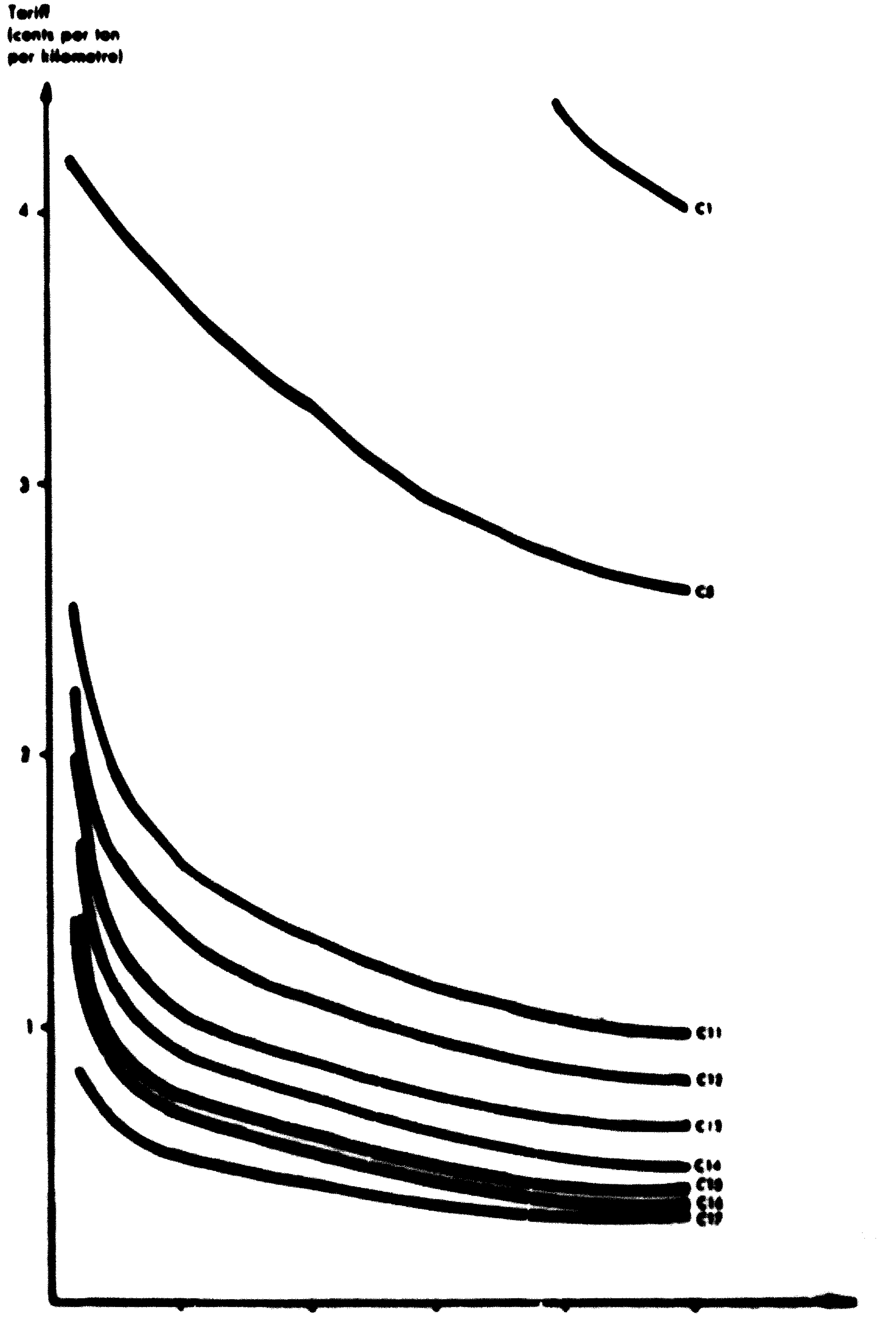


Figure XIX. Sudan Railways: tariffs for various classes

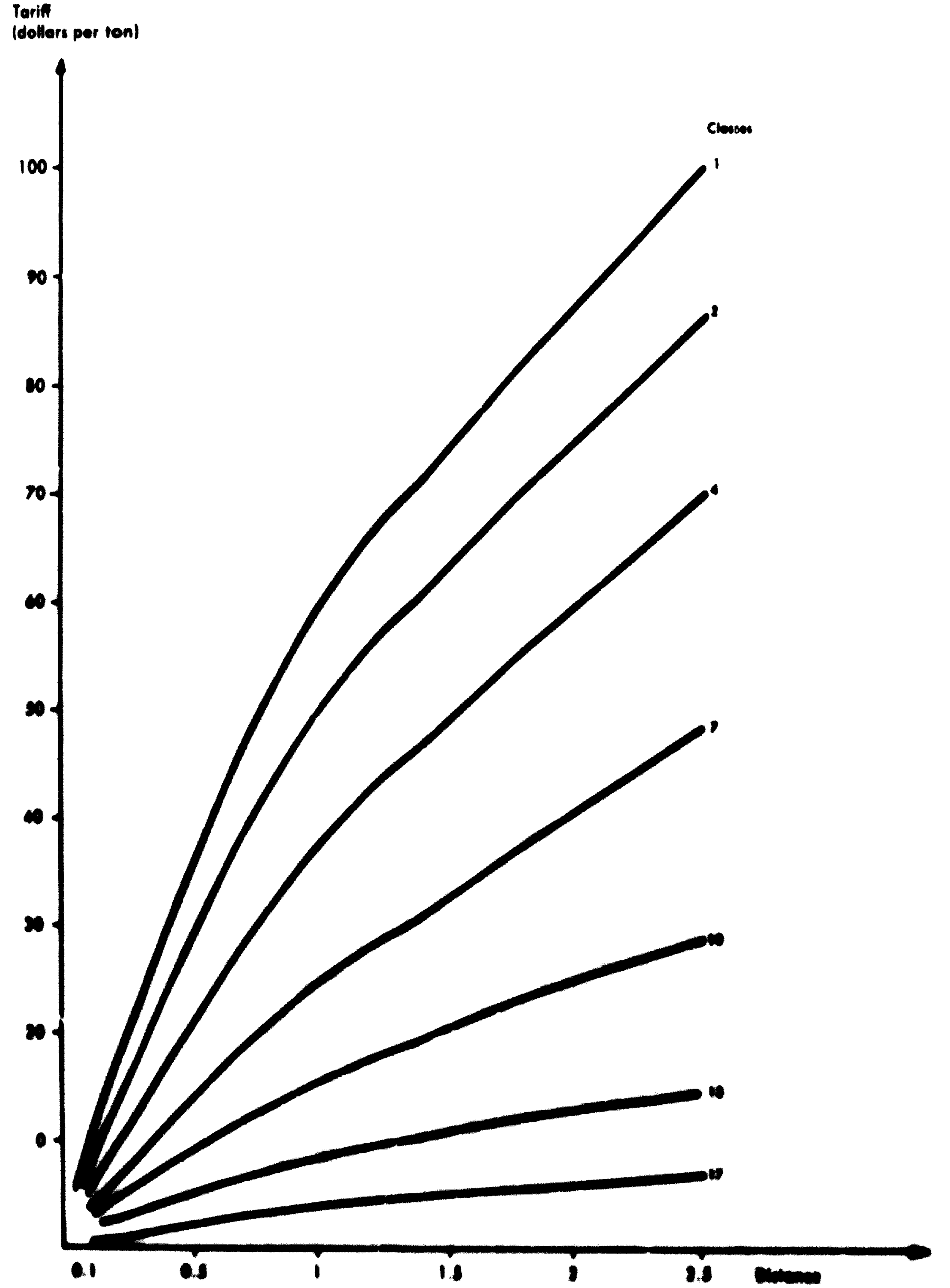
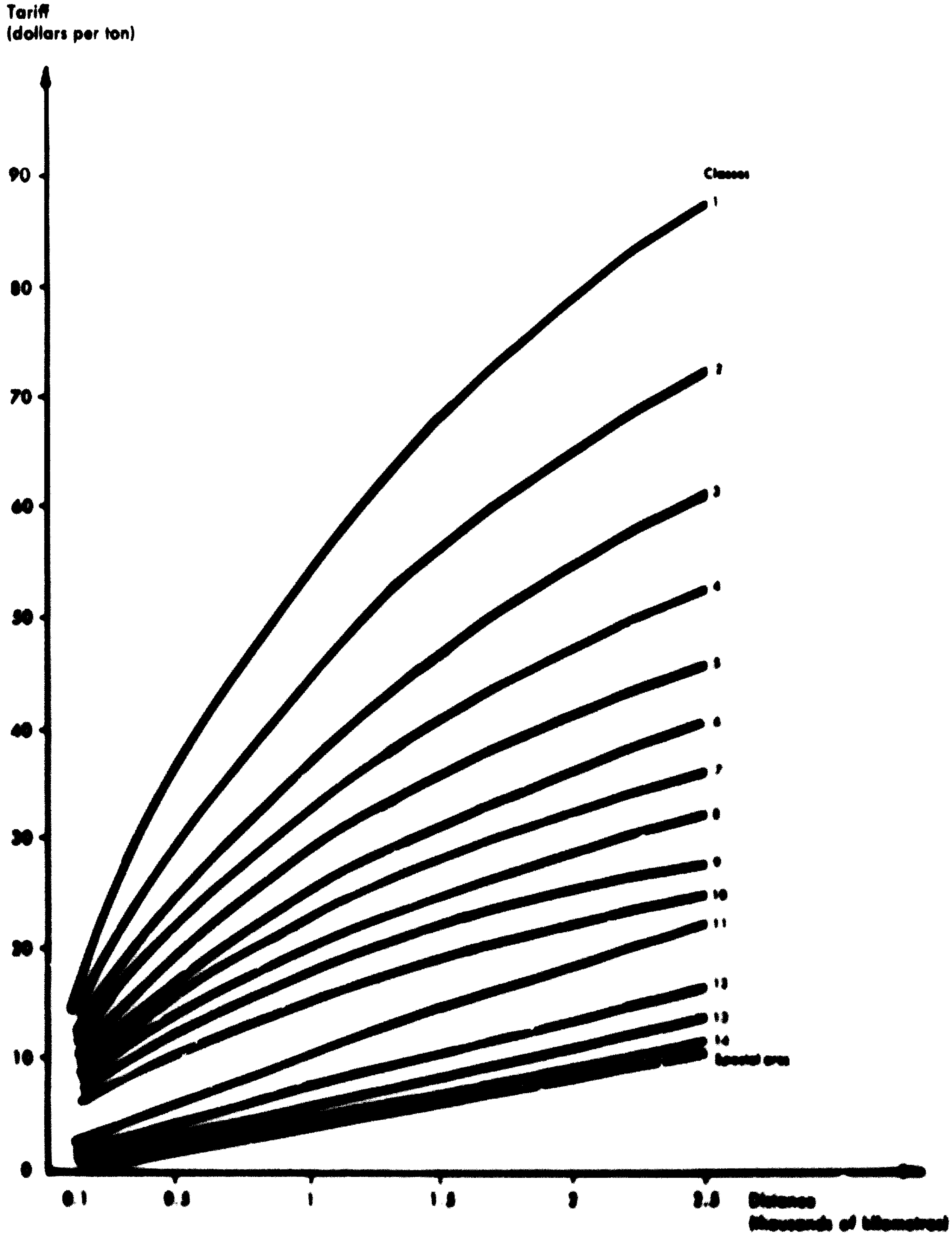


Figure XX. Zambian and Southern Rhodesian railways: tariffs for classes 1-14 and for special ores



ANNEX III

Map 9. Africa: penetration routes in the Great Lakes region

[See insert facing page 160]

29. 9. 71

on their intentions in regard to the financing of subregionally based industries. It was agreed to postpone discussion on the document relating to the establishment of an iron and steel authority until the various Governments had had an opportunity of examining it and stating their views in writing, after which these matters would be further discussed at the next meeting of the committee early in March 1966.

C. Central Africa

The only steel-making facilities currently operating in Central Africa are those of the electric scrap-melting plant at Jadotville with a capacity of 8,000 tons per annum and a current output of 7,000 tons per annum. Studies have been made on the possibility of manufacturing reinforcing bars and light sections for the countries comprising the Customs and Economic Union of Central Africa (UDEAC) and for the Congo (Democratic Republic of) but neither scheme has been proceeded with. In the meantime, the ECA Mission for Economic Co-operation in Central Africa (July 1965) has advocated the desirability of setting up an iron and steel industry on a subregional basis, which would require a detailed survey of the relative advantages of various possible sites for locating an integrated works on the lines of those already carried out in the East and West African subregions.

From the point of view of raw materials and manufacturing costs, a coastal site in Gabon is likely to be favoured, while from the point of view of the market, the Democratic Republic of the Congo, which is expected to account for about two-thirds of the total steel consumption in the subregion, has a predominant interest. In the longer term, the major iron and steel development is likely to be based on the Mekambo iron-ore deposits of Gabon or on the Sangha deposits of the Congo (Brazzaville). The Mekambo deposits rank among the most important in the world and with the construction of the railway to the coast are likely to be exploited from 1973-1974 onwards. The iron content is 64 per cent, and the ore is low in phosphorus. As far as other materials for steel-making are concerned, manganese ore can be obtained from the Franceville area and fuel oil from the Port-Gentil refinery, or, alternatively, natural gas could be used. Ample limestone is available in the vicinity, but as elsewhere in West or Central Africa, metallurgical coke was to be imported. It has been shown that there is a suitable site at Ovendo which, taking into account port development plans, has a good harbour and will be well connected to the rest of the subregion.[18] It is possible to envisage an integrated iron and steel works with a capacity of 400,000 tons of crude steel per annum, based on conventional blast-furnaces, Lenz-Donhau steel, continuous casting and conventional rolling mills. It should be noted that production costs in Gabon were estimated in the ECA study to be not significantly greater than in Liberia (between 6 and 7 per cent), which seems likely to be the site of the first integrated iron and steel plant in West Africa.

Given the time required to construct the railway and to develop the mine, full-scale production would hardly be possible at Ovendo before 1975. In the meantime, it is possible that the Inga hydroelectric scheme will have been initiated, which would permit the development of an integrated iron and steel plant in the Democratic Republic of the Congo, based on electric smelting. To begin with, this could be based on the high-quality ore available from Mauritania, and later, from Gabon. On a subregional view, such works might have a capacity of 100,000 tons per annum, supplying bar and rod, and sections, for which the market by 1970 would be sufficient, while the Gabon plant would produce flat-steel products.

D. East Africa

The iron- and steel-making facilities available in the East African subregion consist of the integrated works at Que Que in Southern Rhodesia and the scrap-melting works at Jinja in Uganda, and at Akaki near Addis Ababa, Ethiopia.

The Que Que works consists of blast-furnaces with a capacity of about 250,000 tons per annum and open-hearth steel furnaces with a capacity of 150,000 tons per annum. The rolling mills have a capacity of about 160,000 tons per annum, including 45,000 tons of light sections, as well as medium sections, rails, billets etc. The immediate extension plans of the Rhodesian Iron and Steel Company include increased capacity in both iron- and steel-making. Ore preparation will be improved to increase the output of the existing blast-furnaces and with a new 23-foot diameter furnace, output will increase to 820,000 tons per annum, very largely for exportation. Steel-making improvements will increase the output of the open-hearth furnaces to about 200,000 tons per annum.

The Ethiopian iron and steel works at Akaki has an ingot steel capacity of 12,000 tons per annum and a rolling capacity of 18,000 tons per annum. The bulk of the production is sold as reinforcing bar. Current production is about 6,000 tons per annum, and scrap availability within Ethiopia is sufficient for a production of 9,000 tons per annum.

The East African steel works at Jinja has a steel-making capacity and a rolling capacity of 24,000 tons per annum. The main product is reinforcing bar although angles and flat bar are also produced. Current production is about 8,000 tons of finished steel per annum. Scrap for the works is collected from Kenya, Uganda, and the United Republic of Tanzania, and is ample for current rates of production, but could not sustain the maximum output. Expansion plans include the production of baling strip and tubing.

Other steel activities in the subregion include the manufacture of tubes, the drawing of wire and the galvanizing of sheets. Steel pipes (current output of about 3,000 tons per annum) and conduit tubing are produced in Zambia, and seamless tubes (about 9,000 tons per annum) in Southern Rhodesia. Wire rod and wire are produced at Que Que, where the steel plant has a capacity of about 25,000 tons per annum. Wire is also produced at Akaki. Galvanizing and corrugating plants with a capacity of about 50,000 tons per annum are in operation in East Africa, and new galvanizing lines are projected for Ethiopia and Uganda.

A plan for the co-ordinated development of the iron and steel industry in the subregion was presented at the Conference on the Harmonization of Industrial Development Programmes in East Africa, held in Lusaka from 26 October to 6 November 1965. As in the case of West Africa, calculations were made to show the advantages of various sites for locating an

[18] See "Sidérurgie et première étape de transformation" (E/CN 14/INR/72, 2 vol.).

integrated works,[14] but in this case it was not assumed *a priori* that a single plant serving the whole subregion would necessarily be the best solution on purely economic grounds, although in fact it turned out to be so. Calculations were made for a number of possibilities, including a single integrated works, an integrated works and re-rolling works, two integrated works and three integrated works and re-rolling works. The estimated surplus, over and above that necessary to give a return of 25 per cent on capital (including depreciation), which would be earned under the various proposals at current prices of imported products is as follows:

	Annual surplus (millions of dollars)
Single integrated works at Que Que	71.5
Semi-integrated works at Que Que and Mombasa	62.0
Integrated works at Que Que and Tororo	50.8
Integrated works at Que Que and Lusaka	50.3
Integrated works at Que Que, Tororo and Lusaka, and re-rolling at Dar-es-Salaam	34.0

The proposal for three integrated works, although the least profitable, was recommended mainly to secure a balanced development of the subregion. In detail, this proposal suggested, by 1980, the erection of three integrated works, each of about .5 million ton annual capacity at Que Que (Southern Rhodesia), Tororo (Uganda) and Lusaka or vicinity (Zambia), together with a large re-rolling mill (250,000 tons capacity) at Dar-es-Salaam and smaller re-rolling works of about 50,000 tons annual capacity at Addis Ababa and in Madagascar. The profitable operation of the re-rolling works would require them to be supplied with billets from the proposed integrated works at prices somewhat below market levels.

In view of the limited market until 1980 and the fact that the railway between the United Republic of Tanzania and Zambia would have to be constructed, it was proposed that the construction of the Lusaka works should be postponed until 1975, but that the expansion of the Que Que works and the erection of the Tororo works could begin immediately.

These proposals are to be submitted to the Council of Ministers, which it was agreed should be established to co-ordinate industrial development in the subregion.

[14] United Nations Economic Commission for Africa, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87 and Add.2).

E. Region

The policy for co-ordinating iron and steel development in Africa, as adopted in the East and West African subregions, is that of establishing one or a limited number of integrated plants supplying the whole of each subregion, so as to obtain economies of scale, and supplementing these, where desirable, by re-rolling mills located in particular countries and supplying normally national requirements. Since the integrated plant will be selling to a number of countries, it has been found necessary to propose the establishment of a regulating authority to control prices, to arrange for a removal of duties etc., as elaborated above in the case of West Africa, and to supervise any market-sharing arrangement or specialization adopted to avoid wasteful duplication. From a regional point of view, there is likely to be little potential competition between the various subregional plants. Although certain operations in iron and steel manufacture, e.g., the blast-furnace and the wide strip, still have economies of scale at outputs over 1 million tons per annum, these are not sufficient in general to offset transport charges and make such large units competitive throughout the continent. An exception might be where the transport of steel is possible by coastal shipping, but even then it would probably be uneconomic to admit similar products from other subregions except to relieve established shortages, e.g., those caused by lack of balance. The position is otherwise in regard to heavy sections, heavy plant, rails and special steel, for which the subregional market is not sufficiently large to permit an economic scale output, and it would appear reasonable to allow these products to flow freely between subregions just as other steel products are expected to flow freely between countries in the same subregion. A regulating authority of some kind would then probably be required in due course to designate these products and to supervise the removal of duties and control of prices as in the case of subregional products. At the current time the only machinery for such intersubregional discussions is that of working parties, and the working party in industry will probably be meeting next in 1966 to consider industrial problems on a continental basis.

ANNEX

General relationship between steel consumption and economic development

Since steel enters into every sector of economic development, i.e., durable consumer goods, machinery, construction and transport equipment, it is appropriate to relate it to the gross domestic product.

Writing O for the value at constant prices of the gross domestic product;

I for that of gross capital formation;

a_1 for the weight of steel used directly and indirectly per unit of expenditure on consumption;

a_2 for that per unit of expenditure or capital formation;

S for the weight of steel used in the economy both directly and indirectly,

then

$$S = a_1 (O-I) + a_2 I$$
$$= a_1 O + (a_2 - a_1) I$$

and if the proportion of gross domestic product devoted to investment is p, i.e., $I = pO$

$$= O[a_1 + p(a_2 - a_1)]$$

If a_1, a_2 and p are constant, then

$$\frac{1dS}{Sdt} = \frac{1dO}{Odt} = g \text{ (growth)}$$

i.e., steel consumption increases at the same rate as gross domestic product. In general, however, in developing countries, a_1 and a_2 are increasing. This is largely because the non-monetary or subsistence sector in these countries makes a substantial contribution to gross domestic product, perhaps on the average about one-quarter, and uses virtually no steel. It follows that if, for example, the contribution to gross domestic product of the monetary sector increases by 10 per cent, the total domestic product will increase by 7.5 per cent and steel consumption by 10 per cent. Such countries may also be at the stage where a_1 and a_2 are increasing because of the expenditure on such steel intensive activities as railways, but sooner or later, as the economy develops, a_1 and a_2 will decrease because of the disappearance of the subsistence sector and the increasing expenditure on services etc. which have no steel content.

If p is constant, then the rate of the expansion of the economy will also be constant and will depend upon the output/capital ratio, so that if:

$$g = \text{rate of growth} = \frac{1}{O} \cdot \frac{dO}{dt};$$

r = output/capital ratio;

s = rate of scrapping of assets;

$$g = p.r. - s^{*}$$

For developing countries, r is usually about 0.4, so that if one takes p to be equal to 0.14, i.e., investment at 14 per cent of the gross domestic product, the rate of growth of the economy will be 0.056 minus s equals about 5 per cent per annum, and both investment and steel consumption will increase at this same rate.

If, however, p is not constant, but is increasing, for example, by 0.7 per annum from an initial level of 0.14, the rate of growth of the economy will steadily increase, i.e.:

$$\frac{dg}{dt} = r \cdot \frac{dp}{dt} = 0.28 \text{ per cent}$$

Then the rate of increase of investment will have to be twice as great as before:

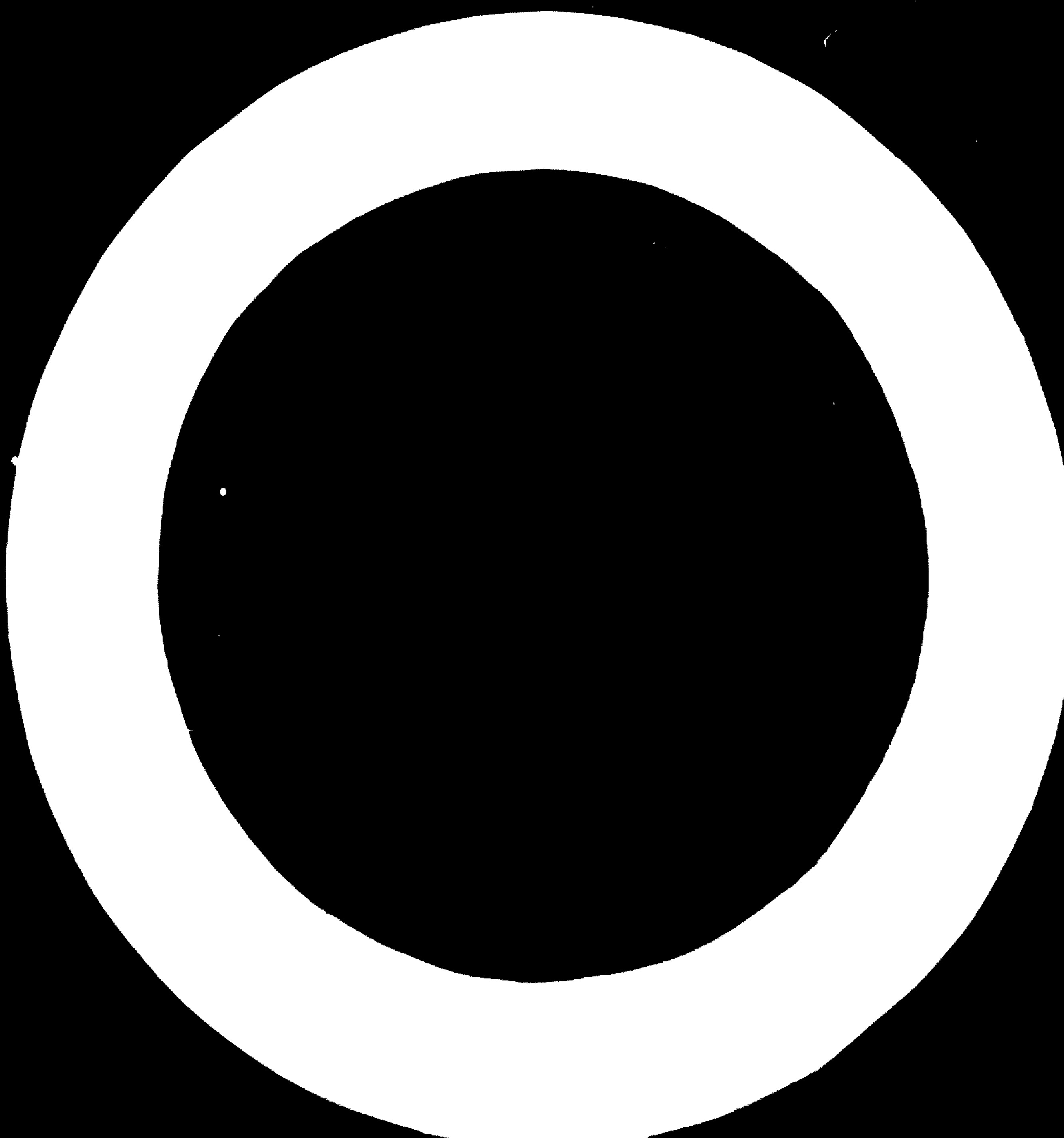
$$\frac{1}{I} \cdot \frac{dI}{dt} = \frac{1}{p} \cdot \frac{dp}{dt} + \frac{1}{O} \cdot \frac{dO}{dt} = .05 + .05 = .10$$

Therefore steel consumption will increase at a rate roughly half-way between the rate of growth of gross domestic product and of investment. Taking a_2 as six times a_1, which is the usual condition in developing countries, then:

$$\frac{1}{S} \cdot \frac{dS}{dt} = \frac{1}{O} \cdot \frac{dO}{dt} + \frac{a_2 - a_1}{a_1 + p_1 (a_2 - a_1)} \cdot \frac{dp}{dt}$$

$$= .05 + .02 = .07$$

* R. Robson, *Note on the Output Capital Ratio and the Return on Capital in Developing Countries* (Oxford Economic Paper, July 1965).



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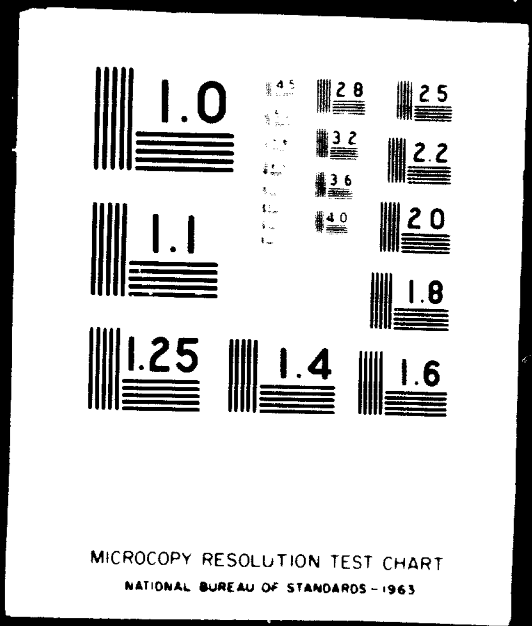
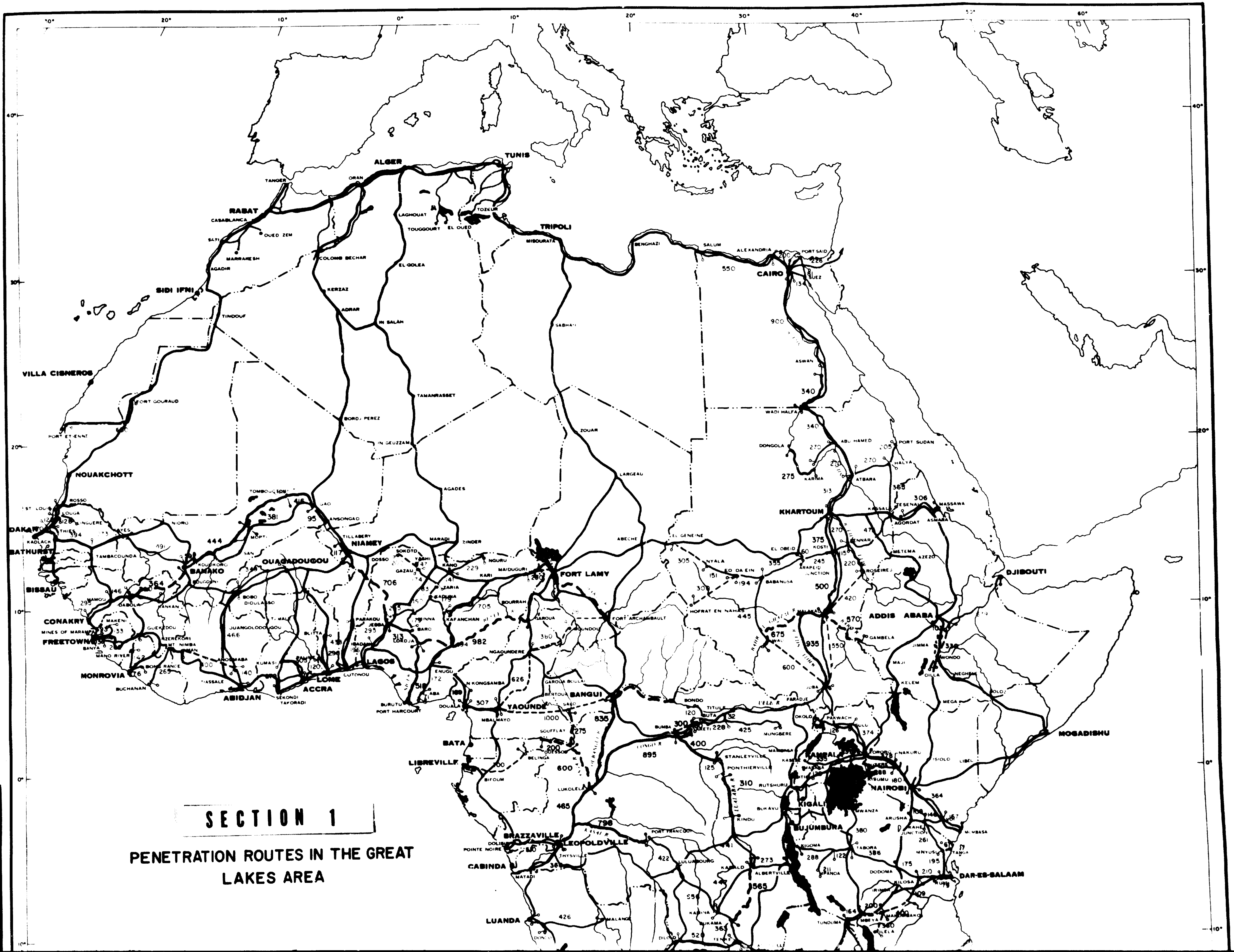
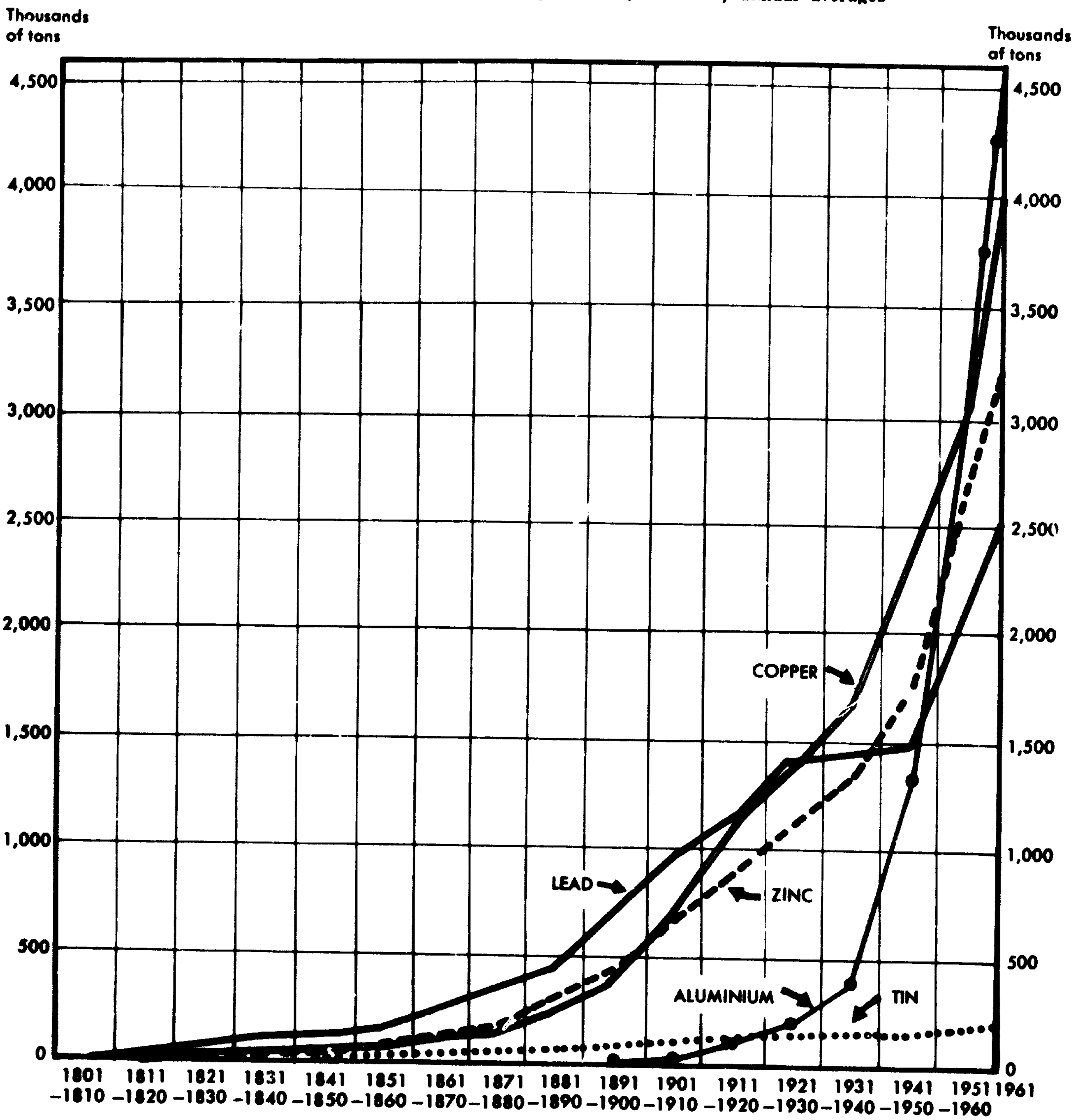




SECTION 1

PENETRATION ROUTES IN THE GREAT LAKES AREA

Figure I. World non-ferrous metal production, 1801-1961, annual averages



SOURCE: Hans Bachmann, "Aluminum as an export industry", paper prepared for the United Nations Conference on Trade and Development, Geneva, 1964.

aluminium in 1963 in each country is given in annex I, table 15.

B. Past and projected rates of world growth of aluminium

Over the period 1900-1960, world aluminium production has advanced at the compound rate of 11 per cent per annum. This has been the equivalent of demand doubling every seven years. There have been some variations in this rate of growth within different decades, but, in the most recent period, 1950-1963, the rate of growth also averaged 11 per cent per annum. However, the greater part of the growth took place in the five years from 1950 to 1955, partly stimulated by the Korean War. There was a sharp decline in growth between 1955 and 1963. A resumption of a high rate has taken place in 1964/1965, but various estimators do not expect the longer term to see a continuation of the rate of 11 per cent per annum. The record of world rates of growth is given in annex I, table 16, up to the level of 6.1 million short tons reached in 1963.

It will also be noted in that annex that the free-enterprise economies contribute about three-fourths of the current world production of aluminium and the centrally planned economies the balance of almost one-fourth. The Union of Soviet Socialist Republics has advanced rapidly since 1940 to produce about 17 per cent of the world primary aluminium supply, and the relative position of the United States of America at 38 per cent has been declining slightly. The other free-enterprise economies produce the same proportion as the United States of America, and this has also been declining slightly since 1940. In the emergence of the USSR from a developing status to one of the leading industrial countries of the world, aluminium has been given a prominent position. It had been the target of the Soviet Seven Year Plan, 1959-1965, to achieve an annual rate of increase in production of 16 per cent, but this was not reached.

A study of projections of demand for, and consumption of, aluminium made by various organizations and experts for the world as a whole and for various regions and countries was completed in 1965 by an agency of the Government of the United States of America. This study concluded that for the next few decades, for the world as a whole, a slowing down is expected in the rate of growth of aluminium production to a level of between 6 per cent and 8 per cent per annum; for Western Europe, a rate of between 4.7 and 7.2 per cent per annum; for the United States of America, between 5 and 10 per cent; and for Australia, India, Japan and the USSR, the highest figures were between 9 and 15 per cent per annum. In general, consumption is expected to grow at faster rates, though from lower levels, in the less developed countries than in the more developed countries. Contributing to a slowing down in the rate of growth in aluminium consumption in the United States of America is expected to be the increasing competition from other materials and the more mature state of over-all development. A summary of the various projections of demand and production appears in annex I, table 17.

From the viewpoint of the developing countries of Africa, the opportunity will be open to supply to the growing world markets for aluminium, including their own markets, the raw material, bauxite; the intermediate product, alumina; the crude aluminium itself and the electric power needed for the aluminium. The projections look towards a doubling of the world demand for all these factors every ten or fifteen years for a few decades. This means that by the year 1975 or 1980 the world as a whole may roughly double its 1963 requirements for aluminium industry. These will then call for the following additional amounts each year: (*a*) bauxite, 30 million long tons; (*b*) alumina, 12 million short tons; (*c*) electricity, 10.5 million kilowatts of firm capacity; and (*d*) aluminium, 6 million short tons.

If the world aluminium demand were again to double by the years 1990-2000, the additional annual quantities required above those of 1963 would be approximately as follows: (*a*) bauxite, 90 million long tons; (*b*) alumina, 36 million short tons; (*c*) electricity, 32 million kilowatts of firm capacity; (*d*) aluminium, 18 million short tons.

There will also be important additional quantities of other materials needed for the growing aluminium industry, particularly carbon electrodes from petroleum coke, synthetic cryolite, soda and lime or caustic soda and fuel for the alumina plants. Developing countries can also contribute some of these requirements, but the principal opportunities for them are in bauxite, alumina, aluminium and electricity.

C. Investments, capacities and costs of stages of the aluminium industry

A brief description and flow charts of the stages of the aluminium industry and examples of investment requirements are given in Annex III. The charts are from a comprehensive analysis of requirements of materials and investments for operations of different capacities given in a document prepared for the United Nations Centre for Industrial Development.[5] Another summary of the economics of the world aluminium industry appeared as a paper contributed to the United Nations Conference on Trade and Development, Geneva, 1964.[6]

Among the conclusions to be drawn from annex III for developing countries are the following:

(*a*) Bauxite will continue to be used as the predominant raw material for aluminium production so long as it is available at acceptable costs of production at the shipping point (commonly between $2 and $4 per long ton), plus other costs, including royalties and taxes paid to the producing country, and shipping costs to the receiving points. Substitute minerals are abundant, but are currently more costly to use than bauxite. The industrialized countries are becoming increasingly dependent upon countries in the tropics for bauxite;

(*b*) Capacities and production costs at different stages of the industry cover a wide range throughout the world. The smelters include plants with less than 10,000 tons of annual capacity and plants with 100,000 tons and more. Recent costs per pound of ingot at the smelter have been as low as $0.14 per pound and as high as $0.27. Internal prices have been as high as $0.37 when the world price of metal delivered anywhere from Canada was as low as $0.225. Protectionism has permitted small smelters and high prices to serve domestic markets, but has not given the ability to compete in international markets;

(*c*) However, the world-wide tendency is to build larger smelters to reach optimum levels, e.g., 100,000 tons of capacity per annum, illustrated by the new plant under construction in Ghana;

(*d*) An integrated smelter of such a capacity in the United States of America, including foreign bauxite mines, an alumina plant and a power-plant in the United States, could require an investment on the order of $140 million, or $1,400 per ton, or even more;

(*e*) In this investment the bauxite development could represent $16 million: the alumina plant, $30 million; the smelter, $70 million; and the power-plant, $24 million if thermal or $72 million or more if hydroelectric;

(*f*) Total employment in such an integrated enterprise would be small, as little as 2,000 workers, each requiring an investment of at least $70,000;

(*g*) However, a high-cost and protected integrated enterprise, as in India, has operated until recent years with a smelter capacity less than 6,000 tons, an alumina capacity of 14,000 tons and a fabricating mill with a

[5] Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

[6] Hans Bachmann, "Aluminium as an export industry", Paper prepared for the United Nations Conference on Trade and Development, Geneva, 1964.

total historical investment of under $10 million. Such an enterprise could not compete internationally;

(*h*) The principal elements of the cost of ingot delivered to market are alumina, power and the transportation of all the component materials;

(i) Many plants produce fabricated aluminium products in developing countries with a small capacity, below 2,000 tons per annum, and individual investment in shops of between $50,000 and a few hundred thousand dollars. As both capacity and diversification increase, the investment rises into millions of dollars. Employment per unit of capacity and investment is many times greater than in the integrated smelter enterprises, to the order of at least ten times as many jobs.

To the developing countries in Africa, the future growth of the world aluminium industry poses questions with regard to: (*a*) the extent to which Africa will supply bauxite to other regions; (*b*) the extent to which Africa will integrate further to supply alumina and metal for export; and (*c*) the extent to which Africa will develop its internal markets for aluminium.

There are no inevitable answers to these questions that would follow simply because Africa has abundant bauxite and energy resources for low-cost electric power. Other countries also have suitable bauxite in substantial quantity. Rarely do they have the same low-cost power potential at major hydroelectric sites as does Africa, but some have economical fuel resources. In addition, the more industrialized countries currently have relatively acceptable power costs from some fuels and will possibly have from nuclear power in future, so that they can locate and are locating new smelter capacity within their own borders rather than uniformly trying to place such capacity close to the bauxite sources. Thus, there is considerable freedom of choice for the location of the alumina and aluminium plants, and only a more restricted freedom when it comes to obtaining bauxite.

D. Ownership and competition in the world primary aluminium industry

The opportunities for Africa to participate in the aluminium industry are conditioned by the relatively few private enterprises that control most of the world industry, by the somewhat expanding role of government enterprises in some countries, and by the willingness of many Governments to promote the private or public industry with subsidies or other forms of assistance. These circumstances place a handicap on many African countries, which lack the large capital and other resources to offer to either private companies or government enterprises of their own; have yet to achieve the political stability and security needed to attract a maximum amount of private investment, or investment from foreign government enterprises if this is desired; and do not yet have their own technical experts and administrative personnel capable of establishing and operating the stages of the aluminium industry.

A description of the structure of the world aluminium industry is given in annex II. This material shows that two-thirds of the industry is owned or controlled by private companies and almost one-third by Governments, mainly the Governments of centrally planned economies. Outside of the area of the industry controlled by the centrally planned economies, only six companies control or influence by minority interest most of the primary productive capacity. Ten small private companies own about 12 per cent of the capacity, and Governments of free enterprise economies own about 10 per cent.

Annex II also reviews the intensive rivalry between the leading private companies to gain positions in various markets of the world and the growing practice of sharing investment risks through joint ventures. This practice includes joint ventures between private companies and Governments, as well as some mutual assistance between Governments. The number of Governments participating directly in the industry is increasing, although they usually call on private enterprise for help. Some Governments have encouraged the development of primary aluminium capacity beyond the needs of the domestic market and have looked towards export markets to absorb the surplus, even if it is necessary to sell the metal at discounted price levels. This means, however, a reduced return on investment to both private and government aluminium enterprises. Under temporary conditions of excess capacity, as occurred between 1956 and 1962 in North America, the effects can be very adverse.

E. Access to consuming markets

There is a difference, of course, between control of primary production and control of the consuming markets. Government enterprises in the centrally planned economies control their own internal markets, but they have to face competition in export markets. Government enterprises in such free-enterprise economies as China (Taiwan), the Federal Republic of Germany and Norway, have to compete for markets both at home and abroad, although protectionism is used by some Governments to guarantee disposal of their own primary metal at home.

All major private companies control in various degrees the market for their primary metal. Because their fabricating capacities are usually much greater than their primary ingot capacity, these companies restrict the volume of business freely open to other producers of primary aluminium.

Market restrictions are not only created by ownership of fabricating plants, as is the case of the large producers of primary aluminium in the United States of America, but, in addition, others, for example, producers in the Federal Republic of Germany, France and Switzerland, have built up trade relations with customers that are difficult for competitors to upset. Private crude aluminium producers have been further restricting opportunities for competitors by purchasing some semi-fabricating companies, or by entering into alliances with them to provide technical assistance. The large companies, furthermore, can offer technical aids in production methods and can help in developing a market demand that small private companies and small government enterprises cannot equal.

Developing countries in Africa and elsewhere thus find that even if they could build their own government aluminium smelters, they would have substantial problems of disposing of metal in export markets. If they wish to obtain aluminium smelters in advance of the ability of domestic markets to absorb the output, they have to make arrangements with outside companies or foreign Governments who can provide the technical assistance and the necessary markets. This was the basis of the smelter built in Cameroon by two French companies who take almost all the metal for exportation, and of the smelter now being built in Ghana by two companies from the United States of America, who will take most of the metal for exportation.

F. Bauxite, alumina and developing countries

The same solution is necessary also for African countries wishing to obtain bauxite development or alumina plants, long before an integrated domestic industry is needed. Bauxite production in Ghana is in the hands of a company from the United Kingdom of Great Britain and Northern Ireland. The alumina plant in Guinea is owned by a consortium of foreign private companies, and the new bauxite mine of Sierra Leone is operated by a Swiss company. Guinean bauxite production was originally in the hands of a Canadian-controlled French company. This was taken over by the Government of Guinea in 1962 with technical help from the Government of Hungary, but with a substantial loss of the bauxite market. Consequently, the Government of Guinea turned again to a foreign company to help develop the major bauxite deposits of the country, but this time on a basis of joint ownership with the Government.

Developing countries in Africa and elsewhere have made different types of arrangements for the mining and exportation of their bauxite. Although the national benefits from producing the bauxite for exportation are much smaller than those from producing alumina and the metal for exportation, these benefits have been very significant to some of the less developed countries who are major producers. This has been the case particularly in the Caribbean area with British Guiana,[7] Jamaica and Surinam. Benefits have been unimportant to small bauxite producers like Ghana.

Benefits result from modest amounts of employment created, but much more importantly, from substantial financial contributions in royalties and income-taxes. In some countries, the concessions for bauxite mining have also been conditioned contractually or informally upon commitments of companies immediately or later to establish alumina plants, as in Australia, British Guiana, Guinea, Jamaica and Surinam. As was the case in Guinea, and may be the case in Australia, such commitments may not be possible to fulfil on a predetermined time schedule because of unpredictable market conditions.

The experiences of a number of bauxite countries are summarized in annex IV, giving the history of the bauxite developments and arrangements made between Governments and companies. This annex reviews also the history of bauxite in Ghana, Guinea and Sierra Leone.

G. African aluminium smelters and export markets

The smelter in Cameroon and the one now under construction in Ghana prove that private companies with international markets have been willing to produce aluminium ingot in Africa on a substantial scale for exportation. This willingness has also been indicated by previous investigations by companies into the possibility of producing in Angola, the Congo (Brazzaville), the Congo (Democratic Republic of) and Guinea, and also in taking power from the Kariba project along with Malawian bauxite in East Africa. The United Arab Republic (Egypt) evidently hopes to work out some export arrangements to support a smelter to use power from the Aswan project.

All of these African projects, except possibly that of the United Arab Republic, involve the immediate or ultimate use of alumina based on African bauxite. In addition, however, there is the possibility of using African energy sources of low-cost power as an independent reason for producing aluminium. Two major primary aluminium countries, Canada and Norway, owe their position entirely to low-cost electric power. They import all of their bauxite and much of their alumina, and they export most of their metal. Other countries have been trying to follow this pattern by seeking companies to produce aluminium with domestic low-cost energy resources, again even though all of the bauxite or alumina would have to be imported and nearly all of the ingot would have to be exported. Ghana is a successful example, although native bauxite may be used ultimately. Not yet successful are Iceland and Peru, with hydroelectric potentialities, and Kuwait, which is adjacent to East Africa and has large amounts of wasted natural gas released during petroleum production. These countries have been seeking aluminium developments through foreign participants. Kuwait already has an agreement with the Reynolds Metals Company to build a smelter, but the outcome is now uncertain.

As may be seen in annex III, low-cost electric power is no longer a sufficiently controlling influence upon the location of some aluminium smelters. The combination of transportation, power and labour costs is more controlling, and this allows considerable cost variation in each factor. In the United States of America, smelters have located in the past fifteen years in regions closer to consuming markets, where the cost of power using coal at 0.4 cents per kWh is 100 per cent greater than the cost of hydroelectric power in the more remote Pacific North-west. The transportation economies have offset the higher cost of power. In Japan, a nation which must import all of its bauxite and must use power recently at costs as high as 0.8 cents per kWh, the primary aluminium industry has been expanding rapidly under a policy of protecting the domestic market for the domestic producers. In the Netherlands, where one of the world's largest natural-gas fields has been only recently discovered offshore in the North Sea, an aluminium smelter is being built to use electricity generated from the gas at a considerably higher cost than in other parts of the world. Even so, this plant will be economical with imported bauxite or alumina because of its proximity to the markets.

As pointed out in the pre-investment report prepared by Reimers for the United Nations,[8] typical power costs among aluminium smelters of the world cover a wide range:

	Cents per kWh
Canada	0.15 to 0.35
Japan	0.27 to 0.8
Western Europe	0.40 to 0.60
Norway	0.15 to 0.27
United States of America	0.2 to 0.4

African countries, therefore, cannot rely upon their low-cost power potential as a sufficient reason to attract

[7] Now the independent State of Guyana.

[8] ST/ECLA/CONF.11/L.24.

aluminium smelters to serve foreign markets. The Ghanaian smelter of the Volta Aluminium Company was the result of special policies of the United Kingdom, the United States of America and the International Bank for Reconstruction and Development (IBRD). They committed loans totalling $98 million to match another $98 million to be supplied by the Government of Ghana for the Volta power project. The Government of the United States of America also agreed to provide $110 million in loans and to guarantee a private investment of $54 million for the aluminium smelter. Other African projects for power and aluminium early in 1965 were in the "hoped-for" stage. These include:

(a) *Congo (Brazzaville)*: The Kouilou power project, with an ultimate capacity of 820,000 kW and an investment of $170 million; and a proposed aluminium smelter with an ultimate capacity of 275,000 short tons and an investment of about $150 million;

(b) *Congo (Democratic Republic of)*: The Inga power project, to be built in stages ultimately to 25 million kW, with over $3,000 million in ultimate investment; and an aluminium smelter to be built in stages to an ultimate capacity of 550,000 short tons, with an investment of about $400 million;

(c) *Angola*: Aluminium smelter with an initial capacity of 28,000 short tons and an investment of $28 million, based on the Cambambe power project, already partly completed;

(d) *Guinea*: The Konkouré power project with an ultimate capacity of 450,000 kW capacity and an investment of $140 million; and an aluminium smelter with an ultimate capacity of 265,000 short tons and an investment of $175 million.

However, the Guinean project may proceed according to an announcement in August 1965, that the USSR has agreed to build the Konkouré hydro-electric project and an aluminium plant, and that the programme will begin in 1971. No information is available as to who will buy the aluminium or what conditions will be met to justify proceeding with the project.

The above-mentioned aluminium-power projects were the subject of investigations in the 1950's by consortiums of private companies and indicate the possible role of Africa as a major aluminium producer in the world. The proximity of African bauxite to these power projects gives an additional incentive beyond the attraction of the power projects themselves. But these possibilities, in the views of the private companies, became less attractive because of political insecurities in parts of Africa, the new developments of bauxite in Australia encouraged by the African insecurities and the transportation economies of building smelters closer to large consuming markets. These African aluminium-power projects and others that may be planned are, however, promising for ultimate development in view of the requirements of the world aluminium industry as projected above in section B of this chapter. There will be room for additional African power and aluminium, as well as for other continents, depending upon what individual countries will offer as economic and political encouragements if they wish to attract foreign participants, either private or governmental.

A much smaller scale and much slower growth of African aluminium development would occur if service to African internal markets were regarded as the principal purpose of future power and smelter projects in Africa. The encouragement of aluminium consumption in Africa as a matter of policy by most Governments would be helpful and justified. This subject is examined in the next chapter.

II. The African aluminium market potential

A. Current markets

The total African consumption of aluminium by a population of some 273 million people (1960), as already noted, was at the bottom of the scale of world regions in *per capita* consumption in 1960, at about two-tenths of a pound. In the developed countries of Western Europe, the consumption in 1960 was more than thirty times larger *per capita*, above 6 pounds, and in the United States of America, it was more than 100 times greater, above 22 pounds *per capita*. Among other large newly developing regions such as Brazil and mainland China, *per capita* use of aluminium also was greater than in Africa. Among the larger regions only India comes close to the small *per capita* consumption of Africa. Such comparisons appear in Annex 1, table 18. This table shows the changing positions in *per capita* aluminium consumption of various countries between 1938 and 1961, as well as the general, but not the precise, relationship between national income *per capita* and the consumption of aluminium *per capita*.

It is especially interesting to note that in 1938 the United States of America was behind the Western European countries in the *per capita* use of aluminium, and yet in only twenty-three years, the United States of America advanced far ahead of all countries into world leadership as an aluminium consumer.

The current position of Africa in aluminium consumption merely reflects the economic condition of Africa as a whole. Africa is also at the bottom of the world scale in *per capita* measures of income, of steel and electric power consumed, in automobiles and in general indicators of illness and health and literacy.

In 1960, the total African consumption of aluminium was estimated at roughly 26,400 tons, including some Middle Eastern countries. By 1963, the apparent consumption in Africa alone was much larger, around 51,000 tons, according to import data for most African countries, as shown in table 4. But no firm conclusion as to the rate of growth can be confidently drawn because of limitations of the 1960 estimate. Of the apparent African consumption in 1963, at least one-third, or nearly 18,000 tons, was used in Southern Africa. About the same amount was used in Western Africa. Approximately 9,000 tons were consumed in North Africa. In East Africa in 1963, aluminium imports were about 6,500 tons (including the Sudan). All of the aluminium imports required foreign exchange by the various African countries to the order of $36 million. Of this amount, about $12 million was spent by Southern Africa and about $5 million by East Africa (including the Sudan).

Table 4. Aluminium consumption in Africa as indicated by imports, 1963 or latest year

Subregion and country	Quantity (tons) Unwrought aluminium	Quantity (tons) Wrought aluminium	Quantity (tons) Total	Value (thousands of dollars) Unwrought aluminium	Value (thousands of dollars) Wrought aluminium	Value (thousands of dollars) Total
North Africa						
Algeria (1961)			2,304			1,545
Libya			307			224
Morocco (1961)			3,200[a]			2,136
Tunisia	7	373	380	6	375	381
United Arab Republic (Egypt) (1961)			2,800			2,211
TOTAL			8,991			6,497
Western Africa						
Angola						
Cameroon			1,487			999
Central African Republic			180			137
Chad			47			44
Congo (Brazzaville)			265			179
Congo (Democratic Republic of)			864			1,121
Dahomey			82			68
Gabon			134			89
Gambia						
Ghana	194	7,322	7,516	141	5,302	5,443
Guinea			...			
Ivory Coast			393			286
Liberia (1962)			478			326
Mali			20			6
Mauritania			14			12
Niger			41			40
Nigeria	2,708	3,275	5,983	1,730	1,969	3,699
Portuguese Guinea			...			
Senegal			212			136
Sierra Leone			123			168
Togo			52			52
Upper Volta			17			13
TOTAL			17,908			12,818
East Africa						
Burundi						
Ethiopia			154			247
French Somaliland			...			...
Kenya	1,761	1,433	3,194	867	770	1,637
Madagascar			251			209
Malawi, Southern Rhodesia and Zambia			1,158			1,104
Mauritius	1	291	292		283	283
Mozambique (1962)			400			577
Rwanda			42			36
Somalia[b]			37			47
Sudan[c]			670			333
Uganda	...	79	79	...	79	79
United Republic of Tanzania	233	172	405	125	142	267
TOTAL			6,482			4,819
Southern Africa						
Basutoland, Bechuanaland South Africa, South West Africa, Swaziland	14,300[a]	3,260[a]	17,560[a]	7,261	4,754	12,015
AFRICA, TOTAL			50,941			36,149

SOURCES: United Nations, *Yearbook of International Trade Statistics, 1963* (United Nations publication, Sales No.: 64.XVII.12); United Nations, Foreign trade statistics of Africa, 1963; European Economic Community, *Foreign Trade of Associated Overseas Areas*, 1961, 1963; Alcan African Limited; national publications; other trade sources.

[a] Estimated.

[b] Southern only.

[c] For these data, the Sudan is included in East Africa, rather than in North Africa.

Incomplete as the data are on African uses of aluminium, there is no question but that the trend is upwards. The growth also is clearly exceeding that anticipated in the projection made in 1960 when it was expected that not until 1970 would Africa and the Middle East use 55,000 short tons of aluminium. That point was passed in 1963. The growth is concentrated in South Africa, but it is also taking place in some other African countries. This is shown in the figures (see table 5) compiled from Alcan International and other sources in an electric-power report made by ECA.

Table 5. Apparent specific consumption of aluminium in selected countries

(Pounds per capita)

Country or territory	*1958*	*1959*	*1960*	*1961*	*1962*
Federation of Rhodesia and Nyasaland	0.2	0.2	0.3	0.4	0.4
Ghana		1.1	0.7	1.0	1.7
Kenya, Tanganyika and Uganda				0.3	0.3
Nigeria		0.2	0.3	0.3	0.3
South Africa	1.4	1.4	1.8	1.9	2.3
United Arab Republic (Egypt)	0.2	0.3		0.2	0.3

SOURCE: United Nations, *Situation, Trends and Prospects of Electric Power Supply in Africa* (United Nations publication, Sales No.: 65.II.K.2).

In East Africa, however, over the five-year period, 1960-1964, no definite trend is evident in aluminium consumption as indicated by imports of all forms of aluminium to the principal countries. The total for 1964 was higher than for 1960, but in between there was a drop in imports, as is shown in table 6.

Table 6. East Africa, aluminium imports, selected countries, 1960-1964

(Short tons—all reported aluminium products)

Country	*1960*	*1961*	*1962*	*1963*	*1964*
Ethiopia	176	176	1t0	154	198
Kenya	4,383 (Kenya, Uganda and United Republic of Tanzania combined)	2,452	2,097	2,815	1,566
Uganda		335	217	85	185
United Republic of Tanzania		137	182	368	3,529
Malawi, Southern Rhodesia, Zambia	t,278	t,399	1,311	1,263	1,392
Mauritius	200[a]	200[a]	254	324	386
TOTAL	6,037	4,699	4,17t	5,009	7,256

SOURCE: Compiled by Alcan Africa Limited (Montreal, Canada), from data of East African Common Service Organization and national statistics of individual countries.

[a] Estimated.

African capacity to process aluminium is confined largely to small rolling and corrugating mills and to utensil plants. Only in South Africa is there also capacity to make extrusions, wire and cable, and large sheet products. A list of African countries having fabricating plants and their capacities as of 1962 is given in annex III, table 27. The following table gives a more complete, but partial, listing of forty-four plants in Africa. Most of them make utensils. Fourteen plants are in East Africa.

Table 7. Partial list of aluminium fabricating plants in Africa, 1965

Country	*Number of plants*	*Principal products*	
		Utensils	*Sheet*
Algeria	5	×	×[a]
Cameroon	1	×	
Congo (Democratic Republic of) (Jadotville, Bukavu)	1	×	
Ghana (Tema)	2	×	×[b]
Ivory Coast	1	×	
Nigeria (Lagos)	6	×	×
South Africa	6	×	×[cd]
Sudan (Khartoum, Omderman)	2	×	
United Arab Republic	3	×	
	30		
East Africa			
Burundi (Bujumbura)	1	×	×[e]
Ethiopia (Asmara and Addis Ababa)	3	×	
Kenya (Mombasa)	2	×	
Rwanda	1	×	
Southern Rhodesia (Salisbury)	1		×
Uganda (Kampala)	2	×	
United Republic of Tanzania (Dar-es-Salaam)	3	×	×[d]
Zambia (Lusaka)	1	×	
	14		

[a] One rolling mill and four corrugating plants, of which one also makes utensils.

[b] Windows, ladders, furniture and castings also.

[c] Extrusions, wire and cable also.

[d] Including rolling mills processing ingot.

[e] Corrugated sheet.

Aluminium is processed in Africa from imported ingot and sheet mainly for utensils and building products. Smaller amounts are imported for such purposes as windows and doors made from imported extrusions, foil for cigarette and other packages, tubes for pipe and wire. Only in South Africa and, on a small scale, in the United Republic of Tanzania, are some of these products also made directly from the crude metal. As the economies of African countries grow and diversify, the uses of aluminium will likewise follow and more aluminium products can be made, at first in small plants of a few hundred or a few thousand tons of capacity per annum.

B. Projecting African aluminium consumption

In Africa, it would be misleading to use methods of projecting aluminium consumption that have been worked out in developed countries. These methods take two approaches. One is the statistical method of correlating aluminium consumption with population and gross national product. The other method is to build up projections by adding the estimated growth in the major fields of aluminium consumption, such as transportation, building construction, electrification, household utensils and appliances, etc.

These methods are not applicable in Africa for a number of reasons. First, dependable statistics over a period of years do not exist in Africa. Secondly, the African national economies are in such early stages of development that there has been insufficient time to establish relationships between aluminium demand and the growth of population and gross national product.

Then, the projection of developments in transportation, building construction and other fields where aluminium is used extensively in some countries is not yet possible in Africa, where national planning and development programmes are being shaped for the first time in many countries. And finally, the ways and extent to which aluminium will be used in Africa in the early stages of development may not be similar to other countries. The patterns of aluminium consumption in developed and developing countries are reviewed in annex V.

It is necessary to keep in mind the main characteristics of Africa that so sharply distinguish it from industrialized countries. These affect the ways and quantities that aluminium can be used.

(*a*) The African population of some 273 million (1960) is about 8.5 per cent of the world population but accounts for only 2 per cent of the world output. It is weak in productivity;

(*b*) Productivity of the population of most African countries is held down by chronic sickness and malnutrition. In most of tropical Africa (167 million people in 1957/1958), 30 per cent to 50 per cent of the infants die, and possibly not more than half that survive infancy reach adulthood. Sickness with one or more chronic diseases is the normal condition of most adults;[9]

(*c*) Most of the population lives by subsistence farming and has little purchasing power for the money economy. Even the low *per capita* income measure of about $112 is no basis for estimating cash buying-power;[10]

(*d*) The literacy level in all Africa is about 16 per cent, the lowest among world regions.[11] This also holds down productivity;

(*e*) In the two decades, 1940-1960, *per capita* output in Africa increased but slightly, compared with industrial countries, between 10 to 20 per cent as compared with over 60 per cent, while real average income changed but little;[12]

(*f*) Productivity in African agriculture is about half that of industrial countries, and in industry about one twenty-fifth, measured over the entire population;[13]

(*g*) The continent covers 22.4 per cent of the world's land area and is second only to Asia in size, but it is divided into some fifty political units, most of them recently independent of former colonial status. Effective political and economic co-operation between much of Africa has yet to be achieved and is handicapped by huge spaces between railroads and all-weather roads, which prevent people and commodities from moving economically and regularly inside much of the continent between north and south, and between the Atlantic and Indian Oceans;

(*h*) The density of population in the vast continent is very low, about nine persons per square kilometre as against twenty-three for the world as a whole, and around 100 in Europe outside of the Soviet Union.[14] The thin population density and long distances between urban centres impede the development of interconnected power systems, the growth of electric-power consumption and the growth of associated demands for domestic and rural goods in which aluminium is a component material.

These basic conditions presumably will be improved over a period of time, but there is no way to predict a dependable time schedule of improvement. The various ECA estimates of expected growth in gross national product of different African countries are based partly on national plans. These plans and the investigations of possible growth rates in industrial sectors indicate possibilities, but not probabilities. The trend of countries over all of Africa is towards working out comprehensive long-range plans in order to increase rates of growth, but the machinery to carry out the plans is weak.[15] The plans for the public sector can be controlled to some extent by Governments; the steps for the private sector to take are less controllable. The ambitions of most African countries require substantial capital investments from outside sources, and the amount and the time schedule of such investments cannot be fixed by the African Governments.

In the case of aluminium consumption, if it were assumed that no special governmental encouragement policies were adopted, it would be reasonable to conclude that:

(*a*) The metal would move into some public works on its merits as being more economical than other materials in certain uses;

(*b*) Commercial buildings would use more of the metal for the same reason;

(*c*) Private enterprises would continue to promote the sale of the metal, especially to the middle and higher income groups, but also in utensils to poorer populations, where the superiority of aluminium over enamelware, pottery and other materials has been demonstrated in part of Africa, and where the small cash outlay is still possible for much of the population.

From these relatively safe assumptions, it may be concluded that the *per capita* use of aluminium in Africa will be at least at the recent level of 1963 and that total consumption will at least increase in proportion to the growth of population. This approach gives a minimum projection by 1975 of 66,000 tons and by 1980 of 75,000 tons. These result from the population projections, medium estimate, by the United Nations, of a 28 per cent increase by 1975 and 47 per cent by 1980.[16]

The anticipated growth in African gross domestic product may also be taken as a guide on the assumption that aluminium use will increase in at least the same proportion. A rate of 5.5 per cent per annum is taken, using as a guide the same figure employed until 1970 in one ECA study of the building materials industry,[17] and a rate above 6 per cent per year employed until

[9] George H. T. Kimble, *Tropical Africa* (New York, The Twentieth Century Fund, 1960), vol. I, p. 89, vol. II, pp. 33-51.

[10] United Nations, *Industrial Growth in Africa* (United Nations publication, Sales No.: 63.II.K.3).

[11] United States of America, Agency for International Development, *Selected Data for the Less Developed Countries* (Washington, D.C., April 1965), p. 8.

[12] *Industrial Growth in Africa.*

[13] *Ibid.*

[14] United Nations, *Situation, Trends and Prospects of Electric Power Supply in Africa* (United Nations publication, Sales No.: 65.II.K.2).

[15] See United Nations, *Report of the ECA Mission on Economic Co-operation in Central Africa* (United Nations publication, Sales No.: 66.II.K.11), pp. 11-12.

[16] United Nations, *World Population Prospects as Assessed in 1963* (United Nations publication, Sales No.: 66.XIII.2). The 1965 population was estimated at 306 million, 1975 at 393 million and 1980 at 449 million. The proportional increases may be applied to the 51,000 tons of aluminium imported into Africa in 1963.

[17] United Nations Economic Commission for Africa, "The building materials industry in Africa, present structure and future growth", part III (HOU/WP/4/Add.2), p. 2.

1980 in another ECA study for East Africa.[18] The results are a minimum projection of 87,000 tons of aluminium consumption by 1975 and a maximum of 114,000 tons by 1980.

For East Africa, the population projections applied to the 1963 consumption of 6,500 tons (including the Sudan) give an aluminium consumption in 1975 that is 23 per cent higher at 8,000 tons, and in 1980, 38 per cent higher at 9,000 tons. The projections of gross domestic product give for 1975 an increase of 89 per cent or 12,300 tons, and for 1980 an increase of 150 per cent, or 16,300 tons.

It would be tempting, of course, to go further and project a possible scale of African aluminium consumption from experiences in some developed countries where the use of aluminium has increased much more than in proportion to the growth of population or gross domestic product. Thus, in the United States of America, within the period 1900-1960, aluminium consumption grew 7.9 times faster than population and 3.3 times faster than gross national product. But the adoption of such reasoning would ignore variations that occurred in these relationships over shorter periods within the United States of America. It would also disregard the differences between Africa today and a given developed country previously, and would assume also that economic history elsewhere can repeat itself in Africa today for the aluminium industry.

To summarize, the range of projections of minimum aluminium consumption for Africa as a whole and for East Africa is as follows, based on an assumed direct relationship with growth of population or gross domestic product:

Projections of consumption of aluminium (tons)

	Based on population		Based on gross domestic product	
	1975	*1980*	*1975*	*1980*
Africa as a whole	66,000	75,000	87,000	114,000
East Africa[a]	8,000	9,000	12,000	16,300

[a] Applied to 1963 consumption of 6,500 tons, including the Sudan.

These projections assume, on the basis of population, a stable minimum consumption of nearly four-tenths of a pound *per capita* for all of Africa and only two-tenths of a pound *per capita* for East Africa. On the basis of gross domestic product, by 1980 the minimum consumption would be nearly six-tenths of a pound for all of Africa and three-tenths of a pound *per capita* for East Africa.

All of these projections would still mean that by 1980 Africa would remain at the bottom of the scale among regions in *per capita* aluminium consumption, assuming the projections for the rest of the world materialize by 1970 as shown in table 2 (see p. 165). But the possibilities for aluminium in Africa may be much brighter, and may lie in the inherent values of this metal as a material under African conditions and in the opportunities for African Governments to encourage the use of aluminium as a matter of national policy.

This is evident by referring to table 5, in which the *per capita* consumption of aluminium in recent years is shown for various African countries. As can be seen, in 1962, when all Africa used between three-tenths and four-tenths of a pound of aluminium *per capita*. Ghana used more than four times as much and South Africa more than six times as much *per capita*. But the Ghanaian income *per capita* was not four times greater than Africa as a whole. It was roughly two times greater. Likewise, the South African income *per capita* was not six times greater than Africa as a whole but roughly three times greater.[19] Ghana and South Africa made greater use of aluminium *per capita* than the incomes would have suggested because of two circumstances. In Ghana, the Government adopted the policy of promoting the use of aluminium in buildings and discouraging the use of galvanized iron. In South Africa, the relatively high rate of income and economic development enjoyed by the white population favoured the use of aluminium through the sales efforts of private enterprise. Whereas in Ghana, the Government acted to increase the use of aluminium, the same results were achieved in South Africa where private enterprise sold aluminium on its merits to people who could afford it.

The forces of both government policy and private enterprise are working side-by-side in most of Africa and can achieve similar results. In so far as incomes *per capita* do increase throughout Africa by 1980, the presumption is that private enterprise, if allowed freedom to demonstrate the advantages of aluminium, is likely to increase *per capita* consumption proportionately more than *per capita* incomes. And the same result can take place if African Governments foster policies under which aluminium will be proved more economical and desirable than some other material. Such special opportunities for aluminium to serve African conditions have to be demonstrated, and in this report they can only be discussed in a preliminary way.

C. Special opportunities for aluminium in Africa

African Governments should be interested especially in encouraging the uses of materials that do certain essential jobs at lower cost than other materials, or do essential jobs that other materials cannot do at any cost. Economies of these types help reduce imports of less essential goods, conserve foreign exchange and make the most effective use of limited domestic capital resources. Aluminium has won its place in many applications in developed countries because it does serve such purposes. At the same time, however, aluminium has been regarded in some quarters as more of a luxury metal, "... essentially a metal related to a high standard of living. Its *per capita* use follows the same general trend as the *per capita* application of electric power, the adoption of modern forms of transportation, the ready availability of consumers goods and the sophistication of packages used for food."[20]

It is also accurate to state that even in the developed countries aluminium has won positions where it has raised agricultural productivity, increased worker efficiency, improved the health of men and animals, reduced the costs of making or preserving such essential products as food and fibres, and lowered the costs of transporting people and things. In Africa, precisely the same needs exist. The Governments, therefore, have the opportunity of looking critically at ways of using

[18] United Nations Economic Commission for Africa, "Projections of gross domestic product", memorandum, 20 June 1965.

[19] See United Nations, *Industrial Growth in Africa* (United Nations publication, Sales No.: 63.II.K.3), showing Ghana, $243 *per capita*; South Africa, $360 *per capita*; and Africa as a whole, $112 *per capita*.

[20] Dr. E. G. West, quoted in *Metal Bulletin*, London (16 November 1962).

aluminium which might be highly desirable and of encouraging some of these applications.

D. Aluminium utensils, fuel economy, deforestation and soil erosion

The use of aluminium in utensils is one of the original markets that supported the industry in its early years in the United States of America. In India, the Government favours the use of aluminium to displace imported copper for cooking and other purposes. As a result, aluminium for utensils has led all other uses until recent years, when the Indian electrification programme pushed aluminium for electrical conductors (instead of copper) into first place. In Africa also, the most popular use of aluminium is in utensils, made in all but one of the African countries having fabricating plants. But the amount of aluminium used annually for utensils is evidently much less than would be the case if Governments and individuals understood more widely the economies of aluminium in cooking.

The aluminium utensil is the most economical of common materials used in cooking in Africa. It cooks much faster and more uniformly than other utensils and saves on fuel, owing to the thermal conductivity being three times greater than iron. Unlike the ceramic utensils, the aluminium product does not break. Unlike iron, it does not rust. It is unaffected by most food-stuffs, whereas the iron utensil will affect acid foods, as will the enamelware when the enamel has been chipped away, exposing the iron. The aluminium utensil does not affect the taste of foods cooked or stored in it. It does not have to be dried after cooking like iron to prevent rust or cleaned to remove rust, although it is stained lightly by certain foods. But the ability of aluminium utensils to heat foods three times faster than ironware should be of the greatest interest to African Governments in countries where the problem of fuelwood in most important.

Many African countries, including much of East Africa, are experiencing large-scale soil erosion from the cutting of wood for fuel used in heating and cooking. In the period 1959-1961, 88 per cent of all removals of wood in Africa were for fuelwood in the rural subsistence sector. This consumption of fuelwood is very great per 1,000 of population, 665 m^3, compared with an average world consumption of 335 m^3 per 1,000. In East Africa, the fuelwood removed in 1959-1961 was 89.6 million m^3 out of 99.9 m^3 of all wood removed.[21]

Moreover, there is a very great wastage in the use of fuelwood. Much of it is not seasoned and is burned in wet condition, losing heat to drive off moisture. The heating of rural houses is inefficient, and cooking stoves are poorly designed. Finally, much wood is wasted in the process of cooking itself, losing heat to the utensil as compared to the more rapid heat conductivity of the aluminium utensil in cooking the food.

How much of the annual fuelwood cut in Africa could be saved from more efficient uses of the wood has not yet been discussed in ECA publications. Likewise, what saving could result from the use of aluminium utensils is not known. But these economies are needed. The cutting of fuelwood, especially from hilly slopes, is responsible for soil erosion under tropical rains, for the loss of land productivity and for contributing to the flooding of lower lands. Much of Africa badly needs better forest management in order to protect watersheds, to prevent flooding, to restore fertility to exhausted lands and to obtain the maximum value from the lands. In particular, some abused forest lands may be usable to produce pulpwood to meet the growing deficiencies in pulp and paper in developed countries. According to ECA and the Food and Agriculture Organization of the United Nations (FAO), African forests are menaced by indiscriminate cutting and other practices and need more programmes of control, including control of the taking of fuelwood.[22] These needs will increase with the growth of population.

The need for afforestation and reforestation has been recognized in different degrees in East Africa. Southern Rhodesia began a forestry programme with imported eucalyptus in 1922, and enlarged the forestry schemes after the Second World War. Plantation forests were begun in Malawi. Kenya has afforestation and reforestation schemes based on the extreme deficiency of commercial woods. Tanganyika started afforestation about fifteen years ago as did the Belgian Government in Ruanda-Urundi, the most badly deforested area in tropical Africa. Ethiopia lacks trees despite the great demand for fuelwood and the limited spread of the eucalyptus in the high plateaus. The forests of tropical Africa are perhaps its greatest wealth, and their protection and improvement are indispensable to major tree protected crops, such as cocoa, tea, coffee and banana, to the preservation of soil, to the sustaining of ground-water reservoirs and to the support of the entire agricultural and domestic economy of Africa.[23]

Like so many other problems in Africa, more than one method of attack is required to deal with deforestation, land destruction and waste of fuelwood. The greater use of aluminium in cooking appears to be one constructive method. The opportunities to increase this use are substantial. In the Democratic Republic of the Congo, about 200 tons of aluminium were consumed in 1952 for all purposes, mainly utensils, according to one African manufacturer who produces utensils in seven countries, including the Democratic Republic of the Congo. This company established a utensil plant in 1952 in Burundi and sent trucks into the Democratic Republic of the Congo to sell utensils. In 1962, the company established another utensil plant in Bukavu in the eastern province of the Democratic Republic of the Congo. In consequence, the demand for aluminium for utensils increased over a twelve-year period by about six or seven times. The same company now has a utensil factory in Ethiopia where it is confident that consumption can be greatly stimulated. In that country, the total capacity to produce utensils among three plants in Asmara and Addis Ababa is about 1,200 tons per annum, but the current consumption is only about 600 tons per annum. Although enamelware and home-made pottery are used widely in Ethiopia, in Addis Ababa, one estimate is that about half of the cash market is in aluminium utensils.

In Ghana, consumption of aluminium utensils is about 500 to 600 tons per annum by a population of some 8 million, as compared with about half that consumption by some 22 million in Ethiopia, and possibly twice that consumption by some 15 million in the Democratic Republic of the Congo.

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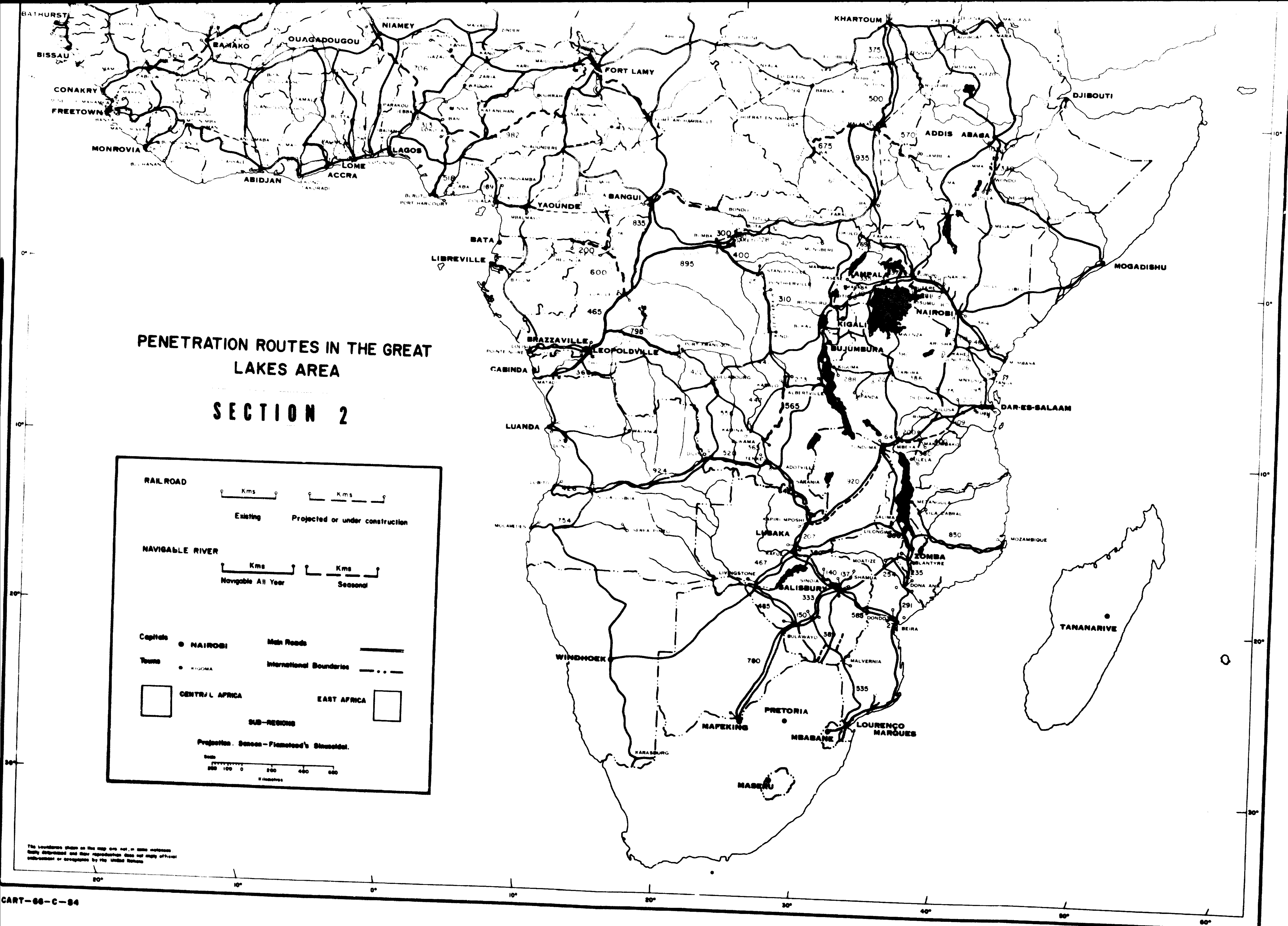
[21] United Nations Economic Commission for Africa and Food and Agriculture Organization of the United Nations, "Timber trends and prospects in Africa" (Rome, 1965), pp. 2, 40.

[22] *Ibid.*, pp. 9-11.

[23] George H. T. Kimble, *op. cit.*, vol. II, pp. 195-224.



PENETRATION ROUTES IN THE GREAT LAKES AREA
SECTION 2
RAILROAD
Kms
Existing
Projected or under construction
NAVIGABLE RIVER
Kms
Navigable All Year
Seasonal
Capitals
NAIROBI
Towns
Main Roads
International Boundaries
CENTRAL AFRICA
EAST AFRICA
SUB-REGIONS
Projection. Sanson-Flamsteed's Sinusoidal.
BATHURST
BISSAU
CONAKRY
FREETOWN
MONROVIA
ABIDJAN
ACCRA
LOME
LAGOS
BAMAKO
OUAGADOUGOU
NIAMEY
FORT LAMY
KHARTOUM
DJIBOUTI
ADDIS ABABA
MOGADISHU
BANGUI
YAOUNDE
BATA
LIBREVILLE
BRAZZAVILLE
LEOPOLDVILLE
CABINDA
LUANDA
KAMPALA
KIGALI
BUJUMBURA
NAIROBI
DAR-ES-SALAAM
LUSAKA
ZOMBA
BLANTYRE
SALISBURY
BEIRA
BULAWAYO
LIVINGSTONE
WINDHOEK
MAFEKING
PRETORIA
MBABANE
LOURENCO MARQUES
MASERU
TANANARIVE
MOZAMBIQUE
KARASBURG

CART-66-C-84

Table 8. Estimated aluminium utensil use, selected African countries

Country	*Population, 1965 (millions)*	*Aluminium utensil use*		*Per capita income, 1960 (dollars)*
		Tons, 1965	*Per capita (kilogrammes)*	
Ghana	7.8	500–600	.07	243
Congo (Democratic Republic of)	15.3	800–1000	.06	84
Ethiopia	21.8	300	.01	33

These fragmentary data show the usual direct relationship between *per capita* use of aluminium and *per capita* income. Aluminium utensils are necessarily purchased by those with the most cash income. Cheaper enamelware or home-made pottery is preferred by those with less cash income, even though the aluminium utensil will outlast the other utensils and will be cheaper in the long run. Tradition and custom in some African countries also have proved to be obstacles to changing to aluminium, as is the case with other products. But the spread of aluminium utensils over much of Africa shows that tradition and custom are yielding. Tradition can also be overcome when it is necessary for a Government to accelerate a change, as in India, where the Government, through the use of import restrictions, is interested in accelerating the change from brass to aluminium utensils and from copper to aluminium electrical conductors in order to save on the large amount of foreign exchange needed for imported copper and zinc.

The encouragement of the use of aluminium utensils by African Governments is in the public interest, both to the persons concerned with cooking and economy of fuel, and to the Governments concerned with forestation and reducing the drain of fuelwood. Possible methods of encouragement begin with tariff adjustments so as to increase the competitive ability of aluminium utensils against imported enamelware and other utensils, and particularly to encourage the domestic manufacture of aluminium utensils. The tariff on aluminium sheet or circles for making utensils is either eliminated or kept very low to stimulate domestic manufacture. The tariff on other utensils or utensil materials is kept higher, but is not necessarily increased if this would arouse public resentment.

Other methods include the use of aluminium utensils as part of government instruction techniques in education, health, sanitation and reforestation. Such utensils would be shown and demonstrated in the travelling exhibits and other media that African Governments will be using increasingly as they follow the example of other agrarian nations in the twentieth century in seeking rapid progress through methods of mass instruction.

E. Aluminium in agriculture, food and fibre production and storage

Africa needs to produce more food and fibre, to do so more efficiently, to increase the protein consumption of much of the population and to provide better means of preserving and storing perishable foods under tropical heat. Aluminium has shown unique abilities in helping to meet such needs in warm climates elsewhere in the world and in doing this with substantial economies that pay in a short time for the cost of the aluminium.

1. Aluminium, cooler temperatures, and productivity

New aluminium surfaces reflect 80 per cent of the sun's heat, as compared with a reflectivity by new galvanized iron of 50 per cent. Inside a building under an aluminium roof, 10 per cent of the sun's heat is emitted, compared with 50 per cent in the case of new galvanized iron. Over a period of time, as aluminium loses some of its reflectivity, it still retains an advantage compared with galvanized. These characteristics permit the temperature inside structures with aluminium roofs to be kept as much as 15 degrees lower during hot weather than do structures with galvanized roofs and other roofing materials.

Studies made by agricultural colleges and others in the southern part of the United States of America have shown that high temperatures and heat radiation reduce the amount of output of farm animals in milk, eggs and meat for consumption. Among the results of such studies were findings that:

(*a*) In poultry production, in the mid-Atlantic area of the United States of America, the use of aluminium roofing instead of an asphalt and wood covering, during one season, reduced the mortality of birds and gave a 6 per cent increase in the weight of bird sold;

(*b*) In beef production in the south-western United States of America, cattle sheltered under aluminium instead of asphalt roofing gained, during one season, 13 per cent more weight;

(*c*) In milk production in the south-western United States of America, the use of aluminium roofing and fence shades in one summer contributed to an increase in output of 3 pounds of milk per cow per day, or 540 pounds per cow in the season;

(*d*) In one investigation, the gain in weight of cattle kept under an aluminium shelter, as compared with those kept under galvanized iron, produced enough profit in one season to pay for the extra cost of aluminium over galvanized roofing;

(*e*) Another case showed the gain in milk production in one season from cows kept under aluminium, as compared with galvanized roofing, paid in seventeen days for the extra cost of aluminium. Similar results were found in the value of the gain in hog production and egg production.[24]

There are other ways of reducing radiation and heat besides using a reflective aluminium surface, for example, by using white paint or aluminium paint on wood or on other roofing materials, or more recently, by using aluminium coated steel. But there are additional advantages in the use of aluminium itself. There are savings in not having to repaint it periodically, the savings in transportation costs of shipping it and the savings in labour costs of installing it, as compared with steel and other heavier materials.

2. Aluminium and food storage and preservation

It is not enough to produce more food in Africa. It is necessary also to protect food against deterioration so that it can be transported, stored and used. Meat, eggs, milk and fish would be consumed in greater amounts if they could be stored for longer periods in Africa. The reflectivity of aluminium makes it desirable to use with

[24] Reports on investigations of this type are available from the Reynolds Metals Company, Richmond, Virginia, United States of America.

other insulating materials to protect perishable foods. Under aluminium roofs and in aluminium containers, costs of refrigeration are reduced, compared with certain other materials, and perishable foods are protected longer. In transport by refrigerated trucks and railroad cars, the lightness of aluminium also permits the carrying of a greater amount of pay load at lower unit cost, as well as giving it greater protection against deterioration at lower unit cost. The Southern Rhodesia railway has recently ordered thirty-six aluminium refrigerator cars.

3. Aluminium, sprinkler irrigation and greater crop output

In the past twenty years, aluminium has made possible a substantial increase in agricultural productivity in the United States of America and in other countries through the techniques of sprinkler irrigation with aluminium pipe. This pipe weighs about one-third the weight of steel pipe and is easily moved around by two farmers or even by children. It is laid in rows connected to a main pipe that is fed usually by pumping water with a gasoline motor from a pond, stream, lake or well. The sprinkler heads are spaced at intervals along the rows of pipe and scatter the water over the crops in the same manner as rain. This method eliminates the irrigation method of running water in open ditches along rows of crops and sloping the ditches so that the water runs downhill.

Sprinkler irrigation is used not only in regions with prolonged dry seasons, but in regions where rainfall is abundant but irregular. The advantages of this type of irrigation over normal rainfall or gravity ditch irrigation are:

(*a*) More accurate control over the exact amount of water needed for plants and trees so as to avoid waste of water, including sprinkling at night when the evaporation rate is reduced;

(*b*) Supplying the water at the most advantageous time in the growing season and, particularly, for young plants;

(*c*) Distribution of fertilizer materials through dissolving them in the water pumped through the system, saving the labour costs of fertilizing;

(*d*) Irrigation of steep slopes and the use of other lands for crops that cannot be used with ditch irrigation because the soil would wash down, unless terracing were used.

Some African Government officials estimate that sprinkler irrigation can save 20 to 30 per cent of the water used under current practices of gravity irrigation.

In Africa, all of the above mentioned advantages of sprinkler irrigation are needed. North Africa is chronically short of water. Over half of tropical Africa experiences seasonal surpluses and shortages of water. Much of Africa suffers from land erosion. For such conditions, sprinkler irrigation is appropriate. There is also a limited contribution to health in much of Africa that the sprinkler system can make, compared with the open-ditch system between rows of crops. The sprinkler system eliminates these ditches, which, along with other open bodies of fresh water, support the mollusc that carries the parasite that causes bilharziasis (schistosomiasis). This disease is incurable, affects about one-third of the population of Africa (over 62 million in 1960) and is particularly prevalent in the United Arab Republic. It is "one of the most unpleasant and debilitating diseases found anywhere in tropical Africa".[25] It can get into the system whenever the African wades, bathes or otherwise steps into a body of infected water. The open irrigation ditch is one means of spreading infection. The sprinkler irrigation system can reduce the exposure to infection. This should be regarded only as a limited aid and one that would cease with the use of other methods of control of infection, including the use of concrete lined main canals in which the mollusc will not live, the use of covered canals and the chemical treatment of canals.

The costs of sprinkler systems depend upon the acreage to be covered. Although such systems are used on large farms, they also can be used on very small farms producing a high value crop. Thus, in the United States of America, an investment of $3,500 was made in an irrigation system for only 4.4 acres that produced enough additional tobacco in the year 1960 to pay for itself in one season. In California (United States of America), an investment of $5,500 to irrigate 55 acres of apple orchard also paid for itself in one season.[26] In Assam, India, sprinkler irrigation has been used on tea plantations with the result of reducing by as much as two years the period between planting and the first harvest; reducing or eliminating the loss of seedlings from drought; and increasing yields, illustrated by one tea plantation that obtained an average increase of 576 pounds per acre.[27]

Sprinkler irrigation systems are being used in some parts of Africa including European plantations in East Africa, and recently in the United Arab Republic, but they are in the early stage of application because African agriculture generally is in the early stage of transition from subsistence farming to more productive methods. Sprinkler irrigation may have its most immediate opportunities on the large European plantations in Africa, but may have much greater opportunities in the long run as the various government agricultural programmes advance, whether in major irrigation projects or in helping the small landholders to adopt systems of permanent cropping.

If, as it would seem, Governments must increasingly promote methods to store water for use in agriculture during dry seasons, the demand for sprinkler irrigation systems could grow substantially. The method itself is far more protective to soils than the erosive tropical rains. Where small holdings of land are involved, the communal and co-operative methods already established in Africa may be one solution to financing, with government help, the costs of ponds, wells and reservoirs, and the associated sprinkler irrigation equipment.

As pointed out by some agriculture officials of African Governments, the shortage of governmental funds favours at first the use of gravity irrigation schemes with their lower total investment and smaller annual operating costs. They generally agree, however, that as the production of cash crops increases and as the most easily developed gravity schemes are completed, the trend will be increasingly towards sprinkler irrigation. Some officials do point out that steel, rather than aluminium pipe, is favoured where the stronger steel pipe withstands rough treatment by African

[25] George H. T. Kimble, *op. cit.*, vol. II, pp. 37-38.

[26] Reported by Reynolds Metals Company, Richmond, Virginia, United States of America.

[27] Reported by James Hardwick, Aluminium Limited, Montreal, Canada.

workers, but other experiences indicate that with proper supervision and training of labour, the merits of aluminium over steel pipe in irrigation will be recognized in Africa as they have in other parts of the world.

The subject is also part of the complications of African agriculture and land tenure, and simple solutions cannot be borrowed uncritically from methods of farming in other countries. How sprinkler irrigation can best fit in with successful agronomical methods has to be proved in Africa, where, as reported by Kimble, the leading soil problem is not fertility but stability and stamina, where tropical soils respond differently than soils elsewhere to exposure and cultivation, and where agricultural research organizations admit they are a long way from making African soils "safe" for modern farming methods.[28]

F. Aluminium and African building construction

The growth of demand for building materials in Africa sets the framework in which aluminium must find its place. This place can be more easily measured for government and commercial buildings than for general housing. The investment in public and commercial buildings can be controlled so as to obtain from alternative materials the lowest costs over the service lives of the structures, except in the case of those public structures where luxury or prestige are more important than costs. The choice of materials for general housing, on the other hand, is governed principally by the ability of only a small part of the African population to pay for housing. For most of the population, the cost of housing by standards of developed countries is beyond their ability to pay, and they have little choice of materials. They have to use native materials close at hand in each region, such as clay, mud, cow dung, timber, stone, straw, twigs and palm leaves. They have also to provide their own labour. For most of the population of Africa, the effective housing demand is much smaller than housing needs as indicated by number of persons or family units per room of dwelling, or number of dwellings without sanitary and other facilities. People have to crowd together in low-grade housing in urban areas of Africa because they can't afford anything else.

This is obvious from the statistical chasm between the estimated average *per capita* income in Africa of $112 per annum in 1960 and the cost of Government-sponsored housing in selected African countries, usually between $1,000 and $3,500 for a small dwelling with 50 square metres (505 square feet).[29] The *per capita* income ($112) is not all cash, and it is an average that only a small proportion of people equal or exceed. But the costs of the dwelling exclusive of the land are all cash ten to thirty-five times the *per capita* income, but less according to the number of income earners per dwelling. In terms of annual income of workers, the ECA concluded that an acceptable social dwelling would cost three and one-half to six times the annual income of an unskilled labourer, although only two times the income of a skilled labourer. Over the twenty years, 1960-1980, ECA estimated that if all African housing needs, urban and rural, were to be met, more than 70 million dwellings would have to be built at a cost of about $112 million. This would require more annual investment than could be made from domestic fixed capital formation. Therefore, ECA concluded that at current income levels and housebuilding cost levels, not more than one-fifth of the current housing needs of Africa can be met.[30]

As a broad guide to the growth in demand for all building materials, ECA assumed that gross national product would expand at 5.5 per cent per annum throughout Africa until 1980; investment in total construction would rise from $1,900 million in 1960 to $9,200 million in 1980; expenditure on building materials would rise from $1,100 million per annum to $5,600 million; and this expenditure would reflect a growing proportion of the gross national product, increasing from 4.1 per cent in 1960 to 7.4 per cent in 1980. The annual increase in expenditures on building materials would come to over 8.5 per cent per annum.[31] As of 1960, Africa imported, by value, 54 per cent of the building materials used. ECA looked towards the possibilities of replacing imports with domestic production.

These broad guides do not directly help to project aluminium's position in African building construction, even if the assumed growth in over-all demand for building materials were certain to come to pass. The ECA itself concentrated on projections of requirements in Africa for the basic construction materials—cement, clay and ceramic products, wood products and iron and steel.[32]

It is reasonable to conclude, however, that the demand for aluminium does face a prospect for a rate of growth in building construction at least as high as that for all building materials. This should result from the growing attention that Governments are giving to housing programmes, from the past experience and the continued expectation in Africa that as the *per capita* income rises, the quality of housing will rise, and from the associated growth that will occur at the commercial and industrial level, as well as the level of government services requiring new government buildings. In other words, there will be a disproportionate gain in the construction of buildings for the Government and for factories, commercial purposes and public housing, as the over-all economies of Africa advance.

As a broad estimate, it may be assumed that in 1963, out of some 55,000 short tons of aluminium consumed in Africa, at least one-third, or 18,000 tons, were used in building applications. If demand for such uses were to do at least as well as the ECA projection for all building materials of 8.5 per cent per annum to 1980, the minimum needs would then be 72,000 tons of aluminium per annum for construction. This is only a broad guide as to what might be expected, and a guide on the low side. The major ways in which aluminium can be justifiably used in African construction should be examined.

Looking briefly at the United States of America, the economies there of using aluminium as a building material have been so successful that construction has been for some years the leading field for the metal, only

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[28] Kimble, *op. cit.*, vol. I, p. 158.

[29] United Nations, Economic Commission for Africa, "Housing in Africa, problems and policies" (E/CN.14/HOU/2), 3 May 1963, p. 70.

[30] United Nations, Economic Commission for Africa, "The building materials industry in Africa, present structure and future growth (HOU/WP/4), 15 January 1964, pp. 17-19.

[31] *Ibid.*, pp. 19-20.

[32] United Nations, Economic Commission for Africa, "The building materials industry in Africa, present structure and future growth", part III, Summary and conclusions (HOU/WP/4/Add.2), 20 September 1964.

recently matched by transportation equipment (led by automobiles). The major applications are in sheet for the sides and roofs of buildings, both corrugated and flat with variations in surface treatment and colour — and in extruded profiles used in making doors, windows and supporting framework for panels on the outside and inside of buildings.

In Africa, sheet for buildings may now be the leading use also and may take more aluminium than utensils. In Ghana, out of a possible consumption of some 8,000 short tons of aluminium in 1964, about 6,000 tons were in corrugated-sheet form. In Nigeria, out of some 4,000 tons consumed in 1964, about two-thirds were also in corrugated sheet, according to Alcan Africa Limited. In other countries of Africa, the proportions of aluminium consumption in building use are evidently lower. Extrusions are produced only in South Africa and used only in limited amounts, and they are imported in other African countries, usually for government and commercial buildings.

Aluminium has its most obvious economies in government buildings, including hospitals and schools, and in commercial buildings, where it is more durable, requires less maintenance than wood and steel and needs no painting. It may not be as appropriate as concrete in North Africa nor in some sections of Africa where concrete roofs are used as catchment-basins for water on public buildings. Where labour and transportation costs of materials are important, the lighter aluminium also saves additional costs. Consequently, if Governments and business establishments would consistently calculate the alternative costs of building materials over the service life of a building, including the initial costs of the materials as installed and the costs of maintenance and replacement, aluminium would steadily grow in demand in Africa, particularly in the humid areas.

For factories and workshops, aluminium on roofing and outside walls likewise contributes to cooler inside temperatures during the day and to greater productivity of labour. In parts of Africa where the nights are cold, the inside surface of the aluminium can act as a reflector of any interior heat, warming the building. The use of aluminium in this manner would not always be desirable in structures where heat is produced during the day from manufacturing operations and arrangements have to be made for the heat to escape to the outside. Therefore, the ways in which aluminium should be used with or without other materials requires study, according to the conditions affecting each building.

The quantities of aluminium economically justifiable for use in government and commercial buildings in Africa can only be determined in the short-term as plans become known for governmental and private projects. For this report, inquiries were made of some African Governments as to their plans for public buildings and material requirements, and also their attitude towards aluminium in public housing. The results reflect conflicting viewpoints and experiences. There is a limited acceptance of aluminium for windows, but also continued use of steel painted windows; some dissatisfaction was expressed with certain previous experiences with aluminium roofing that indicated improper installations and improper uses, which were typical of early experiences in other countries also. There is insufficient familiarity with the metal and technical methods of installation, and insufficient sales promotion by aluminium companies or agents. Other factors are high prices for aluminium products, associated with the small consumption, and, in certain countries, a common acceptance of the asbestos-cement roofing made in those countries.

Nevertheless, it would seem that in public housing and private housing in Africa, including rural dwellings, aluminium is bound to continue to make inroads on galvanized-iron roofing and asbestos-cement roofing. The galvanized iron deteriorates and becomes unsightly, as well as unusable, after some years of exposure to rain and oxidation in most countries. Only repeated painting can lengthen its life. The asbestos-cement roofing material is heavy and suffers considerable loss from breakage in transport and in installation. An unattractive fungus covers it at times. Aluminium does not have these disadvantages. For true economy, where, as is true in many cases, a dwelling, even if made of mud and grass, can be maintained for forty years or more and kept attractive with plaster and paint, aluminium would justify encouragement in housing programmes by Governments. This would be particularly appropriate as part of campaigns for better housing in order to improve sanitation and to reduce disease.

The grass and thatch roof over a clay-mud wall is common in tropical Africa. This combination shelters disease-carrying insects, including ticks, fleas and lice, which spread typhus (rickettsia) and relapsing fever, and mites, which also spread typhus. These diseases are prevalent in countries of East Africa (Ethiopia, Mozambique, Uganda and Zambia, for example), and in West Africa.[33] The clay mud wall, if sufficiently thick, has the advantage of a cool interior during the hot days. If sprayed with insecticides and if the cracks are sealed, the wall can become relatively sanitary. The grass or thatch roof cannot be given the same effective treatment. It is also a constant fire menace and requires periodic repair or replacement.

The metal roof has, consequently, been adopted in rural and urban dwellings of tropical Africa, whenever people can afford it. One of the first steps they take when they acquire sufficient cash is to install a metal roof, not only to save on maintenance, but also as a matter of prestige over their neighbours. Galvanized iron has been commonly used, placed above the mud-clay walls. However, with the exception of certain locations in Africa, as in the high elevations of Ethiopia, galvanized sheet deteriorates rapidly unless repainted periodically. Furthermore, as already noted, it transmits heat into the dwelling unless insulated from the interior by another material. Aluminium, on the other hand, reflects most of the heat when new, does not require another insulating material and still retains an advantage over galvanized after both become dull. Consequently, the shine of the aluminium roof is seen commonly as one flies by airplane over parts of West Africa, and it is increasingly appearing in remote sections of East Africa.

Some countries have made the question of better roofs a matter of government policy. In Venezuela, the Government in 1958 was contributing part of the costs of aluminium roofs to farmers who would remove the thatch roof with its hazard of disease carriers. In Ghana, a scheme was adopted in 1955 to make loans to rural villagers, through village housing societies, for

[33] Kimble, *op. cit.*, vol. II, pp. 48-49

the improvement of roofs. About 5,500 loans were made in five years, averaging 109 each ($306). The various materials used for roofing in this scheme were not reported.[34]

Ghana has made the general encouragement of the use of aluminium instead of galvanized iron a government policy. In the Volta River resettlement housing scheme to care for persons displaced by the reservoir of the Volta project, the Government adopted aluminium roofing and siding. The Ghana Housing Corporation builds a rental dwelling for lower income groups using aluminium sheets on the roof of a two-storey building with six dwellings, which is built of concrete.[35] The Government does not grant import licenses currently for galvanized sheet. To stimulate the growth of aluminium consumption in Ghana and looking towards the future supply of ingot from the Volta power-aluminium project, the Government granted special concessions in 1959 to Aluminium Limited (Canada) to establish an aluminium building-sheet plant, in which the Government also obtained a 40 per cent participation in the equity capital. The company promoted the sale of corrugated aluminium and other sheet products by means of direct selling methods to reach illiterate sections of the population. A colour cartoon film was shown in regular cinemas and was sent by mobile trucks into villages. In addition, sales vans, roofed and decorated with aluminium sheets, went around the countryside, manned by Ghanaian salesmen, giving sales talks through a loud-speaker system to the crowds congregating around the trucks.[36]

The greatest difficulty facing the adoption of corrugated and other aluminium roofing in Africa is its initial higher cash cost over galvanized iron in most countries. An additional factor may be the growing capacity to produce galvanized iron in Africa. Typical retail or wholesale prices in 1965 for galvanized iron and aluminium in competing gauges in East Africa were as shown in table 9, adjusted to dollars (field trip).

[34] "Roof Loans Scheme for Rural Housing", memorandum report of B. A. W. Travallion, Chief Town Planning Officer, Accra, Ghana, to the United Nations Bureau of Social Affairs, 3 November 1960.

[35] United Nations, Economic Commission for Africa, "Pilot enquiry into housebuilding costs" (HOU/WP/5), 31 July 1964, p. 6.

[36] J. A. Person, "The promotion of aluminium fabricating in West Africa", paper presented at the Conference on Africa of the School of Advanced International Studies, Johns Hopkins University, Washington, D.C., October 1960.

Table 9. Prices of corrugated galvanized iron and aluminium in East Africa, 1965, most common gauges in each country

(Dollars)

Location	*Size and gauge*	*Price basis*	*Corrugated galvanized iron*	*Corrugated aluminium*
Addis Ababa, Ethiopia	1 by 2 metres, 39 and 37 gauge	Per piece:		
		Retail	1.32	1.32
		Wholesale[a]	1.12	1.12
Mombasa, Kenya	24 ga, 2½ sq ft	Retail	0.234	0.35
Dar-es-Salaam, United Republic of Tanzania	24 ga, 2½ sq ft	Retail	0.234	0.35
Salisbury, Southern Rhodesia	23-24 SWG, 100 sq ft	Wholesale	17.22[b]	16.94[b]

[a] Wholesale price, subject to negotiation. Ordinarily, there is no difference between wholesale and retail price.

[b] Cost per 100 square feet including roof fasteners.

It will be noted that in Addis Ababa, the prices of galvanized iron and aluminium corrugated sheets of the same gauge and size are identical. In Kenya and the United Republic of Tanzania, aluminium is about 50 per cent more expensive than the galvanized iron for equal gauge and coverage. In Salisbury, Southern Rhodesia, aluminium is slightly less costly than galvanized iron, including the cost of roof fasteners, when priced per 100 square feet at wholesale. In Salisbury and also in Lusaka, Zambia, where corrugated asbestos-cement roofing is manufactured locally, the price is as much as one-sixth less than either galvanized iron or aluminium roofing per 100 square feet.

In some other countries, the retail prices of corrugated aluminium and galvanized iron are about the same for equal gauges and area coverage. In Ghana, a square metre of corrugated aluminium roofing on a government housing scheme costs $5.10, as compared with a price range for a square metre of galvanized iron of between $5.40 and $8.30 on government housing programmes in other African countries. No explanation was given for this advantage of aluminium.[37] The ECA staff on housing reports that in Cameroon, where corrugated aluminium is produced from imported sheet, the price is about the same as for galvanized iron. In the United States of America in 1964, a typical wholesale price for corrugated aluminium was 40 cents per pound, as compared with galvanized iron at 7.2 cents per pound for 26 gauge. At retail, the price was 44.5 cents per pound of aluminium and 16 cents per pound of galvanized iron. But for equal thickness, one-third of a pound of aluminium gave the same coverage as one-pound of galvanized iron, and the retail price was almost the same for each, based on coverage. In one case, 100 square feet of aluminium weighing 27 pounds sold for $12, whereas 100 square feet of

[37] "Pilot enquiry into housebuilding costs" (HOU/WP/5), p. 29. The price of $5.10 pertains to aluminium roofing, although it is erroneously shown as corrugated iron roofing.

galvanized iron weighing 81 pounds sold for $13. For such competition to be truly equal in price, the aluminium must be used in such a way that its lesser strength does not require other costs of adjustment. If an aluminium roof is to be walked on frequently, as has been reported in some African areas, then it will not be able to withstand denting as would an equal gauge of galvanized iron. In such a case, aluminium may not be appropriate unless the economies can be gained to compete with galvanized by using longer lengths of aluminium of thicker gauge, as offered by one company in Southern Rhodesia.

These illustrations of equal price indicate possibilities where both metals are produced at low cost and where competition is intense, as in the United States of America. In addition, where transportation costs rise with weight, aluminium will have the lower cost for the same thickness as the galvanized iron, being one-third the weight. Finally, where service life is compared, galvanized iron, unless repainted regularly, may not last over twelve years in common use, according to experience in the United States of America, whereas the aluminium may last forty years or longer. Aluminium is the least expensive material under such conditions. While this point may not appeal to the poor person who wants to pay the least cash today, it is important to Governments investing in public housing programmes and to commercial buildings where the test may be to get the least cost over service life.

In East Africa, however, an additional consideration for government policy is that there is far more galvanized iron corrugating capacity in existence and planned today than corrugated aluminium capacity. This capacity, shown in table 10, is based on imported flat iron sheet and imported zinc at coastal posts. As far as foreign exchange is involved, for an equal gauge of galvanized iron and aluminium, disregarding differences in weight, there would be little difference between importing and corrugating either flat aluminium or iron sheet. Zinc need not be imported for galvanizing, as it is produced in Zambia, but it is, in fact, imported from elsewhere. There is also little difference as of 1964 in importing aluminium ingot into Dar-es-Salaam for casting, rolling and corrugating, or importing into Dar-es-Salaam flat iron sheet for galvanizing and corrugating. The c.i.f. price of the aluminium ingot was $540 per ton and, adjusted on a volume basis of one-third, was equal at $180 to the volume of a ton of flat iron sheet at a c.i.f. price of $186, approximately. No adjustment is made here for melting and scrap losses in converting aluminium to sheet, nor for scrap losses of the galvanized iron.

This rough equality, from a foreign-exchange point of view, between corrugated aluminium and corrugated galvanized iron would change in favour of aluminium during its service life if two or three times as much more galvanized iron had to be imported for replacements. If the galvanized iron were protected by periodic painting, this extra cost would also have to be considered in the comparison. If the flat iron sheet were to be made in East Africa by 1980, as is possible,[38] the cost comparison, from a foreign-exchange point of view, would have to be adjusted again.

The consumption of galvanized-iron sheet in much of East Africa was approximately 45,000 short tons in 1959, as measured by imports of flat and corrugated sheet. Incomplete data for 1962 indicate a sharp drop in imports (see table 11).

Table 10. East African plants for galvanizing and corrugating iron and corrugating aluminium, 1965

	Estimated capacity (tons per annum)	
Galvanizing and corrugating plants		
Existing		
Steel Africa Ltd., Mombasa, Kenya	18,000	
Uganda Batti, Kampala, Uganda	5,000	
Mabati Ltd., Dar-es-Salaam, United Republic of Tanzania	25,000	
	48,000	
Planned		
Steel Company of Ethiopia, Asmara, Ethiopia	12,000	(1966)[a]
Chandaria family, Lusaka, Zambia	12,000	(1966)
Sabean Utility Share, Co., Akaki, Ethiopia	24,000	(1965)
Uganda Steel Ltd., Mbale, Uganda	n.a.	
	48,000	
Aluminium corrugating plants		
Existing		
Aluminium Africa Co. Ltd., Dar-es-Salaam, United Republic of Tanzania	6,000[b]	
Alcan Aluminium of Rhodesia, Ltd. Salisbury, Southern Rhodesia	n.a.	
	6,000	

SOURCES: Ethiopian Aluminium Company, Addis Ababa; and W. S. Atkins & Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965.

[a] Will corrugate aluminium also.

[b] Mixed products.

Table 11. East Africa: imports of galvanized and flat iron sheet

(Short tons)

Country	*1959*	*1962*
Kenya:		
Flat	**2,289**	**13,487**
Corrugated	**19,124**	**3,859**
Uganda:		
Flat	**159**	**97**
Corrugated	**5,[illegible]00**	**2,343**
United Republic of Tanzania		
Flat	**292**	**175**
Corrugated	**4,592**	**2,440**
Malawi, Southern Rhodesia and Zambia:		
Flat	**3,856**	**n.a.**
Corrugated	**9,511**	**n.a.**
TOTAL	**45,123**	**n.a.**

SOURCE: Alcan International Limited and Alcan Africa Limited.

[38] W. S. Atkins & Partners, "Development of the steel industry in East and Central Africa" (E/CN.14/INR/87), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965.

It would appear from this review of the place of aluminium in building construction that the subject deserves the attention of the African government agencies concerned with public works, public housing and health. The development of uniform and co-operative policies in these matters, where justified, would accelerate the demand for aluminium and would have the more important benefits of carrying out vital public purposes.

G. Aluminium and African transportation

African Governments should also have a special interest in encouraging the use of aluminium in buses and trucks on public highways and in railway cars on public railway systems. The metal has made much progress in such uses in Europe and the United States of America, for commercial reasons. It reduces the weight of the vehicles and increases the revenue per vehicle by increasing the weight of cargo or number of persons which can be carried. By 1963, in the United States of America, the consumption of aluminium in transportation—automobiles, trucks, railroads, aeroplanes, ships and boats—was almost as great as in building construction, the leading field.

Aluminium also reduces the costs of maintenance and repair required for steel and wood in transportation vehicles. Likewise, it reduces both the over-all weight of the vehicle and the amount of wear and tear per unit of commercial traffic (cargo or passengers), both of the vehicles and of the railroad bed or the highway. It reduces the cost of fuel consumed per unit of commercial traffic and permits greater speeds.

Economies of this type are very important to developing countries, and especially in Africa, where repair and maintenance of roads and railroads can be costly due to rainfall and humidity. Vehicles do not last long without constant repair, and roads deteriorate rapidly from climatic conditions and the pounding of heavy vehicles. In Thailand, buses and trucks are changing from the use of wood to aluminium to reduce costs of repairs and to increase pay loads.

In India, the Government's railroad system is using aluminium in cars. In the United States of America, where the railroads are usually privately owned and have made substantial investments in traditional steel freight-cars, aluminium cars are now being used to haul bulk cargoes, such as wheat and coal. Also in the United States of America, as elsewhere, aluminium is commonly used in passenger buses, and especially in the bodies of trucks and trailers that haul cargoes.

Aluminium is especially important if used on metre and narrower gauge railways. These account for about one-fourth of the railway mileage in all Africa, and all of the mileage in Ethiopia, Kenya, Uganda and the United Republic of Tanzania.[39] Aluminium on the bodies of railroad cars, both freight and passenger, lowers the centre of gravity, improves stability and reduces sway. For the narrower gauge railroads, these benefits from aluminium improve the safety of the trains and permit a greater speed.

Experience in India showed that the substitution of aluminium panels, of the same thickness as steel, reduced the weight of a railway coach by 1-1.5 tons. The narrow-gauge coaches with aluminium panels which were adopted on the Simla-Kalka line in 1928 were used for thirty-two years and were found to have no deterioration. The Indian Railways have found that 200 other coaches panelled with aluminium have shown no corrosion since put into use in 1954.[40]

In all of Africa, Governments are deeply concerned with programmes to improve transportation and with the enormous costs involved. In East Africa, one project alone, the proposed rail link between Central Africa and the East African railway system, will require nearly 1,600 km of new construction and a capital cost of about $180 million. This project as well as all others concerning roads and inland waterways, will affect movements between countries and requires the determination of policies co-operatively between the affected Governments. Since use of aluminium is one of the demonstrable and important ways of improving the transport system, the subject deserves joint consideration by the transport and road agencies of the Governments.

H. Aluminium and electrification programmes

In countries having a high degree of electrification, aluminium used for conductors and other products related to electrification has become a principal market. The other products include such items as motors, generators, transformers, capacitors, conduit pipe or tubes and air conditioning and refrigerating units. In the United States of America, the electrical field is the third largest market for aluminium. By contrast, in the developing country of India, where electrification is a major programme of the Government along with the replacement of copper imports by domestic aluminium, the field of electrification and related electrical products has become the leading consumer of aluminium.

The principal use of aluminium in the electrification field is for conductors on transmission and distribution lines. The total costs of such lines including the cable or wire, the insulators, the other hardware and the transmission towers is considerably less with aluminium than with copper conductors, due to the weight savings. Although, for equal volume, aluminium is one-third the weight of copper, for equal electrical conductivity, the aluminium conductor must be thicker and is about half the weight of the copper conductor. At 1964 prices, a pound of aluminium costing 24 cents in crude form would carry the same amount of electricity as nearly 2 pounds of copper costing almost 66 cents. The advantage of aluminium is reduced somewhat by the costs of conversion to wire. The savings of aluminium over copper are further reduced in some applications by certain additional costs, such as the need in high-voltage transmission cables to use a steel reinforcement to strengthen the aluminium product. On balance, however, the economies of aluminium are substantial in most electrical uses.

Where the question of foreign exchange for imports arises, as in India, aluminium has the additional advantage of being a domestic product, whereas nearly all copper has to be imported. For expected imports of copper in India for 1965, of the order of 100,000 tons the foreign-exchange requirements would be roughly

[39] United Nations Economic Commission for Africa, "Transport development in the East African subregion" (E/CN.14/WP.4/1), 28 July 1965, pp. 8-9.

[40] B. R. Nijhawan and KN. P. Rao, *Substitution of Imported Copper and Other Non-ferrous Metals by Aluminium and Other Indigenous Metals* (Government of India, Planning Commission, June 1963), pp. 27-28.

$75 million. Much of this can be saved by the ultimate use of domestic aluminium products. In addition to the Government's savings, substantial economies for the consumer also take place in India, even though the costs and prices of domestic aluminium are considerably higher than imported aluminium.

In Africa as a whole, both aluminium and copper are produced—aluminium currently in Cameroon and shortly in Ghana, and copper principally in the Congo (Democratic Republic of), Southern Rhodesia and Zambia. Electrical grade copper suitable for conductors is made only in Zambia. The former Federation of Rhodesia and Nyasaland asked the copper producers whether they would offer a domestic price of copper lower than the world price, in order to sustain consumption in electrical conductors. The companies were unable to comply with this request, and as a result, aluminium is now used exclusively in transmission and distribution conductors up to the point of connexion with the meters of customers throughout Southern Rhodesia and Zambia. The same practice is followed by the privately owned power company serving Kenya. The conductor wire and cable is imported into East Africa, some from South Africa and most from other countries, especially from Canada.

Within the time limitations of this report, it has not been possible to analyse the small current annual consumption in Africa and in individual countries of aluminium and copper electrical conductors, the country sources and relationships. The over-all demand for electrical conductors in Africa will grow as electrification proceeds, even though the demand is restricted by the low *per capita* consumption of electricity, the small radius for individual generation and transmission systems, and their confinement generally to urban and special industrial load centres. The construction of individual hydroelectric projects at a distance from load centres will add the demand for conductors, but the major market potential in the long run rests in raising the African *per capita* income and in the associated consumption of electricity when power lines spread over the continent.

On the continental scale of Africa, the demand for transmission conductors is limited by the small consumption. Measured by kilowatt hours per square kilometre, the average for the continent of Africa of 1,420 kWh is about 1 per cent that of France, which in turn is close to the European average.[41] The consumption *per capita* in kWh in Africa in 1961 was 165, but half the population used less than 35 kWh per person. For the world as a while, the *per capita* consumption was 800 kWh in 1961.[42] Most of the African population is at the earliest stage of needing and paying for electricity, requiring only a few hours of electricity at night for lighting and radio. However, total consumption of electricity for all uses is growing at a rate that would double consumption every eight or nine years. The areas in which transmission conductor demand will grow the earliest are those in which industries will grow, and where railroad electricification may be adopted.[43]

In African countries where *per capita* and total consumption of electricity are high, industries make the largest demands. Where total and individual use of electricity are low, industry is much less important. In a few countries, one industry may be responsible for most of the power development, as in Cameroon, where a single aluminium smelter absorbs 95 per cent of the national electric supply, and in Zambia where industry takes 90 per cent, largely due to copper smelting.[44] Therefore, special industrial development is the easiest direction in which to promote large increases in power consumption, and at the same time in making available additional power at low cost for other users. The Volta scheme in Ghana and the Kariba project in Zambia–Southern Rhodesia are the outstanding examples. The aluminium industry is making the Volta power project possible, and the copper industry made the Kariba project possible. The Volta project involves the construction of 500 miles of high voltage transmission lines to serve southern Ghana as well as the aluminium smelter. The Kariba project required the construction of 935 miles of high voltage lines, 330 kv.

A study for the ECA anticipates that railroad electrification may become increasingly economic in parts of Africa. At the current time, only 7 per cent of the continental rail mileage is electrified.[45] Most of this mileage is in North and Southern Africa. One sixth of the Southern African mileage is electric. The ECA report observed that among East African countries, Kenya might be approaching the point where the volume of freight traffic would make electrification feasible.

Co-operation between African Governments is indispensable for the maximum development of electric-power generation, industrial development and railroad electrification. Some power projects, such as the Kariba on the Zambezi River, are on rivers that are boundaries for two or more countries. Some projects, for example, as Kariba and the proposed Inga project in the Congo (Democratic Republic of), are so large in their potential that they require transmission lines to serve markets in more than one country. Where railroads which are to be electrified go through more than one country, international co-operation is again required. In East Africa, interconnexions of transmission lines exist between Zambia and the Congo (Democratic Republic of); between Kenya and Uganda and the United Republic of Tanzania; and between Southern Rhodesia and South Africa and Mozambique. The Kariba project and related transmission system serves both Southern Rhodesia and Zambia.

Power development, particularly when related to international river basins, is one of the most outstanding instances where co-operation between Governments produces far more benefits than unilateral developments. A treaty between Canada and the United States of America that went into effect in 1964 is making possible developments of the Columbia River in both countries for extremely low-cost power, flood control and new industries, which would otherwise have been impossible to achieve. For similar reasons, the United Nations has sponsored the co-operation of countries in South-East Asia in investigations of the Mekong River basin. In East Africa, the Kariba project was made possible only because of the common interests and original political unity of the Federation of Rhodesia and Nyasaland and, subsequently, the continued parti-

[41] United Nations, *Situation, Trends and Prospects of Electric Power Supply in Africa* (United Nations publication, Sales No.: 65.II.K.2), part III.
[42] *Ibid.*, part II.
[43] *Ibid.*, part II.

[44] *Ibid.*, part II.
[45] *Ibid.*, part II.

cipation of Southern Rhodesia and Zambia. Further developments on the Zambezi River could also require co-operation with Mozambique. The Nile River basin is another international stream, some developments of which likewise involve the interests of more than one Government, such as the possible diversion of waters for irrigation and power into the Danakil depression of Ethiopia.

III. Questions of African government policies towards aluminium

A. Semi-fabrication plants and factories

It has not seemed necessary to discuss sizes and locations of the aluminium-processing plants that may develop in Africa. Such plants are already well distributed in African countries and will continue to spread. They are generally located near the largest consuming centres for two main reasons:

(*a*) To save the high costs of transporting the product to the users;

(*b*) To be able to give better service by personal dealings with users.

Aluminium processing plants have been reported in seventeen African countries (see p. 173, table 7), and there may be others not reported. Furthermore, factories that handle other materials may be processing aluminium even though they are not counted as aluminium plants.

All over the world, in both developed and developing countries, small aluminium-fabricating plants have been successfully established with capacities of a few hundred or a few thousand tons per annum (see annex III and table 27). Investments can be $50,000 to $500,000, and employment may be between fifteen and 100 persons in the smaller plants.

Although the trend in industrialized countries is towards plants of larger capacities, mills with capacities of 5,000 to 10,000 tons are also economical, using the new continuous-casting processes for sheet and wire plants (see annex III).

It would also have little meaning to suggest today the future location of plants of specific capacity for specific products, assuming a minimum consumption in Africa by 1980 of 114,000 tons per annum. The most practical division of capacity cannot be anticipated as between rolled products, extrusions, wire and cable, and other forms. A single plant may well produce more than one of these categories. The capacity of each plant will always be flexible and capable of up to three times a one-shift basis, depending upon the number of shifts in twenty-four hours. Finally, the projection of 114,000 tons, based on an assumed gross domestic product, is not a valid target for Africa. A much larger figure may be achievable if African Governments recognize the values of aluminium and encourage its use. If they do this in a common co-operative programme, they will also have a basis for discussing some allocation of capacity between the co-operating countries if they are not satisfied with the distribution that results from decisions of private enterprise.

It is not necessary to rely upon private enterprise exclusively or largely, but the willingness of private capital to expand aluminium fabrication can reduce the demand for public funds, badly needed for many other purposes. Government joint ventures with private capital also are possible, as is illustrated in the cases of Ghana, Guinea and Venezuela.

B. Tariffs, special taxes and common market policies

As consumption expands throughout Africa, every country can expect to have one or more plants engaging in either semi-fabrication or end-product manufacture. Under these circumstances, the most important problem for the African Governments is to make sure that their tariff policies encourage aluminium semi-fabrication, preferably within a common market. A common market policy will not interfere with the probability that each country will obtain some aluminium fabrication as a consequence of the economies of locations near the consuming centres. But a common market policy would protect all domestic manufacturers against periodic price cutting or "dumping" from other countries. Such price practices would discourage the domestic manufacture that the African countries want to build up.

For example, in 1959 corrugated aluminium sheet was offered at Mombasa, Kenya, from the United Kingdom at a delivered price of £229 10.0d per long ton when the price in the United Kingdom was over £336 per long ton. Aluminium circles were offered in Mombasa from European sources also at between £235 and £245 per long ton, when domestic prices in Western European countries were between £296.16.0d and £409 14.8d per long ton.[16] Again, a manufacturer of aluminium utensils in Ethiopia reports that before he established his plant in Addis Ababa in 1963, the price of imported utensils was commonly about $2.00 per kg. After his plant began to produce, the prices of imported utensils dropped sharply to $1.28 and then $1.10 per kg, below his cost of production. These imports came particularly from mainland China, Hong Kong, Hungary, and India. The Ethiopian Government originally promised this manufacturer sufficient tariff protection. Until this is granted, the illustration shows the importance of a prompt and an effective policy. Otherwise, domestic manufacture will be discouraged and terminate since it cannot operate indefinitely at a loss.

As another example, in order to encourage a company to establish in Ghana an aluminium building-sheet plant using imported coil, a tariff arrangement was adopted by the Government in 1959. This was necessary because imports of building sheet were coming into West Africa, often at prices 30 per cent to 40 per cent below those of the exporting country, and there was no anti-dumping legislation in Ghana. Furthermore, the prospects for selling aluminium were being impaired by intensive import competition selling thinner gauges of poorer quality roofing sheets that could not give dependable service. This situation would destroy confidence of customers in the product. The Ghanaian Government also wanted to encourage the company to build up enough business so that when the

[16] Kenya Aluminium Industrial Works, Mombasa; and *Light Metals* (London), 28 July and 28 August 1959.

Volta aluminium smelter came into operation, the company would buy ingot from the smelter and convert it into sheet for further processing. This venture has now succeeded and, along with other government policies, it has helped to place Ghana among the leaders in Africa in *per capita* consumption of aluminium.

The Government of Nigeria also adopted a modest tariff of 15 per cent to encourage the same company to establish a small utensil factory with a capacity of 300 tons. This policy prevented extreme price cutting from other countries and, at the same time, protected the Nigerian consumer against being charged unfair high prices by the new producer.

External tariffs on some aluminium products for certain East African countries are given in table 12. The former British colonies and Southern Rhodesia have a common market policy for aluminium and admit each other's products free of duty and without quotas. Kenya, Uganda and the United Republic of Tanzania propose, in general, to impose quotas between themselves, under the Kampala agreement of 1964, to help deficit countries to build up productive capacity, but whether this policy will affect aluminium products is not yet known.

Table 12. External tariffs or import duties on some aluminium products, selected East African countries, 1965

(Percentage *ad valorem*)

Country	Ingot	Corrugated	Sheet Flat	Circles
Ethiopia (Addis Ababa)	38[a]	n.a.[b]	42[c]	n.a.[b]
Kenya	Free	30	33⅓	33⅓
Uganda	Free	30	33⅓	33⅓
United Republic of Tanzania	Free	30	33⅓	33⅓
Malawi	5-10	5-10	5-10	5-10
Southern Rhodesia	5-10	5-10	5-10	5-10
Zambia	5-10	5-10	5-10	5-10

NOTE. Countries shown, except Ethiopia, admit each other's aluminium products duty free.

[a] Based on $12 per 100 kg, equivalent to 22 per cent on current world c.i.f. price of 24.5 cents per lb; plus 12 per cent federation tax, plus 1 per cent municipal tax on c.i.f. price, plus 3 per cent at Addis Ababa.

[b] Information not available.

[c] Based on $16 per 100 kg, equivalent to 22 per cent on current price of about 73 cents per kg; plus 12 per cent federation tax, plus 1 per cent municipal tax on c.i.f. price, plus 5 per cent at Addis Ababa.

It will be noted that except for Ethiopia, in so far as aluminium products come into all these countries from the United Kingdom and from self-governing countries of the British Commonwealth and British colonies and protectorates, aluminium products are admitted duty free. The result is that the use of aluminium as such is in no way discouraged by duties. On the other hand, the duties imposed by Ethiopia are very high regardless of exporting sources and do not encourage the use of aluminium.

In view of the common interest of African countries in obtaining the benefits of greater aluminium consumption, the need is apparent for a uniform tariff and trade policy to encourage the use of aluminium. Furthermore, in order to protect and encourage semi-fabrication within each country, it is desirable to modify the tariff structure so that the tariff rises in amount, *ad valorem*, as each stage of processing advances, and so that the raw materials can be imported at zero or the smallest duties.

Along with an encouraging tariff policy, African countries should adopt a system of internal taxes that does not discourage the use of aluminium, as compared with other materials. In India, this problem emerged when in 1960 the Government imposed an excise levy of 10 per cent on aluminium but not on copper, even though the Government was trying to encourage the displacement of imported copper with domestically produced aluminium.

It is therefore recommended that those African countries sufficiently interested undertake a conference on the subject of aluminium development and the adoption of consistent tariff and other trade policies related to aluminium, and that they seek the participation of other African countries.

C. Encouragement of specific aluminium uses

The special values of aluminium in Africa, as pointed out, call for governmental policies to encourage its use in:

(*a*) Agriculture for shelter of animals; for sprinkler irrigation; and for storage and preservation of perishable products;

(*b*) Rural and public housing, for sanitation and the reduction of disease;

(*c*) Utensils, in order to aid in forestation and other land conservation programmes;

(*d*) Transportation vehicles;

(*e*) Electrification.

These subjects require co-operative action by African Governments in undertaking any preliminary investigations necessary to satisfy them that aluminium use should, in fact, be encouraged in particular applications and then in adopting common policies and programmes where agreement has been reached.

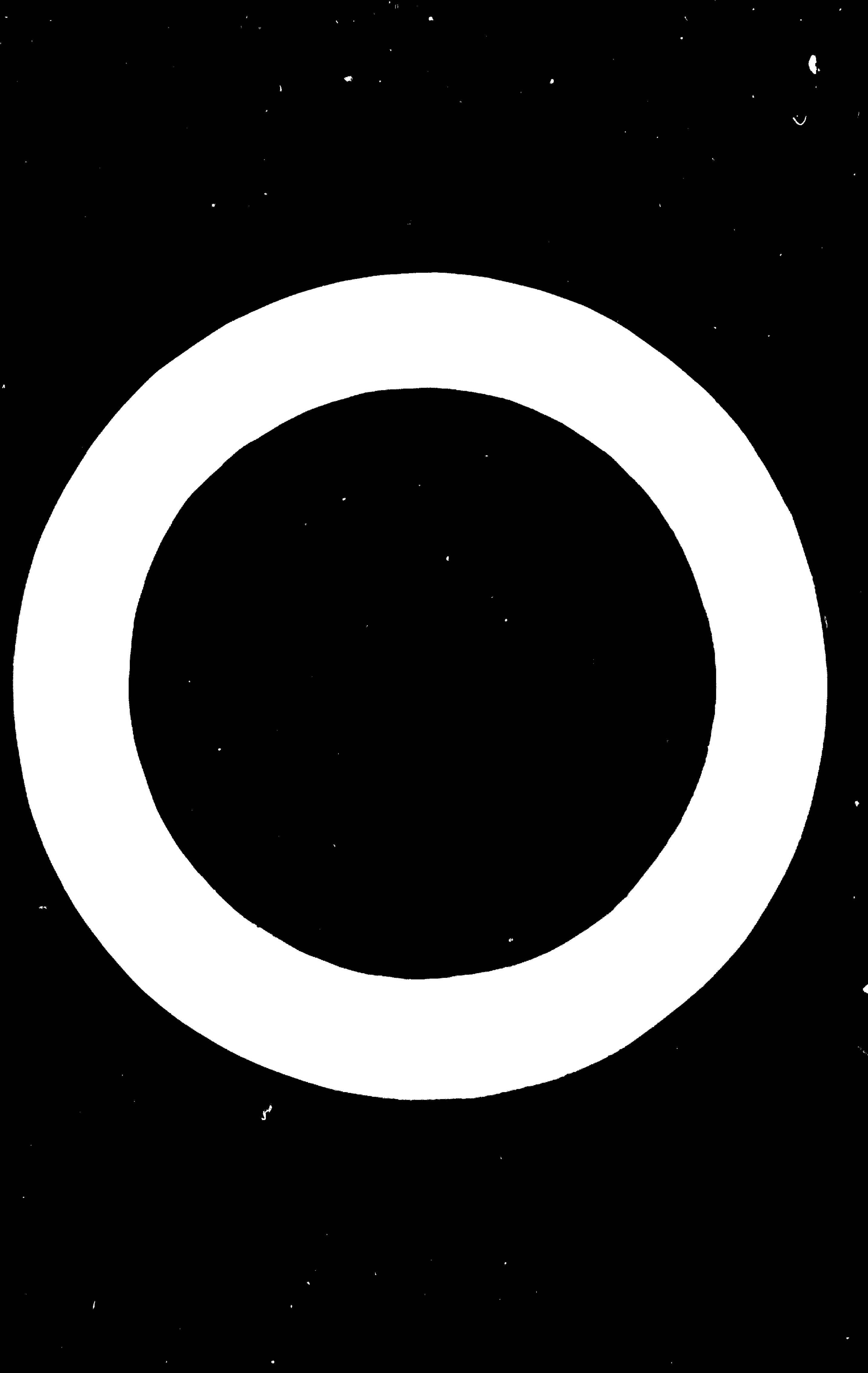
It is recommended that interested African Governments establish a permanent intergovernmental committee to formulate a programme to:

(*a*) Establish the desirability of promoting certain aluminium uses;

(*b*) Define the policies and programmes that may be recommended.

It is also recommended that an aluminium advisory committee be established, representing existing enterprises in aluminium production and fabrication in Africa, so that technical help can be given to the intergovernmental committee. This procedure would be somewhat similar to that used by the Planning Commission of the Government of India. It would also permit representation of the most competent aluminium organizations in the world, since these are already producing or marketing in various countries of Africa. There would be no question but that such organizations would offer to an African intergovernmental committee their fullest co-operation, in view of their interest in a much greater consumption of aluminium in Africa and in participating in expanded production.

At the same time, to protect the Governments against errors of judgement and to protect the interests of other African industries which are competitive with aluminium, it is recommended that an additional industry advisory committee be established to include African enterprises concerned with copper, steel, plastics



and other materials, so that this committee can review policies towards aluminium before final adoption by the intergovernmental committee. This procedure will accomplish two purposes:

(*a*) It will make sure that only sound decisions are made in favour of aluminium after fully meeting criticisms from producers of other materials;

(*b*) It will encourage competitors of aluminium to promote and improve applications of their own materials both technically and in costs and prices, with resulting benefit to the African economies.

D. Spreading knowledge of techniques of using aluminium in Africa

The proper handling and installation of aluminium products in Africa is essential in order to make widespread adoption a success where particular uses are justified. There have been experiences with the wrong uses of aluminium or improper installation, resulting in public distrust of the metal until a new effort at re-education could be made. One instance affecting corrugated aluminium roofing occurred during the 1950's in Zambia. A United Nations Mission on housing to Ghana in 1954/1955 reported that in the uses of aluminium in housing it had observed:

"Faulty handling of aluminium; use of unpractical metals in conjunction with aluminium sheets;

"Absence of storm-proof fixtures for sheets;

"Damage to sheets when fixing them to purlins;

"Bad and dangerous chimney junctions and flashings at wall and roof junctions;

"Use of cement mortar in contact with aluminium and lack of precaution against glare." [47]

Such an experience is typical where aluminium is used by workers unfamiliar with proper installation methods. In the United States of America, the aluminium industry immediately after the Second World War made errors in promoting the use in housing of an aluminium alloy containing copper because large quantities of this alloy were left over from the aeroplane production programme and from aeroplane scrap. The alloy was not appropriate, and the metal deteriorated, discouraging the consumers.

In France, during the German occupation in the Second World War, unsuitable aluminium alloys also were used at seacoast locations, where the metal deteriorated. The metal was also used to replace scarce copper for wiring in electric cords of appliances, for which its brittleness is unsuited. The results were broken cords, short circuits and a reaction by consumers against aluminium.

Aluminium utensils were made from improper alloys out of melted scrap by Indian manufacturers early in the 1950's, causing the utensils to deteriorate rapidly. As a result, India suffered a sharp drop in exports of utensils to African and south Asian countries. To remedy this situation, in 1956 the Government restricted the exportation of utensils to licensed companies that conformed to published standards.

These illustrations do not reflect on aluminium as a material, but on the improper use or lack of knowledge by those who sell it or use it, or who ignore knowledge in order to make a quick sale. The properties and ways of using any new material have to be learned. This, of course, is well known in the case of materials that can be dangerous to humans and animals, for example, some insecticides, unless properly used. It is less noted in the case of such new materials as plastics, which have had far more difficulties than aluminium in being used where they lack the strength or heat resistance needed in the particular application.

In various countries, aluminium enterprises educate workers and customers on how to work with and apply aluminium. In France, the two producers maintain technical training at the Aluminium Technical Centre in Paris. Workers from different factories come here to receive training in such processes as foundry casting, welding, machining, building applications, heat treatment, painting and coating, and X-raying and testing. For Africa, simpler methods of instruction would be appropriate. Instruction is needed so that workers do not place aluminium next to other metals where electrolytic action will occur, or against alkaline materials where corrosion will take place. Workers have to be shown how to nail aluminium with aluminium nails rather then with steel nails, or to use plastic separators.

The most responsible aluminium enterprises in Africa have an interest in supplying such instruction and in co-operating with any government programmes to encourage the proper use of aluminium. It is therefore recommended that, as part of any aluminium encouragement programmes that may be adopted by African Governments, they include, with the help of aluminium enterprises, the popularization and instruction of people on the proper ways of installing aluminium and using it.

[47] United Nations, *Housing in Ghana* (United Nations publication, Sales No.: 57.II.N.3).

ANNEX I

Aluminium statistics

Table 13. Estimated total reserves and other resources of bauxite

(*Millions of tons*[a])

Country	1950 *Reserves*	1963 *Reserves*[b]	1963 *Marginal and sub-marginal resources*
North America			
United States of America			
Arkansas		49	65
South-eastern states		1	25
Oregon			85
Hawaii			126
TOTAL (rounded)	41	50	300
Central America			
Costa Rica			50
Mexico		S?	
Panama			25
TOTAL (rounded)		S	80
Caribbean Islands			
Dominican Republic	6	60	40
Haiti	23	25	
Jamaica	320	600	400
TOTAL (rounded)	349	690	440
South America			
Brazil	192	40	200
British Guiana	65	150	1,000
French Guiana			70
Surinam	50	250	150
Venezuela			100
TOTAL (rounded)	307	440	1,520
Europe			
Austria	1	2	
France	60	70	190
Greece	60	84	
Hungary	250	300	
Italy	6	24	
Norway			30
Poland			S
Romania	20	20	
Spain		7	
USSR	30	100[c]	
Yugoslavia	105	290	
TOTAL (rounded)	532	900	320
Africa			
Angola		S	10
Cameroon			985
Ghana	229	254	
Guinea	6	1,100	2,400
Madagascar			25
Mali and Upper Volta			L
Morocco			20
Mozambique		S	2.4
Nyasaland			60
Rhodesia			2
Sierra Leone		S	
TOTAL (rounded)	235	1,350	3,500

Table 13 (*continued*)

Country	1950 *Reserves*	1963 *Reserves*[b]	1963 *Marginal and sub-marginal resources*
Asia			
China (Mainland)	50	150	1,000
China (Taiwan)		.1	
India	25	50.1	200
Indonesia	26	25	10+
Iran		7	16
Malaya	10	10	40
North Viet-Nam		.3	
Pakistan			9.5
Philippines			28
Sarawak		5.6	
Turkey	6	9.3	65
TOTAL (rounded)	117	210	1,370
Oceania			
Australia	21	2,060.3	1,190
Admiralty Island			.6
Fiji			.2
New Zealand			20
Palau	3	3	
Other islands	1		.5
TOTAL (rounded)	25	2,060	1,210
TOTAL (rounded) FOR WORLD	1,605	5,760	8,740

SOURCES: 1950 data from United States of America, Bureau of Mines, *Materials Survey, Bauxite* (Washington, 1953), pp. 59-60; 1963 data from Sam H. Patterson, United States Geological Survey, Professional Paper 475-B (Washington, 1963), pp. B158-159.

NOTE: L = large, S = small.

[a] Most figures are in metric or long tons; however, many estimates used in compilation failed to designate type of tons used.

[b] Measured and indicated reserves that in some degree have been inventoried in terms of commercial enterprise and could be used under the economic and technological conditions existing in 1963.

[c] Rough estimate based on geological inferences. Much low-grade bauxite is included that would be classed as marginal and submarginal resources in other countries.

Table 14. Africa: hydroelectric capacity, installed and potential

(*Megawatts*)

Country	*Approximate installed capacity*[a]	*Estimated gross theoretical potential* Q 95	*Estimated gross theoretical potential* Arithmetical Mean
Algeria	180	225	6,000
Angola	120	4,250	78,300
Basutoland	U	310[b]	490
Bechuanaland	U	22	3,730
Burundi	U	U	U
Cameroon	159	4,800[b]	28,700[b]
Canary Islands[c]	1.1	U	U
Central African Republic	3.5	3,500[b]	13,800[b]
Chad	U	1,000 (E)	4,300[b]
Congo (Democratic Republic of)	763	97,000	180,000
Dahomey	U	600	2,240
Ethiopia	8.5	4,250	35,000

Table 14. Africa: hydroelectric capacity, installed and potential (*continued*)

(*Megawatts*)

Country	Approximate installed capacity[a]	Estimated gross theoretical potential: Q 95	Estimated gross theoretical potential: Arithmetical Mean
French Somaliland	U	U	U
Gabon[d]	18.6	6,000[b]	21,900[b]
Gambia	U	U	U
Ghana	42	1,500	7,500
Guinea	20	500[b]	8,000[b]
Ivory Coast	20[b]	500[b]	7,300[b]
Kenya	6[b]	1,500	16,800
Liberia	3[b]	4,250	7,500
Libya	U	0	200
Madagascar	24	14,300[b]	80,000[b]
Mali	1	750[b]	4,400[b]
Mauritania	U	200	2,500
Mauritius	13.6[b]	20 (E)	100 (E)
Morocco	320[b e]	300	1,500
Mozambique	70	3,750	15,000
Niger	U	500	12,000
Nigeria	20	9,500	22,000
Portuguese Guinea	U	0	150
Reunion	3.5[b]	20 (E)	100 (E)
Rhodesia and Nyasaland	810	4,680[b]	22,500
Ruanda	U	U	U
Senegal	U	500 (E)	5,500[b]
Sierra Leone	U	2,000	3,750
Somalia	U	0	300
South Africa	5[b]	335	10,000
South West Africa	U	150	1,500
Spanish Guinea	U	750	3,000
Spanish West Africa	U	260	750
Sudan	U	750	20,000
Swaziland	U	700[b]	U
Tanganyika	40	3,000	26,000
Togo	U	100 (E)	600[b]
Tunisia	27	30	380
Uganda	121	3,000	15,000
United Arab Republic (Egypt)	365	375	900
Upper Volta	U	500	15,000
TOTAL	3,185	176,677	684,690

SOURCE: Lloyd L. Young, *Summary of Developed and Potential Waterpower of the United States and Other Countries of the World, 1955-1962*, Geological Circular 483, United States Geological Survey (Washington, 1964), pp. 15-16.

NOTE: U = unknown or not found. E = estimated. Q 95 = Available 95 per cent of the time.

[a] As of 31 December 1962.

[b] From World Power Conference (1962).

[c] Installations in Santa Cruz Province.

[d] Considerable potential due to heavy rainfall and large rivers.

[e] 300 MW in 1960, plus estimated growth of 20 MW since then.

Table 15. World production of aluminium, by country, 1963[a]

(*Thousands of short tons*)

Country	1963
North America	
Canada	719
United States of America	2,312
TOTAL	3,031
South America: Brazil	33[b]
Europe and China (mainland)	
European Common Market	
France	329
Federal Republic of Germany	230
Italy	101
TOTAL	660
Centrally planned economies	
China (mainland) (Manchuria)[b]	110
Czechoslovakia[b]	65
Eastern Germany[b]	65
Hungary	61
Poland (including secondary)	51
USSR[b]	1,060
TOTAL	1,412
Others (Europe)	
Austria	84
Norway	242
Spain	48
Sweden (including alloys)	20[b]
Switzerland	67
United Kingdom	34
Yugoslavia	40
TOTAL	535
TOTAL: Europe and China (mainland)	2,607
Africa: Cameroon	58
Oceania-Australia	46
Asia	
China (Taiwan)	13
India	61
Japan	247
TOTAL	321
WORLD TOTAL	6,096

SOURCE: United States of America, Bureau of Mines.

[a] Data may not add to totals shown due to rounding of some figures.

[b] Estimated.

Table 16. World primary aluminium production: rates of growth and geographical distribution, 1900-1963

	Total world	Free-enterprise economies[a]	United States of America	Other free-enterprise economies	USSR[b]
	(Thousands of short tons)				
1900	7.5	7.5	2.5	5	
1920	137	137	69	68	
1940	863	787	206	581	66
1950	1,650	1,422	719	703	200
1960	4,985	3,977	2,015	1,962	745
1963	6,095	4,643	2,313	2,329	1,060
	Geographical distribution (percentage)				
1900	100	100	33	67	—
1920	100	100	50	50	—
1940	100	92	24	68	8
1950	100	87	44	43	12
1960	100	80	40	40	15
1963	100	76	38	38	17

Table 16. World primary aluminium production: rates of growth and geographical distribution, 1900-1963 (*continued*)

	Total world	Free-enterprise economies[a]	United States of America	Other free-enterprise economies	USSR[b]
	Annual compound rate of growth (percentage)				
1900–1920	16	16	17	13	—
1920–1940	10	9	6	11	—
1940–1950	7	6	13	2	12
1950–1960	12	11	11	11	14
1900–1960	11	12	12	11	[b]
1950-1963	11	10	9	10	14

SOURCE: Computed from production data compiled by United States of America, Bureau of Mines; and American Bureau of Metal Statistics.

[a] Total world, excluding the Union of Soviet Socialist Republics through 1940; total world, excluding the Union of Soviet Socialist Republics and other centrally planned economies after 1940.

[b] First output of Union of Soviet Socialist Republics reported for 1932 by United States of America, Bureau of Mines, at 1,100 short tons. The compound annual rate of growth in the USSR Seven-Year Plan, 1959-1965, is 16 per cent.

Table 17. Summary of recent various projections of aluminium consumption (C) or production (P)

Geographical area	Projection: Period of time	Projection: Short tons (thousands)	Projection: Annual rate of increase (percentage)	Source of projection
World	1957-1980	17,500 (P)	8.0 (First decade) 6.0 (thereafter)	Canadian Royal Commission, 1957
Free enterprise economies	1962-1971	11,400(C)	6.5	Dr. E. G. West, United Kingdom
	1964-1970	8,000(C)	8.5	Kaiser Aluminium & Chem. Co., United States of America
	1964-1970	7,650(C)	9.0 *ex*-USA 7.0 in USA	Bache & Co., New York, United States of America
Western Europe	1955-1975	2,600(C)	5.6	General Agreement on Tariffs and Trade
	1955-1970	1,760(C)	4.7	Twentieth Century Fund, New York, United States of America
European Common Market	1955-1970	2,500(C)	7.2	Aluminium Limited, Canada
	1959-1970	1,700(C)	10.0	European Common Market
	1959-1970	1,200(C)	6-7	European Free Trade Area
	1959-1975	1,540(C)	8.5 (to 1965) 9.0 (1965-1975)	International Bank for Reconstruction and Development
United States of America	1950-1975	3,600(C)	5.6	Paley Commission, United States of America
	1954-1965	4,250(C)	9.9	J. E. Rosenzweig, United States of America
	1955-1975	6,500(P)	7.4	Resources for the Future, United States of America
	1957-1980	7,800(C)	7.5	Wilbert G. Fritz, United States of America
	1960-1980	11,965(P)	9.4	United States Department of Commerce
	1980-2000	32,300(P)	5.1	United States Department of Commerce
	1960-1990	8,700 to 17,400(C)	5.0 to 7.5	Development and Resources Corporation, United States of America
USSR	1959-1965	n.a.	16.0	Government of USSR
Japan	1959-1980	667,000(C)	9.0	Japan, Economic Planning Agency
India	1962-1976	429,000(C)	13.0	Indian Planning Commission
Australia	1961-1970	118,000(C)	15.0	Aluminum Co. of America

SOURCE: A pending publication, "The aluminum industry of the Pacific Northwest", used by permission of the United States of America, Department of the Interior, Bonneville Power Administration (Portland, Oregon).

Table 18. Selected countries: per capita consumption of primary aluminium, 1938 and 1961, and per capita national income, 1961

Country	1938 Population (millions)	1938 Consumption Total (thousands of tons)	1938 Consumption Per capita (kilos)	1961 Population (millions)	1961 Consumption Total (thousands of tons)	1961 Consumption Per capita (kilos)	1961 National income per capita (dollars)
Australia	7.1	9	1.2	10.5	34	3.2	1,262
Austria	6.8	?	—	7.7	38	5.3	646
Belgium-Luxembourg	8.3	2	0.2	9.2	69	7.5	1,032
Brazil	—	?	—	71.0	35	0.5	83
Canada	10.4	6	0.5	18.2	102	5.6	1,466
China (mainland)	—	2	—	582.6	85	0.15	106
Czechoslovakia	15.2	4	0.3	13.7	50	3.7	?
Eastern Germany	—	—	—	17.2	80	4.7	(2,008)[a]
Federal Republic of Germany	—	—	—	54.0	290	5.4	1,114
France	42.0	31	0.7	46.5	202	4.4	1,024
Germany[b]	68.1	173	2.6	—	—	—	—
Hungary	9.0	3	0.3	10.0	45	4.5	(1,256)[a]
India	—	—	—	441.6	30	0.07	68
Italy	43.0	26	0.6	50.5	105	2.1	547
Japan	73.1	50	0.7	93.4	185	2.0	405
Netherlands	—	—	—	11.5	12	1.0	842
Norway	2.9	1	0.4	3.3	19	5.7	1,038
Poland	34.5	?	—	29.7	45	1.5	(3,500)[a]
Sweden	6.3	7	1.1	7.5	34	4.6	1,597
Switzerland	4.2	12	2.9	5.4	48	8.9	1,490
USSR	170.5	57	0.3	208.8	730	3.5	(836)[a]
United Kingdom	46.2	45	1.0	52.7	284	5.4	1,148
United States of America	132.0	117	0.9	179.3	1,792	10.0	2,368
Yugoslavia	15.9	3	0.2	18.5	36	1.9	225

SOURCES: For population: *Statistical Yearbook of Switzerland*, 1937 and 1963, population figures nearest to 1938 and 1961. For consumption (other than United States of America, 1938): Hans Bachmann, "Aluminium as an export industry" (E/CONF. 46/P/10), paper prepared for the United Nations Conference on Trade and Development, Geneva, 1964, p. 49; for consumption in the United States of America, 1938, taken as 1935-1939 average: Engle, Gregory and Mosse, *Aluminium* (1964), p. 252. For national income and rates of exchange: United Nations, *Statistical Yearbook, 1962* (United Nations publication, Sales No.: 63. XVII.1), pp. 487 and 510.

[a] On the basis of the theoretical rates of exchange indicated in United Nations, *Statistical Yearbook, 1962*, p. 519.

[b] Prior to Second World War.

ANNEX II

Private and government ownership in the world primary aluminium industry[a]

The world primary aluminium industry is in the hands of privately owned companies and also of enterprises owned or partly controlled by Governments, both of centrally planned economies and of free enterprise economies. As of 1964, nearly one-third of the capacity was owned or controlled by Governments and just over two-thirds by private companies (see table 19). The current world trend is for government ownership or participation to expand its share of the industry.

[a] Revised from a contribution by the writer to a report pending publication, "The aluminum industry of the Pacific Northwest", used with the permission of the United States Department of the Interior, Bonneville Power Administration, Portland, Oregon.

Table 19. Control and affiliations of world primary aluminium capacity, 1964, and expansions

(Thousands of short tons)

Control or affiliation	Existing capacity 1964	In construction or probable expansion	Planned or possible expansion	Total
Six leading private companies				
Aluminium Limited **(Canada)**				
Brazil	15	7	—	22
Canada	808	—	220	1,028
India	29	44	—	73
Italy	6	—	—	6
Japan	121	17	—	138
Norway (partly with British Aluminium—Reynolds)	48	49	—	97
Sweden	36	20	—	53
TOTAL	1,063	137	220[a]	1,417
Aluminum Company of America (United States of America)				
Australia	44	—	—	44
Brazil	—	—	22	22
Mexico	22	—	—	22
Norway	62	—	33	95
Surinam	—	60	—	60
United States of America	858	176	?	1,034 ?
TOTAL	986	236	55	1,277

Table 19. Control and affiliations of world primary aluminium capacity, 1964, and expansions (*continued*)

(Thousands of short tons)

Control or affiliation	Existing capacity 1964	In construction or probable expansion	Planned or possible expansion	Total
***Kaiser Aluminum & Chemical Corp.* (United States of America)**				
Argentina			24	24
Australia - New Zealand	58	—	135	193
Brazil			24	24
Ghana (with Reynolds)		115	135	250
India	22	44		66
Spain (with Pechiney)	22	8		30
United States of America	610	—	115	725
TOTAL	712	167	433	1,312
***Reynolds Metals Company* (United States of America)**				
Argentina	—	—	25	25
Canada (through British Aluminium)	99	—	106	205
Ghana (see Kaiser)	(—)	(115)	(135)	(250)
Greece (with Pechiney)	—	69	—	69
Kuwait	—	—	55	55
Norway (see Aluminium Limited)	(30)	(31)	(—)	(61)
Philippines	—	—	25	25
United Kingdom	36	—	—	36
United States of America	725	90	—	815
Venezuela (with The Government)	—	11	14	25
TOTAL	860	170	225	1,255
***Pechiney-Ugine*[b] (France)**				
Cameroon	57	—	50	107
France	362	—	63	423
Greece (see Reynolds)	(—)	(69)	(—)	(69)
Spain (see Kaiser)	(22)	(8)	(—)	(30)
United States of America (with others)	—	73	—	73
TOTAL	419	73	113	605
***Swiss Aluminium* (Switzerland)**				
Austria	12	10	—	22
Federal Republic of Germany	52	—	—	52
Iceland	—	—	110	110
Italy	52	—	—	52
Netherlands (with others)	—	33	33	66
Norway	—	66	—	66
Switzerland	70	—	—	70
United States of America	32	30	188	250
TOTAL	218	139	331	688
TOTAL, six leading companies	4,258	922	1,377[a]	6,554
***Other private companies* (10)**				
Argentina			40	40
Brazil	22		33	55
Greece			33	33
India	8	11	55	74
Italy	89		110	199
Japan	202	33		235
Switzerland	6			6
United States of America	346	33	258	637
TOTAL	673	77	519	1,269
Governments				
Free-enterprise economies				
Austria	76	12		88
China (Taiwan)	22			22
Federal Republic of Germany	194	26	40	260
Indonesia			28	28
Norway (including Norsk Hydro)	183	116		299
Spain	34	25		59
United Arab Republic	—		22	22
TOTAL	509	179	90	778
Centrally planned economies				
China (mainland)	290	?	88	378
Czechoslovakia	65 ?		—	65 ?
Eastern Germany	61	11		72
Hungary	61 ?	2 ?	—	63 ?
North Korea	40	?	?	40
Poland	52	103	—	155
Romania	—	33	22	55
Yugoslavia	53	—	55	108
USSR	1,060	440	?	1,500 ?
TOTAL	1,682	589	165	2,436
Control not yet determined				
Angola	—	—	28	28
Congo (Brazzaville)	—	—	275	275
Congo (Democratic Republic of)	—	—	550	550
Guinea	—	—	265	265
Turkey	—	—	25	25
TOTAL	—	—	1,143	1,143
GRAND TOTAL	7,122	1,767	3,294[a]	12,180

Sources: Company reports to stockholders, publicity releases, *Metal Bulletin* (London), Aluminium issue (December 1963).

[a] After retirement of 3,000 tons in 1965.

[b] The French company, Ugine, co-operates closely with Pechiney.

The privately owned sector of the world industry is controlled and influenced by a handful of companies. As of 1964, outside of the centrally planned economies, six companies controlled or influenced by minority interest about 78 per cent of the world capacity of 5.4 million tons (see table 20). Ten other private companies owned about 12 per cent, and Governments of free-enterprise economies about 10 per cent. Aluminium Limited (Canada) held the largest single share of the capacity of free-enterprise economies, one fifth. The Aluminum Company of America (Alcoa) held a slightly smaller share. Kaiser Aluminum & Chemical Co. and Reynolds Metals Co. (both in the United States of America), the two French companies who act co-operatively (Pechiney and Ugine) and Swiss Aluminium accounted for 41 per cent.

Table 20. Control and affiliations of world primary aluminium capacity, 1964

	Short tons (thousands)	Percentage: Free-enterprise economies	Percentage: Whole world
Six leading companies	4,258	78	60
Aluminium Limited (Canada)	1,063	20	15
Alcoa (United States of America)	986	18	14
Kaiser (United States of America)	712	13	10
Reynolds (United States of America)	860	16	12
Pechiney-Ugine (France)	419	8	6
Swiss Aluminium (Switzerland)	218	4	3
Ten other private companies	673	12	9
Governments	2,191	10	31
Free-enterprise economies	509	10	7
Centrally planned economies	1,682		23
TOTAL WORLD	7,122		100
TOTAL FREE-ENTERPRISE ECONOMIES	5,440	100	

SOURCE: Table 19.

These relative positions in the aluminium industry in free-enterprise economies may change somewhat when publicized expansions of capacity, both those under construction and those probably to be undertaken, are fulfilled. The Governments of the centrally planned economies accounted for 23 per cent of the primary capacity of the world aluminium industry in 1964 and would advance to 26 per cent. Privately owned and affiliated capacity would fall from 69 per cent to 66 per cent. If planned and possible capacity is considered also, the longer range outlook is more uncertain. It will be affected by both the amount of such capacity that is actually built and the ownership and control of major projects, especially those in Africa. Details of ownership and affiliations of the world's primary aluminium capacity, current and prospective, are given above in table 19.

The private-enterprise portion of the world primary aluminium industry is not only marked by the dominant position of six companies. It is also complicated by the overlapping of corporate spheres of interest through joint ventures in the various stages of the industry, among five of the six leaders. These overlaps represent a minor fraction of the total investment and capacity of each. Thus far, the overlaps have not been accompanied by any indications of co-operation to dominate the world capacity, production, markets and prices. On the contrary, these overlapping enterprises have competed vigorously in the development of excessive capacity, in price cutting, in absorbing independent semi-fabricating companies and by invading each other's markets. Thus, the Reynolds Metals Company, through its substantial interest in British Aluminium Limited, is part-owner with Aluminium Limited of a Norwegian primary aluminium company, Det Norsk Nitrid, but is also intensively competitive with Aluminium Limited throughout the world and particularly in Canada itself, the home territory of Aluminium Limited. Rivalry between these companies became intense in 1958, when Reynolds moved to obtain nearly a half-ownership of British Aluminium, thereby taking over the principal customer for primary metal from Aluminium Limited. By this means Reynolds also obtained practical control over the Canadian primary aluminium subsidiary of British Aluminium (Canadian British Aluminium). Reynolds has followed by extending materially its semi-fabrication capacity in Canada. Reynolds is also in a joint venture with Kaiser in the Volta Aluminium Company, now building a smelter in Ghana, and with Pechiney and others in a smelter being built in Greece.

The alumina plant of the company Fria of the Republic of Guinea is a joint venture of Pechiney, Swiss Aluminium and British Aluminium (Reynolds), and includes also Olin Mathieson Chemical Corporation, Ugine and the aluminium company of the Federal Republic of Germany, the Vereinigte Aluminium Werke. Pechiney, Aluminium Limited and Kaiser are in a joint venture to construct a major alumina plant in Australia. Pechiney and Kaiser share minority interests in two Spanish aluminium companies. Only Alcoa has avoided joint ventures with others of the six leaders, but has entered into partnerships with other companies in various countries.

The practice of joint ventures has extended beyond the six leaders and has become universal in the world primary aluminium industry. The practice even includes joint ventures between Government-controlled companies and private companies, and between Governments themselves. In the United States of America, the primary aluminium and alumina producer, Ormet Corporation, is a joint venture of Olin Mathieson Chemical Corporation and Revere Copper and Brass Inc. The Tennessee aluminium smelter of the Consolidated Aluminium Corporation, owned by Swiss Aluminium, is being expanded in 1964 under a financing and supply arrangement with the Phelps Dodge Corporation in order to assist that company to become an aluminium fabricator. The smelter being built in the State of Washington (United States of America) by the new Intalco Aluminium Corporation represents a joint venture of Pechiney, American Metal Climax and the Howe Sound Company. Harvey Aluminum is in a joint venture with the leading magnesium producer of Europe, Norsk Hydro (controlled by the Norwegian Government), to build an aluminium smelter in Norway. This plant will utilize alumina from the Harvey alumina plant under construction in the Virgin Islands. Harvey also has a commitment to a joint venture in an Italian smelter.

Among Government-owned enterprises, Vereinigte Aluminium Werke (Federal Republic of Germany) was recently associated with private interests in a project, currently suspended, to build an aluminium smelter in India. The Government of Hungary is associated with the Government of India in a proposed alumina plant in India. In Australia, the Government of Tasmania is part-owner of an aluminium smelter and alumina plant, along with Kaiser and Australian private capital. Reynolds is in partnership with the Government of Venezuela to build and operate a smelter.

In addition to joint ventures in various stages of the aluminium industry, a growing practice is technical assistance between aluminium enterprises, particularly where the company supplying the assistance also obtains a position to supply raw materials. Kaiser Aluminum has such a venture in a fabrication plant in Thailand. Japanese aluminium companies have technical arrangements with producers in the United States of America. The French company, Pechiney, has helped in the design and construction of plants now operated by competitors and is currently assisting the construction of smelters for the Polish and Romanian Governments.

Other joint ventures have been exploratory or conditional. Three different consortiums were formed in the 1950's to investigate the possibilities of establishing aluminium and power projects in Ghana, the Congo (Brazzaville), the Congo (Democratic Republic of) and Guinea. These consortiums comprised different memberships, some overlapping, and included all of the leading North American and European aluminium producers. The Ghana consortium for a while included Alcoa and Olin Mathieson, who then withdrew, leaving Kaiser and Reynolds to proceed. The most ambitious consortium, consisting of eight companies, looked towards an aluminium industry based on the possibility of developing the 25 million-kilowatt power project at Inga Rapids in the Democratic Republic of the Congo. The ultimate investment in this project would have exceeded $3,000 million. A group of nine companies considered a power-aluminium project involving over $300 million for the Congo (Brazzaville). But the only consortiums that finally went into business in Africa were the two companies from the United States of America which were in the Ghana project, and the five companies joined in the Fria alumina project in Guinea. Most recently, in 1963, a consortium of North American and European companies tried to obtain the Boké bauxite concession in Guinea, representing the largest high-grade deposits currently known in the world. However, the Government of Guinea assigned this concession to Harvey Aluminum as part of a joint venture between the Government and the company.

The motivations behind the various consortiums and joint ventures have varied. In some cases, particularly the African projects, the purposes have included the spreading of the large investment and the political risk, and the sharing of output too large for an individual company. In other cases, such as in Australia and Japan, domestic capital or enterprise was already available or established, but needed technical help or access to additional markets that could be supplied by outside partners. A general force everywhere has been the rivalries of the leading aluminium companies in seeking positions in advance of market development in the various countries through alliances to share the growing investment requirements. The recent ventures in Australia, Ghana and Greece are examples.

Stimulating some of these rivalries between companies have been the ambitions of certain Governments to develop power projects for general purposes and to make them more feasible by selling much of the power to an aluminium enterprise. In this category have been the power-aluminium developments in Ghana, Greece and Norway, where joint ventures are building aluminium projects to be supplied with government power. Some Governments also want an aluminium industry in which domestic capital participates as a matter of policy, in order to reduce the influence of foreign companies. Conversely, this policy is accepted by some foreign companies in order to avoid the risks of expropriation or discrimination against an exclusively non-domestic enterprise.

A list of the principal joint ventures and consortiums in the world aluminium industry appears in the appendix, table 21.

Governments also are direct participants in the aluminium industry. Nearly a third of the world primary capacity is operated by Government-owned enterprises. As observed above, 7 per cent of the primary capacity is held by the Governments of free-enterprise economies and 23 per cent by Governments of centrally planned economies. There is no movement afoot to lessen the position of Governments in the industry, but rather for the number of participating Governments to increase. Among the countries shown in table 19 in which the primary production of aluminium is being promoted or is already committed, the Governments plan to own enterprises in whole or in part in India, Indonesia, Turkey, the United Arab Republic and Venezuela. These countries would double to ten the group of five Governments now in the primary aluminium industry. Private enterprise may yield in the near future some of its current domination of 69 per cent of the world primary capacity. This may happen not only because of the growth in the number of countries expecting to have governmental participation in enterprises, but also because a faster rate of growth is likely in aluminium consumption in developing countries, as compared with the more industrialized nations. In the developing countries, the role of the Government in business enterprises is currently increasing.

Thus far, the effects upon the privately owned aluminium industry of competition from the governmental sector have been no different than the competition between some of the private enterprises themselves. The Union of Soviet Socialist Republics has consistently offered primary aluminium in recent years at a discount in Western Europe, leading to some criticism that Soviet policy was politically motivated to upset the world aluminium industry.[b] On the other hand, Soviet exports to free-enterprise economies have been a minor portion—2 to 5 per cent—of total Soviet production. These exports have been growing at a time when the world aluminium industry has felt the excessive capacity of North America.

On the other hand, the Government of Norway, through its aluminium enterprise, Ardal og Sunndal Verk, has followed the same price-cutting policy as the USSR in order to dispose of its exports. A major difference, however, has been that the Norwegian metal has become an accepted and growing part of the world aluminium supply, particularly in the United States of America. Norwegian metal has been offered commonly in recent years in the United States of America at a discount of about 10 per cent, with import duty and freight to a port in the United States absorbed by the seller. The Ardal exports have been the largest factor in the world aluminium trade, next to Aluminium Limited. The Norwegian company has very limited domestic markets and is forced to rely upon exports for most of its revenues. Ardal accounted for nearly half of the Norwegian aluminium ingot exports of 189,000 tons in 1962 and contributed to most of the expansion of imports by the United States of America, from Norway, from 16,000 short tons in 1953 to 87,000 tons in 1963.

The aluminium company of the Government of China (Taiwan) also has sold primary metal in international markets at considerable discounts from time to time. These sales have been very small, but have reflected the inability of the domestic market to absorb all of the output of less than 12,000 tons per annum. Both China (Taiwan) and the Ardal company, like the USSR, have adopted whatever price policy would move the surplus metal. In this way, these Governments have not differed from some private enterprises. The French company, Pechiney, has also sold primary aluminium at a discount from the published price in the United States of America in recent years. The producers in the United States of America have themselves followed similar practices, although more commonly in the disguised form of special allowances for scrap returned to them, in freight allowances and in credit terms and free advertising for customers.

Thus, there has been no unique threat to private aluminium companies arising from the price competition of government enterprises, whether in free-enterprise or centrally planned economies. However, a difference might seem to lie in the motives of some government enterprises.

As a public enterprise, Ardal has tried to sustain employment as long as possible rather than to cut back on surplus production. This motive, when coupled with a Government's over-all financial resources to subsidize a government enterprise through a period of losses or other difficulties, may place some private enterprises at a disadvantage in competing with government enterprises. However, certain of the privately owned aluminium companies have greater revenues or other resources available to them than some of the government aluminium enterprises with which they compete. On the other hand, the alleged non-profit motive of enterprises in centrally planned economies is being modified in Eastern Germany, Hungary and the Soviet Union, to require a return of interest on the investment or the use of profit standards.[c] Such a change in policy will tend to equalize to some degree any competition with private companies.

It is clear, however, that the growing participation of Governments in the aluminium industry does introduce elements of policy and public resources not comparable to those of private enterprise. The Government of China (Taiwan) is interested in expanding its aluminium enterprise in order to serve export markets, even though production costs in domestic currency are higher than some private companies would consider feasible. For a few years, the United Arab Republic has been seeking help from private companies to establish a government

[b] Carroll Kilpatrick, "Soviet bargains? Reds undercut aluminum trade", *Washington Post* (4 April, 1958); and "US probes Soviet metal sales, No evidence of market wrecking intent", *Metal Bulletin* (London) (11 February 1958).

[c] Harry Schwartz, "Soviet joins other red lands in trying capitalist devices", *New York Times* (24 May 1964).

smelter, even though much of the output of one of economical capacity would have to be sold in foreign markets. The Government of Venezuela is in partnership with Reynolds Metals for a projected smelter which will produce for the domestic markets at a cost close to the price of imported metal and which will require a higher price on the domestic market than can be obtained from the sale of any surplus in export markets. The multiplication of such cases, even though each represents a small aluminium capacity, constitutes a continuous problem to the private aluminium industry. But the effects are also adverse to the established aluminium enterprises of Governments themselves. Excessive capacity and competition are felt by all enterprises, regardless of private or public control.

Much more formidable to all participants in the world aluminium industry would be the situation if the Soviet aluminium industry were to seek a position comparable to that of the Norwegian Government in export markets. Based on the construction of large hydroelectric projects and aluminium capacity in central Russia and Siberia, the Soviet Union has been proposing since 1961 that Japan change its own policy of self-sufficiency in primary aluminium and buy from the Soviet Union. This proposal, however, does not by iself suggest more than the possibility of a limited amount of trade between two adjacent countries. The USSR is a high-cost aluminium producer in terms of transportation costs and raw materials. It is deficient in suitable grades of bauxite and must ship materials and products over long distances by rail. If the USSR adheres to objective standards of costs and profitability, it is unlikely to seek more than a limited position in the international aluminium trade.

In addition to the impact of competition by Governments upon the privately owned aluminium enterprises, there has been the effect of governmental financial assistance and promotion of new aluminium enterprises, regardless of ownership. This promotion includes measures associated with electric-power projects, especially hydroelectric projects. In the United States of America, the aluminium industry itself received governmental assistance on a massive scale during the fifteen years including the Second World War and the Korean War. Such assistance included, after the Second World War, the disposal of Government-owned plants at prices averaging around one-third of original cost; income-tax savings from rapid amortization of investment; government loans and loan guarantees; government purchases for the stockpiling of surplus aluminium from new plants built under the Korean War defense programme; and large-scale contracts to purchase bauxite for stockpiling through the Government's agricultural barter programme. The sale of electric power to all customers at low rates by the Tennessee Valley Authority and the Bonneville Power Administration also helps the aluminium industry.

The Government of the United States of America has also extended financial aid to the aluminium industries of foreign countries. Such aid included a loan to the Government of Norway under the Marshall plan for the construction of additional aluminium capacity; a loan, under the subsequent foreign-aid programme, for the expansion and modernization of capacity of the Taiwan Aluminium Company owned by the Government of China (Taiwan); loans to the Governments of Greece and Yugoslavia to support hydroelectric developments from which power will serve new aluminium capacity; participation in loans with the International Bank for Reconstruction and Development (IBRD) and the United Kingdom of Great Britain and Northern Ireland to the Government of Ghana for the Volta River project; and a direct loan by the Export-Import Bank (United States of America) for most of the investment in the private aluminium smelter now under construction in Ghana. Also among governmental aids are the plans of the United Arab Republic (Egypt) to build an aluminium smelter to use power from the Aswan Dam (a project assisted by the USSR), and of the Indonesian Government to build an aluminium smelter with technical assistance and loans from the USSR, both for the smelter and for the associated Asahan Dam. In a similar category is the aluminium smelter to be built in Venezuela as a partnership in investment by the Government and the Reynolds Metals Company, with power supplied by the Government's hydroelectric system of the Caroni River and with a loan supplied to Reynolds by the United States Export-Import Bank. In the same list is the participation of the Government of Norway, through the Norsk Hydro Company, in a joint venture with Harvey Aluminum to build a new smelter.

Thus, throughout the world, the aluminium industry is being promoted in different countries by various governmental aids, regardless of private or public ownership of the aluminium plants. The availability of such aids has influenced some recent decisions to build smelters more than have the adequacy of the markets and the common tests of economic feasibility.

The Volta aluminium project is proceeding under the joint venture of Kaiser and Reynolds after Olin Mathieson and Alcoa withdrew from the original consortium because of doubt as to the immediate market prospects. Without the political and financial support of the Government of the United States of America, the project would probably have been suspended. The Reynolds-Venezuelan aluminium project is to proceed without a sufficient domestic market only because of the Government's contribution of power-supply at an attractive rate, a share of the plant investment and the protection of a high domestic price for the aluminium. In India, a number of aluminium smelters will expand or be constructed as part of the Government's programme to save foreign exchange by encouraging aluminium consumption and the displacement of imported copper, and with the protection of a very high tariff, 38.5 per cent.

Thus, the current and prospective development of the world primary aluminium industry is the product of governmental programmes in many instances. Although private enterprise controls the larger share of the world industry, it has itself been shaped in the past two decades by governmental policies and aids, and has everywhere adapted itself to such policies and encouragements. This is not to imply that economic considerations — that is, sufficient markets and an adequate return on investment — have been abandoned. What all Governments and private companies clearly hope is that investments in the aluminium industry made in advance of domestic market needs or with governmental financial assistance will ultimately be justified as the markets expand and that during any interim period, export markets in other countries may absorb temporary surpluses and, if necessary, at a discounted price level. This expectation can, however, be successful only so long as it is not shared by too many private enterprises and Governments. Otherwise, it will be self-defeating and can produce losses or inadequate return on the investment, as has been the experience of some aluminium enterprises within the past ten years.

Appendix

Table 21. Principal international joint ventures and consortiums in the world aluminium industry, 1964

Home country	*Company, plant location and participants*	*Products and approximate capacity or investment*
North America		
Canada	Canadian British Aluminium Company Limited (Baie Comeau, Quebec): British Aluminium Company Limited (60%); Quebec North Shore Paper Co. (40%)	Primary aluminium: capacity, 95,000 short tons.

Table 21. Principal international joint ventures and consortiums in the world aluminium industry, 1964 (*continued*)

Home country	*Company, plant location and participants*	*Products and approximate capacity or investment*
Mexico	Aluminio, S. A. de C.V. (Vera Cruz): Aluminum Company of America (35%); American and Foreign Power Co. (14%); Intercontinental S.A. and other interests (51%)	Primary aluminium: capacity, 22,000 short tons; cost, $16.9 million.
United States of America	Alroll Inc. (Oswego, N.Y.): Aluminium Limited (50.1%); Cerro Corporation (16.65%); balance held by Scovill Manufacturing Co. and Bridgeport Brass Co. of National Distillers and Chemical Corporation	Sheet re-roll stock: capacity 100,000 short tons; cost, $38 milllion
	Intalco Aluminum Corp. (Bellingham, Washington): Pechiney (Compagnie de Produits Chimiques et Electrométallurgiques) (25% plus interest through Howe Sound); Howe Sound Company (25%); American Metal Climax, Inc. (50%)	Primary aluminium project: capacity, 73,000 short tons; estimated cost, $60 million.
Europe		
Greece	Aluminium de Grèce (Aspra Spitia): Pechiney (50%); Reynolds Metals Company (17%); Greek interests (33%)	Primary aluminium project: capacity, 69,000 short tons, capacity 220,000 short tons of alumina; cost $114 million.
Netherlands	Aluminium Delfzijl N.V. (Delfzijl): Billiton Matschappij N.V. (16⅔%); Koniklijke Nederlandsche Hoogovens en Staalfabrieken N.V. (50%); Swiss Aluminium (33⅓%)	Primary aluminium: capacity, 33,000 short tons; cost, $28 million.
Norway	Mosjoen Aluminium Co. (Mosjoen): Aluminum Company of America (50%); Elektrokemisk (50%)	Primary aluminium: capacity, 62,000 short tons
	Det Norske Nitridaktieselskap (Eydehavn and Tyssedal): Aluminium Limited (50%); British Aluminium (50%)	Primary aluminium: capacity, 30,000 short tons.
	Norsk Aluminium Co. (Hoyanger): Aluminium Limited (50%); Norwegian interests (50%)	Primary aluminium: capacity, 15,000 short tons
	Sor-Norge Aluminium Co. (Husnes): Swiss Aluminium (50%); French banking interests, Compadec (50%)	Primary aluminium project: capacity, 66,000 short tons
	Alnor, S/A (Karmoy): Norsk Hydro (51%); Harvey Aluminum Inc. (49%)	Primary aluminium project: capacity, 66,000 short tons
Spain	Aluminio Español (Sabinanigo): Pechiney (85%); Kaiser Aluminum (15%)	Primary aluminium: capacity, 9,000 short tons
	Aluminio de Galicia (La Coruna): Pechiney (15%); Kaiser Aluminum (15%); others (70%)	Primary aluminium: capacity, 14,000 short tons
Sweden	Svenska Metallverken (Kubikenborg and Mansbo): Aluminium Limited (22%); Swedish investors (78%)	Primary aluminium: capacity, 30,000 short tons; semi-fabrication
United Kingdom	British Aluminium Company, Limited (United Kingdom and other countries): Reynolds Metals Company (47.7%)	Integrated producer, various countries; $144 million in total assets, excluding Canadian British Aluminium
	Imperial Aluminium Co. (England and Wales): Aluminium Company of America (49%); Imperial Chemical Industries Limited (51%)	Semi-fabrication: capacity, 43,000 short tons
	James Booth Aluminium Ltd. (various locations): Kaiser Aluminum and Chemical Corp. (50%); Delta Metal Company Ltd. (50%)	Semi-fabrication: capacity, 50,000 short tons
Africa		
Cameroon	Compagnie Camerounaise de l'Aluminium (Alucam), (Edea): Pechiney-Ugine (89%); Belgian fabricators (11%)	Primary aluminium: 58,000 short tons
Ghana	Volta Aluminium Co. Ltd. (Tema): Kaiser Aluminium and Chemical Corp. (90%); Reynolds Metals Company (10%)	Primary aluminium project: 115,000 to 165,000 short tons; $164 million investment
Guinea	Compagnie des Bauxites de Guinée (Boké): Harvey Aluminum Inc. (51%); Government of Guinea (49%)	Bauxite project to include mines, railroad, port: $30 million to $40 million investment estimated
	Fria, Compagnie Internationale pour la Production de l'Alumine (Fria): Olin Mathieson Chemical Corp. (49%); Pechiney Ugine (26%); British Aluminium Co. Ltd. (10%); Swiss Aluminium (10%); Vereinigte Aluminium Werke, A. G. (5%)	Bauxite and alumina enterprise: capacity, 530,000 short tons.

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7. AFRICA AND THE ALUMINIUM INDUSTRY

*Samuel Moment**

CONTENTS

* Mr. Moment is a consultant who was put at the disposal of the United Nations Economic Commission for Africa by the United States of America, Agency for International Development, under the bilateral technical assistance programme. The terms of reference were prepared by the secretariat of the United Nations Economic Commission for Africa and were discussed with Mr. Moment before he undertook the study.

Preface

To some developing countries, aluminium has meant a large hydroelectric project and a smelter requiring a few hundred million dollars of foreign capital that only a few fortunate countries can obtain. It has also meant the use of much more capital than most other industries require, the need to send the aluminium output to foreign markets and such benefits as small but well-paid employment, low-cost electricity which is also available for other industries and users and, sometimes, reservoirs with irrigation projects, greater agricultural output, inland fisheries, flood control and low-cost water transport to open up some regions for additional development.

In this report, an attempt is made to show African countries that aluminium can mean much more even if it is only fabricated and not produced in crude form. It is a metal to help meet some of the most pressing problems of Africa—to increase crop and protein production, to store and preserve perishable foods, to reduce malnutrition, to improve sanitary rural housing and reduce disease, to increase the revenues and reduce the costs of transport systems, to spread electrification at less cost than copper, to help protect forestation and reduce damage to lands from excessive fuelwood removal and to stimulate co-operation between African countries so as to achieve the common aims of increasing the health and productivity of their populations.

Summary and conclusions

A. Summary

This report is derived from another report prepared for the purposes of examining the possibilities of establishing in the East African subregion any of the primary stages of the aluminium industry—bauxite mining and the production of alumina or aluminium—as well as the expansion of existing capacity for various

Table 21. Principal international joint ventures and consortiums in the world aluminium industry, 1964 (*continued*)

Home country	*Company, plant location and participants*	*Products and approximate capacity or investment*
Asia		
India	Hindustan Aluminium Corp. (Uttar): Kaiser Aluminum and Chemical Corp. (27%); G. D. Birla Associates & other Indian investors (73%)	Primary aluminium: capacity, 22,000 short tons; alumina and semi-fabrication
	Indian Aluminium Company (Kerala and Orissa): Aluminium Limited (65%); Indian investors (35%)	Integrated aluminium enterprise: capacity, 30,000 short tons
	Madras Aluminium Co. (Madras): Montecatini (20%); Indian investors (80%)	Primary aluminium: capacity, 11,000 short tons; alumina plant
	Aluminium smelter (Maharashtra): joint venture of Vereinigte Aluminium Werke, Governments of India and Maharashtra, and private investors	Primary aluminium project: capacity, 28,000 short tons.
Japan	Nippon Light Metal (various locations): Aluminium Limited (50%); Japanese investors (50%)	Primary aluminium: capacity, 112,000 short tons
	Furukawa Aluminium Co. Ltd. (various locations): Aluminum Company of America (33%); Japanese investment (67%)	Semi-fabrication: capacity, 32,000 short tons
	Sky Aluminium Co. (project): Kaiser Aluminum and Chemical Corp. (30%); Yawata Iron and Steel Co. (18%); Showa Denko (52%)	Semi-fabrication: capacity 64,000 short tons
	Mitsubishi Reynolds Aluminium Co. Ltd. (Kitomotomachi): Reynolds Metals Company (33%); Mitsubishi (67%)	Semi-fabrication: capacity, 22,000 short tons
Australia	Comalco Aluminium (BellBay) Limited (Tasmania): Kaiser Aluminum and Chemical Corp. (33⅓%); Conzinc Riotinto of Australia Ltd. (33⅓%); Government of Tasmania (33⅓%)	Primary aluminium: 58,000 short tons
	Comalco Industries Pty. Ltd. (various locations): Kaiser Aluminum and Chemical Corp. (50%); Conzinc Riotinto (50%)	Bauxite and semi-fabrication
	Queensland Alumina Ltd. (Gladstone): Kaiser Aluminum and Chemical Corp. (52%); Pechiney (20%); Aluminium Limited (20%); Conzinc Riotinto (8%)	Alumina project: 670,000 short tons, under construction; $117 million investment
	Alcoa of Australia Pty. (various locations): Aluminum Company of America (51%); balance of investment by Western Mining Corp., Ltd.; North Broken Hill, Ltd.; and Broken Hill South, Ltd.	Integrated aluminum enterprise: 44,000 short tons of primary aluminium capacity, plus bauxite, alumina and semi-fabrication

ANNEX III

Stages and investments in the aluminium industry[a]

I. Production

Most of the world's aluminium is produced from the ore, bauxite. This ore is found principally in tropical countries. Other countries have bauxite, but, generally, the deposits have been more limited. They are all declining in quantity and in quality because of cumulative consumption over the years. Substitutes for bauxite — clay, nepheline and other materials — have been tried, but they are much more expensive to use than bauxite. Some countries may use these substitutes to a limited extent. The Union of Soviet Socialist Republics is now using nepheline for a small proportion of aluminium production and obtains by-products of cement and fertilizer. But as long as bauxite is available at acceptable cost to the other industrialized countries, they will continue to use it, even though they must depend very heavily upon imports, as does the United States of America. This point is well recognized by some of the bauxite-producing countries and in the arrangements they have made with foreign producers to obtain substantial revenues in taxes and royalties.

The bauxite is mined largely in open pits, but some is mined underground also in Europe and in the United States of America. Under the most favourable conditions and using large earth-moving machinery, bauxite mining is inexpensive and costs no more than digging and moving earth. Much of the world supply of bauxite costs $2 to $4 per ton before shipment and before royalties and other payments to Governments. The bauxite may be dried and treated to obtain a higher concentration of its aluminium content, and it is then moved to the alumina plant. There it is treated with a solution of hot caustic soda in order to extract the aluminium oxide called alumina. When produced in large quantities, alumina costs between $35 and $50 per ton, including the bauxite. This white powder is then moved to the aluminium smelter, where the alumina is

[a] This annex is revised from a portion of "Aluminum industry case study", prepared by the writer for use in a seminar of the Economic Development Institute, International Bank for Reconstruction and Development, Washington, D.C., August 1964.

poured into a series of furnaces or "pots" and dissolved in a liquid of molten cryolite; the aluminium is separated by passing large amounts of electricity through burning carbon electrodes. The aluminium is removed from the pots in melted form and is poured into crude shapes called pig or ingot. This product costs between $300 to $600 per ton to produce, including the alumina.

These ingots are then moved to semi-fabricating plants. Ingot is melted again and may be alloyed with small amounts of other metals, such as copper, magnesium, silicon and manganese. The metal is then transformed into other shapes, including plate and sheet, foil, profiles called extrusions, rod and bars, castings, forgings and powder. These forms are then given further treatment in the same semi-fabricating plants or after shipment to other plants. Plate is shaped to be used on ships and armoured military vehicles. Sheet is made into flat forms of coils, strips and circles. The flat forms are then converted into such forms as unpainted, painted or chemically coloured products for housing; corrugated products for the sides and roofs of building; cans; and cooking utensils and parts for household appliances, e.g., refrigerators and toasters. The foil is made into wrappings and packages for cigarettes and food, or is combined with fibreboard into canlike containers for such liquids as motor oil. Extrusions are made in various shapes: beams used in building construction and transportation equipment; tubes for pipes; and frames that are assembled into windows and doors. Rod is drawn into wire and is woven into electrical cable; it is also made into nails, screws and fences. Castings are made for such products as heavy cooking utensils and parts of automobile motors. Forgings are shapes hammered to give extra strength to parts in aeroplanes and other products that must stand up against hard use. Powder may be made into paints or used as a fuel in rockets.

II. Production costs and smelter capacity

The productive capacities of individual plants and the investments at the different stages of the aluminium industry cover a wide range throughout the world. The production costs likewise cover a wide range from high to low. The largest companies and some small companies produce their own bauxite. Some exclusively buy bauxite from others, and some supplement their mines with purchased bauxite. Most make their own alumina. Some produce their own electric power and some buy it from others. The results of so wide a variety of capacities and conditions are that the cost of crude aluminium ingot about six years ago was as low as $308 per ton, or 14 cents per pound in Canada and in the United States of America for some producers, and nearly twice as high in Australia, at about $600 per ton, or 27 cents per pound. In India, costs a few years ago were as high as $500 per ton, or 23 cents per pound.

The lowest cost smelters in Canada and the United States of America have capacities between 140,000 and 330,000 tons per annum. The high-cost Australian smelter had a capacity of 13,000 tons, and the two high-cost Indian smelters had capacities, respectively, of 2,200 and 5,500 tons per annum. Such small smelters were able to operate for the local markets because they were able to sell at prices much higher than the world price under the protection of tariffs and other trade restrictions imposed by their Governments. Thus, in 1958, when the world price of ingot was 22.5 cents per pound, charged by the Canadian exporter, Alcan (the subsidiary of Aluminium Limited), and delivered at this price anywhere in the world, the protected price in Australia was around 27 cents and in India, 37 cents per pound.

A. Protectionism and optimum smelter capacities

Protection of the aluminium industry is practised in many countries. This protection consists of import duties, import quotas, other taxes and levies on imports and special incentives given to domestic producers. Tariffs and some other trade restrictions for various countries are shown in table 22, including the higher prices in some countries, over the world price (Canadian export price). Although protectionism has allowed very small smelters to be built in some countries, there is a general incentive to increase the size of older smelters and to build new ones much larger to produce at lower costs.

Table 22. Domestic prices of standard aluminium ingot and tariffs, selected countries, May 1963

(Cents per pound)

Country	Price	Tariff and taxes on Canadian c.i.f. price	
		Amount	Comments
Australia	25.1	0	Imports prohibited except for grades not domestically produced
Austria	23.9	3.55	10% *ad valorem*; plus $5\frac{3}{4}$% turnover and other taxes
Brazil	n.a.	11.25	50% *ad valorem*[a]
Canadian export price, c.i.f.[b]	22.5	1.25[c]	
China (Taiwan)	32.2	6.29	20% *ad valorem*, plus 20% of duty, plus 3% harbour fee on c.i.f., plus duty
Federal Republic of Germany	24.6[d]	3.00[e]	9% *ad valorem* plus 4% turnover tax[f]
France	22.5	3.49	15% *ad valorem*, plus 0.2% of c.i.f. value, plus 2% on the duty
India	30.2	12.09	38.5% *ad valorem*, 0.6% other taxes, plus 360 rupees per ton
Italy	25.6	5.72	18.45% *ad valorem*, plus other taxes
Japan	27.9	3.38	15% *ad valorem*
Norway	22.5	0	
Sweden	22.5	0	
Switzerland	26.8	6.78	0.65 Swiss francs per kilogramme
United Kingdom	22.5	0	
United States of America	22.5	1.25	

Source: Trade publications, National Bank for Economic Development (Brazil) and Aluminium Limited.

Note: n. a. indicates information not available.

[a] Or 10% *ad valorem* if domestic aluminium is used for 30% of the importer's needs or if domestic aluminium is not available to that amount.

[b] Most common foreign price used by Alcan.

[c] Most favoured nation tariff.

[d] A discount of 1.1 cents from 24.6 cents was allowed by producers in the Federal Republic Germany from 1 June.

[e] Tariff inapplicable to duty-free quotas.

[f] Tariff exemption was granted to Common Market countries for a specific quota. Other countries were granted a reduced tariff of 5% on a specific quota.

In Australia, the trend has led to multiplying by four times the 13,000 ton capacity of the formerly uneconomical smelter to reach a capacity of 53,000 tons. In China (Taiwan), the high-cost smelter has recently been doubled in capacity to about 20,000 tons. Likewise, there has been a trend all over the world to modernize existing smelters by replacing older "pots" with more modern pots with larger capacity. This took place in Japan a few years ago and is still taking place in the United States of America. One of the most modern and most economical aluminium smelters in the world is the 100,000-ton plant in southern France at Nogueres, substantially completed in 1962. This smelter was built by Pechiney, a French company. This company is now participating with two companies in the United States of America to build a 67,000-ton smelter in the United States that should be able to compete with the lowest cost aluminium produced anywhere in the world.

Other modern plants are smaller than these. In 1963, a plant with a capacity of 20,000 tons was completed in Mexico by the Aluminum Company of America, with a market protected by the Mexican Government. A plant with a capacity of 40,000 tons is being completed in 1964 by the same company in Australia, again with a protected market. This company is also building a plant in Surinam, to be completed in 1966 with about 60,000 tons of capacity, operating under the partial protection of the European Common Market. It is thus evident that the appropriate capacity of an aluminium smelter is affected by both the size of the market it serves and the degree of protection it receives from the Government. Yet, whether such protection is permanent or temporary, the most desirable objective for any country is to obtain the lowest production cost. The 100,000-ton size is considered the optimum level by some companies, particularly if no trade protection is obtained. The new smelter being built in Ghana is of this size.

B. Investments for a smelter with 100,000-ton capacity

For such a plant, if built in the United States of America, the requirements of materials, labour, electricity and investment are illustrated in table 23. This enterprise includes an assumed bauxite mine in the Caribbean area, an alumina plant, a smelter and an associated electric power-plant.

Table 23. Approximate requirements for aluminium smelter with capacity of 100,000 tons, United States of America, 1964

Materials and energy	*Per ton of aluminium*	*Total for 100,000 tons*
Bauxite, tons	4 to 5	400,000 to 500,000
Conversion of bauxite to alumina		
Caustic soda, tons	0.076	7,600
Fuel oil, tons	0.613	61,300
Electricity	400 kWh	5,000 kW
Conversion of alumina to aluminium		
Alumina, tons	1.9	190,000
Carbon electrodes, tons	.55	55,000
Cryolite and aluminium fluoride, tons	0.04–0.06	4,000–6,000
Electricity	16,500 – 17,500 kWh	200,000 kW
Labour		
Bauxite, 400,000 to 500,000 tons		
Men per annum		200 to 300
Alumina plant, 190,000 tons		
Men per annum		700 to 800
Aluminium smelter		
Man-hours	17	
Men per annum		850
Total employment		17,50 to 1,950
Investment (dollars)		
Bauxite: Exploration, mine, roads, equipment, ocean pier, housing for workers	160.00	16,000,000
Alumina plant	300.00	30,000,000
Aluminium smelter	700.00	70,000,000
Power-plant[a]	237.50	24,000,000
Total investment	1,397.50	140,000,000

[a] Based on $125 per kW in a 500,000-kW thermal power-plant, shared with a public utility.

Certain features of this schedule are very striking. The investment in the integrated enterprise is very great, about $140 million. But it offers employment to less than 2,000 persons. This is an investment of nearly $70,000 for each job. The same total investment in aluminium fabrication and other manufacturing industries, as well as in agriculture, would create thousands of jobs.

Another striking feature of the schedule shown in table 23 is that to produce 100,000 tons of aluminium, it is necessary to use between 400,000 and 500,000 tons of bauxite. To obtain such a quantity of bauxite, most companies explore and develop their own bauxite concessions. In underdeveloped regions, particularly in the tropics where most bauxite is found, the companies build railroads, roads for trucks, housing for employees and port facilities in order to ship out the bauxite. Such large bauxite needs are of great interest to countries possessing bauxite, for it gives them a basis for obtaining important revenues merely from supplying the ore of the aluminium industry, even if they have no other stages of the industry. The other raw materials shown in the table are needed in much smaller quantities and do not have the supply problems of bauxite.

Table 23 also shows that the investment in bauxite mines for an aluminium smelter of 100,000-ton capacity is only about $16 million of the total investment of $140 million. The remaining investments in alumina plant, smelter and power plant are each much larger. The power investment particularly calls for attention. Although it is shown as $24 million, it actually is part of a much larger power investment shared with a public utility in order to obtain a lower cost than if it were limited to the size merely to serve the aluminium plant. It is assumed here to be a fuel-burning plant. But if it were a hydroelectric plant, the investment might be double or more per unit of power.

Because power has been one of the leading costs in the production of crude aluminium, it has been well known in the history of the aluminium industry that most aluminium smelters have been located close to low-cost sources of electric power, rather than at bauxite mines, where such power has not often been available. This fact has recently influenced such countries as Australia and Ghana, which possess both bauxite and low cost power resources, in their efforts to attract aluminium industries. On the other hand, technological improvements in generating and transmitting electric power in the past twenty years have also allowed the location of aluminium smelters closer to large consuming markets, in order to save transportation costs. Recent developments in nuclear power for very large plants also will favour the location of aluminium plants close to large markets, but may also favour eventually the location of large smelters close to the bauxite resources.

C. Crude-aluminium cost elements

The importance of each element of cost in producing crude aluminium in a smelter of 100,000-ton capacity, assumed to be built in the United States of America in 1961, is illustrated in table 24. This table shows estimated costs at two geographical areas in which the aluminium industry of the United States of America has located substantial capacity in the past ten years. In one area, the Ohio River Valley, electric power is obtained for aluminium smelters from power-plants burning coal and located near the coal mines. In the other area, the Pacific North-west, hydroelectric power is obtained from the Government at a price that is slightly above the cost of production and transmission, a price with little profit. This schedule shows that the costs at the smelter and at the consuming market are not much different, whether cheaper hydroelectric power or more expensive thermal power is used, because the difference is made up by differences in transportation costs. The estimated costs at the smelter in the two regions are $318 per short ton and $332 per short ton, in each case close to 16 cents per pound. The largest cost element is alumina, nearly 30 per cent of the production cost of ingot. The second largest cost is electric power, 18 per cent of the cost of ingot in the Ohio Valley and 10 per cent in the Pacific North-west. The third largest cost is the combination of labour, management and supervision, and social security (old-age pensions and unemployment insurance). This amounts to 16 per cent in the Ohio Valley and also in the Pacific North-west. Transportation is also a major cost when it is segregated for the bauxite as well as for the alumina and for the delivery of the ingot to the processing plants. Adding the transport costs of 4 short tons of bauxite to the alumina plant from the Caribbean, at $1.80 to $6.00 per ton, depending upon the point of origin, the total transport cost of raw materials included in a ton of north-western ingot shipped to mid-western markets is more than $55 to $70, or more than 14 per cent to 20 per cent of the delivered cost of the metal.

Table 24. Estimated delivered costs to markets in United States of America of aluminium ingot from locations in the Ohio River Valley and the Pacific North-west, 1961 [a]

(Dollars per short ton of metal)

Cost item	*Ohio River Valley*	*Pacific North-west*
Alumina		
Production cost at Gulf Coast plant (1.9 tons per ton of metal at $50 per ton)	95.00	95.00
Transportation, barge to Ohio Valley (1.9 tons at $4.00 per ton)	7.60	
Rail transport to North-west (1.9 tons at $12.16 per ton)		23.10
Carbon electrodes and pot lining (0.55 ton)	38.00	38.00
Electrolyte (cryolite and aluminium fluorides)	15.00	15.00
Electric power (15,000 kWh)		
4.1 mills kWh, Ohio Valley (coal-based power)	61.50	
2.1 mills kWh, Pacific North-west (hydroelectric power, price from Federal Government)		32.00
Direct labour (13 man-hours at $3.44)	44.72	44.72
Management and supervision	6.00	6.00
Social security (3.3% of labour costs)	1.69	1.69
Local taxes and insurance	6.00	6.00
Repairs and maintenance	9.00	9.00
Interest at 6% on borrowed capital, one-half of $600 per ton, and depreciation at 5% on $600 per ton investment	48.00	48.00
TOTAL COSTS AT THE SMELTER	332.51	318.51
Add freight to markets:		
Ohio Valley to eastern and mid-western markets, truck and rail, average	4.00	
Pacific North-west to mid-western markets by rail		24.00
TOTAL DELIVERED COST TO MARKET	336.51	342.51

SOURCE: United States of America, Senate Committee on Public Works, *The Market for Rampart Power, Yukon River, Alaska* (Washington, D.C., 1962), pp. 155-156.

[a] Assumed smelter capacity of 100,000 tons per annum with an integrated operation.

In other countries, the schedule of the costs of producing crude aluminium will differ in each detail, but in most cases the same relationships will generally hold. Table 25 shows costs in India for two very small smelters operated by competing companies in 1957. The production of one company was only 2,310 long tons at a cost of $510 per ton or 22.8 cents per pound. Power and fuel together cost 26 per cent of the total. Alumina was 17 per cent. Labour was 3 per cent, but was evidently reported in a different manner than the cost figures given in table 24 for the United States of America. The second Indian company showed alumina as the highest cost item, accounting for 19 per cent of the total. Power and fuel were next with 14 per cent, and labour was 4 per cent. Each company also reported large head-office expenses, an item not shown in the cost estimates for the plant in United States of America.

It is also interesting to compare the investment in a small aluminium enterprise in India with the $140 million required in the United States of America for an integrated company with an assumed capacity of 100,000 tons. The Indian Aluminium Company Limited in 1957 had an integrated enterprise producing its own bauxite, alumina and ingot, but also sheets and circles, extrusions and paste for aluminium paint. The ingot capacity was about 5,500 long tons, and the alumina capacity of 14,000 tons was somewhat in excess of needs, owing to expansion under way in a new smelter. The rolling mill produced about 7,300 tons of rolled products. The original investment cost of the entire integrated operation, excluding new capacity under construction, was about $9.4 million built up since the beginning of the Second World War.

Table 25. Production costs in India of alumina and ingot, 1957

(Rupees per long ton)

Cost item	*Aluminium Corp. of India*	*Indian Aluminium Company*
Alumina		
Production (long tons)	4,527	14,060
Total costs without depreciation (including freight to smelter for Indian Aluminium Company) (rupees)	423.17	410.18
Dollar equivalent[a]	89	86
Aluminium ingot		
Production (long tons)	2,310	5,465
Costs (rupees)		
Raw materials	1,122.73	1,132.57
Power and fuel	645.11	297.54
Labour	84.23	88.54
Repairs, maintenance, consumable stores	82.64	83.42
Pot-lining expenses	76.28	33.25
Other overheads, less credit	72.77	119.17
Royalty	6.68	
Head-office expenses	112.17	190.84
Depreciation	234.35	186.27
TOTAL	2,436.96	2,131.60
Dollar equivalent[a]	510	446
Cents per pound	22.8	19.9

SOURCE: Government of India, Tariff Commission, *Report on the Continuance of Protection to the Aluminium Industry* (Bombay, 1958).

[a] Based on the following exchange rate: Rs. 4.78 = $1.00.

It is likewise interesting to compare employment of around 1,500 persons in the rolling-mill of the Indian Aluminium Company in 1958 (producing in that year 8,800 long tons of rolled products) with the less than 2,000 persons required in the United States of America for the assumed integrated aluminium enterprise from bauxite through ingot, with a capacity of 100,000 tons per annum. As pointed out in the United Nations document, "Pre-investment data in the aluminium industry" (ST/ECLA/CONF.11/L.24, pp. 37-38), a modern rolling-mill with 10,000 tons of capacity would cost between $8 million and $12 million in the United States of America, and one using a new direct-casting sheet process might cost between $4 million and $8 million. Furthermore, a small extrusion plant would cost about $1.5 million and a small plant producing kitchen utensils and similar products, about $400,000. Thus, it would be possible to build a combined rolling-mill, extrusion plant and utensil plant with a capacity of 10,000 tons of mixed products for between $6 million and $10 million, using cost standards of the United States of America, and employ in such a combined plant as many as 1,000 or more workers. The same $140 million required for an integrated ingot enterprise in the United States of America, employing less than 2,000 persons, could be invested in such fabricating plants in each of fourteen to twenty-three developing countries and might employ in these countries between 15,000 and 25,000 workers.

III. Semi-fabricating plants

For aluminium semi-fabricating plants, it is not practical to present a simple schedule of capacity and production costs that is comparable to schedules for alumina plants and smelters. The range of capacities of semi-fabricating plants varies first according to the number of hours used per day and the days per annum. Alumina plants and smelters produce twenty-four hours per day, 365 days per annum, although portions of plants are shut down at times. The products of many semi-fabricating plants are not limited and uniform, as are alumina and ingot. Different combinations of products may be made in some plants at one time, and the combinations can change during the same working year. Different kinds of equipment can be used to achieve similar results. The new technologies of continuous casting to make sheet and rod require a much lower investment cost than do older methods for products within certain limitations of size and character. Furthermore, in both industrialized and developing countries, when markets for aluminium products are local or begin at a small volume, an aluminium fabricating plant may begin with a very small shop, a few pieces of equipment and a few employees. With an investment of between $50,000 and $300,000, a small shop may produce some of the products of a multimillion dollar plant, such as kitchen utensils or window and door assemblies. Such a shop would purchase the stock of metal shapes that a more integrated plant would first make. Some plants may use older equipment purchased from more industrialized countries, or assemblies of old and newer equipment. The amount of labour required would vary according to the degree of plant modernization and the importance of hourly labour costs.

As a rough guide, table 26 shows the capacities, investment and employment for different types and sizes of semi-fabricating plants in the United States of America, for one plant in Colombia and one small plant in Venezuela. The schedule given in table 26 shows a vast range between a rolling-mill with an annual capacity of 185,000 short tons of products (United States of America) to a mill in Colombia with a sheet capacity of less than 2,000 tons per annum (plus extrusions). A world directory of many semi-fabricating plants shows that the developing countries have a far greater proportion of plants with capacities below 2,000 tons per annum than do the developed countries (see table 27). Consequently, many of the opportunities in the developing countries begin with even smaller investments than those of the smallest plants shown in table 26.

Table 26. Requirements for aluminium semi-fabricating plants

Plant and products	*Capacity (tons per annum)*	*Investment per ton (dollars)*	*Total investment (dollars)*	*Total employment*
***Estimates, new plants** (United States of America)*				
Rolling-mill for sheet and finished products (casting foundry, hot mills, cold mills, heat treatment and finished sheet products — corrugated, painted, printed, cut and shaped), estimate	100,000 to 200,000	1,000 to 6,000	60,000,000 to 120,000,000	
Rolling-mill, continuous casting, milling, finishing	5,000 to 30,000	400 to 800	4,000,000 to 12,000,000	
Extrusion plant	2,500 to 5,000	600	1,500,000 to 3,000,000	
Kitchen utensils and hollow ware			400,000 to 800,000	
***Actual plants** (United States of America)*				
Rolling-mill (foundry, hot and cold mills, coiling, slitting, levelling, foil); products include foil, disposable dishes, food containers, utensils, housewares, toys, aluminium boats and roofing sheet, Mirro Aluminum Co. Manitowoc, Wisconsin, built 1958/1959	27,000	360	12,000,000	
Rolling-mill (plate and sheet products); to be built by Harvey Aluminum Inc. in Kentucky, 1966	54,000	1,000	54,000,000	
Rolling-mill (plate and sheet product); owned by Reynolds Metals Co., McCook, Illinois, built during Second World War	185,000			2,800
Extrusion plant (extrusions, tubing, windows); owned by Reynolds Metals Co., Louisville, Kentucky, built 1943	6,500			450
Extrusion plant (extrusions, tubing, pipe); owned by Reynolds Metals Co., Grand Rapids, Michigan, built during Second World War	14,500			400
Extrusion plant (extrusions, pipe, tubing, fabricated parts); owned by Reynolds Metals Co., Bellwood, Virginia, built 1956	19,000			525
Extrusion and foil plant (extrusions, foil containers, wrapping foil, printed foil); owned by Reynolds Metals Co., Torrance, California	1,500 foil, 5,600 extrusions			70

Table 26. Requirements for aluminium semi-fabricating plants (*continued*)

Plant and product	*Capacity (tons per annum)*	*Investment per ton (dollars)*	*Total investment (dollars)*	*Total employment*
Other plants				
Sheet (cold-rolling and extrusion — petroleum pipe, irrigation pipe, sheet for roofing, siding, transportation vehicles, extrusions): Alcan of Colombia, Cali, Colombia, constructed 1960-1962	1,800 sheet plus extrusions		2,000,000	150
Combination extrusion and window-door plant, built 1954-1959 in Maracaibo, Venezuela; two buildings leased				
Extrusions	1,500	200	300,000	
Windows, doors and other products	2,000	140	280,000[a]	62

SOURCES: Individual companies, and Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

[a] Equipment only.

Table 27. Annual capacities of semi-fabricating aluminium plants, selected countries, 1962

(*Tons*)

Area and country	*Capacity not stated*	Number of plants reported in each capacity category: *Below [illegible]*	*[illegible]*	*[illegible]*	*[illegible]*	*[illegible]*	*Over [illegible]*	*Total number of plants*
North America								
Canada	16				3	1	6	26
United States of America	73			—	—	—	62	135
Latin America								
Argentina	—	4	4	2	1	2	1	14
Brasil	1	1	1	3	2	1	1	10
Chile	1	—	1	1	—	—	—	3
Colombia	2	—	—	1	2	—	—	5
Cuba	2	—	—	—	—	—	—	2
El Salvador	—	—	1	—	—	—	—	1
Mexico	4	—	2	1	1	1	1	10
Peru	1	—	—	—	—	—	—	1
Uruguay	2	—	—	—	1	—	—	3
Venezuela	—	—	1	—	—	1	1	3
Europe								
Austria	9	—	—	1	1	2	3	16
Belgium	7	—	1	3	1	2	3	17
Denmark	2	—	—	—	—	—	1	3
Eastern Germany	4	—	—	—	—	2	—	6
Federal Republic of Germany	34	—	1	—	4	3	9	51
Finland	3	—	—	—	1	—	—	4
France	33	—	—	—	1	2	3	39
Greece	2	—	—	—	1	—	1	4
Hungary	2	—	—	1	—	1	2	6
Ireland	1	—	—	—	—	1	—	2
Italy	17	6	1	7	2	3	3	39
Netherlands	3	—	—	1	—	1	1	6
Norway	3	—	—	1	—	—	1	5
Portugal	1	—	—	—	—	—	—	1
Poland	1	—	—	—	—	—	2	3

Table 27. Annual capacities of semi-fabricating aluminium plants, selected countries, 1962 (*continued*)
(*Tons*)

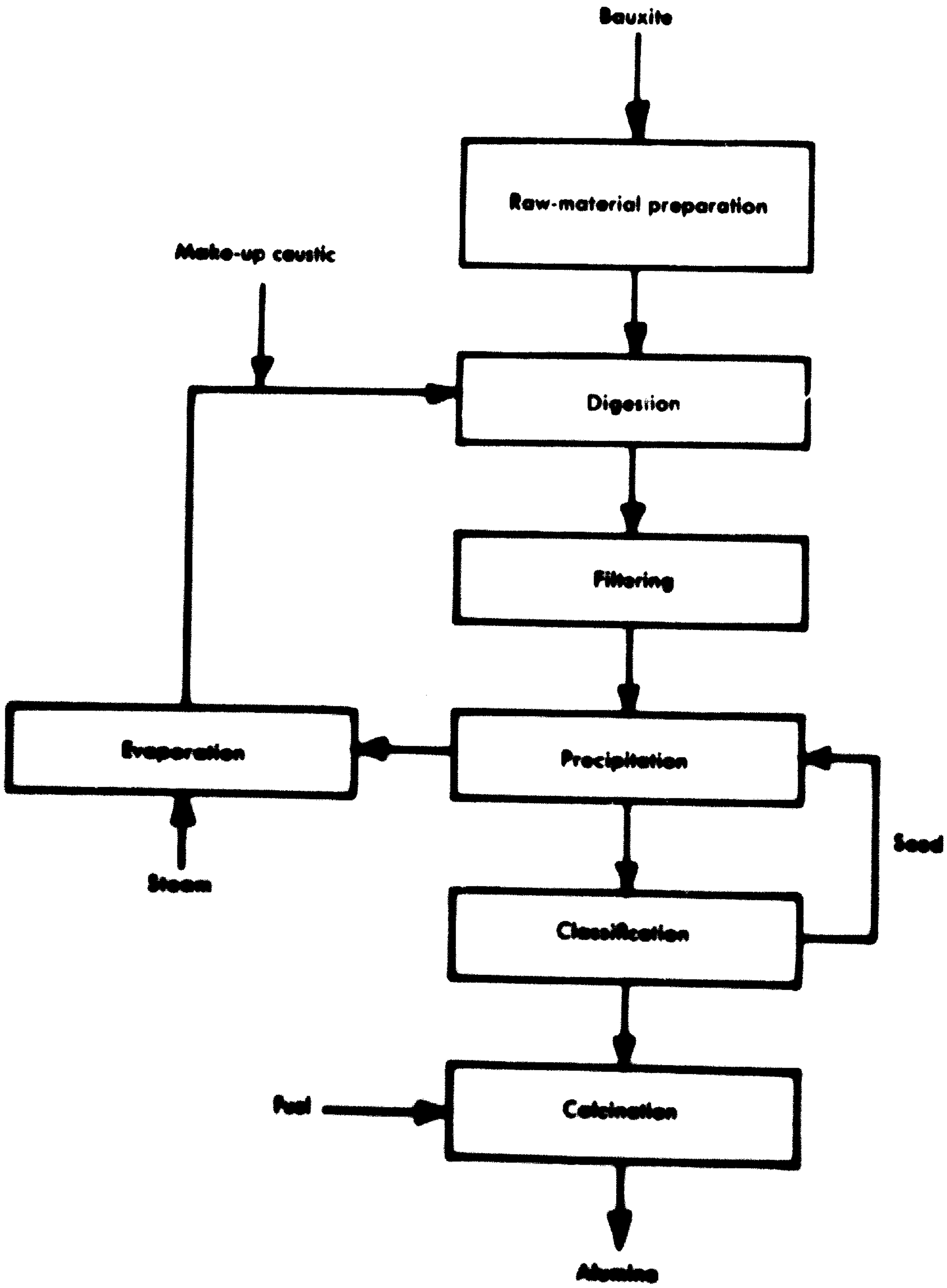
Area and country	*Capacity not stated*	*Number of plants reported in each capacity category* *Below 500*	*500-999*	*1 000-1 999*	*2 000-4 999*	*5 000-9 999*	*Over 9 999*	*Total number of plants*
Spain	6	1				1	2	10
Sweden	5		1	1			3	10
Switzerland	10						2	12
United Kingdom	16			2	6	1	9	34
Yugoslavia	4			—	1	1	1	7
Africa								
Algeria	4							4
Congo (Democratic Republic of)	—	1						1
Ghana		1						1
Ivory Coast	—	1	—					1
Kenya	—	—	—	—	1			1
Nigeria	—					1		1
South Africa	4					1	1	6
United Arab Republic (Egypt)	2		—	—	1			3
United Republic of Tanzania	—		—			1		1
Asia								
Ceylon	1							1
China (Taiwan)	—	—	—	—			1	1
Hong Kong	2	—	—	1				3
India	22	—	3		8	1	2	36
Indonesia	—	—	—	—	1			1
Iran	—		1					1
Israel	5	—	—	—	1			6
Japan	6	6	7	7	6	1	9	42
Lebanon	2	—	—	—				2
Malaysia	—	—	—	—	1			1
Pakistan	1	3	—	1	—		—	5
Philippines	—	—	—	—	—	1		1
Republic of Korea	—	2	1		—			3
Thailand	—	—	—	1	—	1	—	2
Turkey	2	—	—	—	—	—	—	2
Australia-New Zealand	5	—	2	3	4	2	2	18
Total: Latin America, Africa and Asia	64	19	22	18	30	12	17	178
Total: North America and Europe	232	7	4	17	21	21	114	416
World total	321	26	26	35	51	33	131	632

Source: Compiled from directory of *Metal Bulletin* (London), Aluminium issue (December 1963).

The newer technologies of direct casting of rod and bar, and of strip permit the production of wire and wire products, and of sheet products up to moderate widths without certain large investments and heavy equipment needed in the older mills. These newer processes eliminate large melting-furnaces and large rolling-mills to reduce heavy ingots to intermediate shapes. It is thus possible to build a rolling-mill with a capacity of 5,000 tons, using a continuous casting process to produce the strip to be rolled, for about $4 million in the United States of America, and less in some foreign countries. Such a mill can make products for limited markets in developing countries at low cost, being competitive with a much larger investment in a conventional mill with a greater capacity for more diversified products.

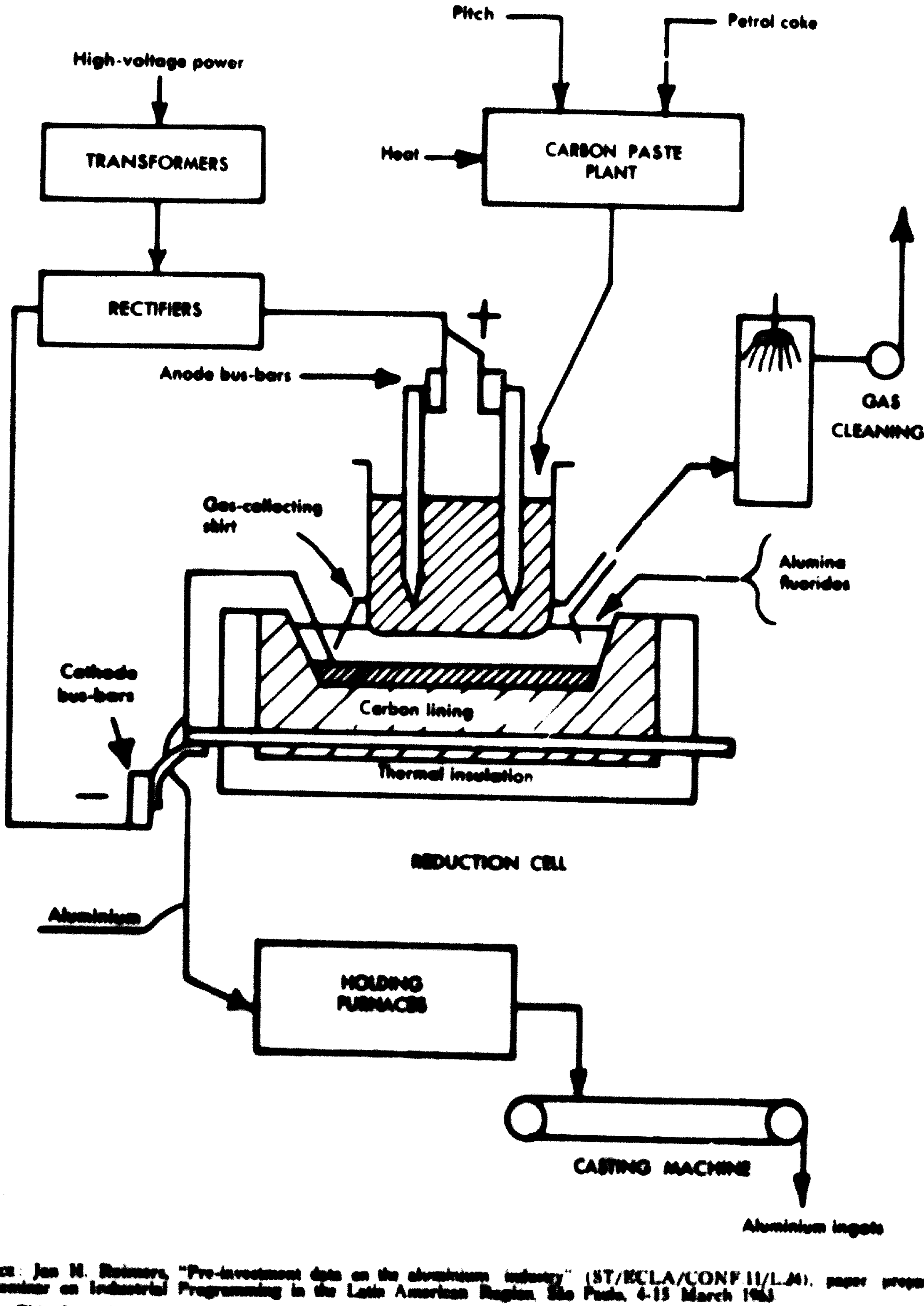
The processes in producing alumina, ingot and fabricated products are illustrated in the following figures. Figure II shows the steps in converting bauxite to alumina; figure III, the steps in converting alumina into ingot in the electrolytic cell; and figure IV, the steps in converting the primary ingot, scrap and alloying metals into various fabricated products. The relationship between unit investment and capacity in an alumina plant is shown in figure V, and the relation of capital cost per unit of ingot capacity to size of the reduction plant is shown in figure VI.

Figure II. Flow sheet of Bayer alumina process



Source: Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.20), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

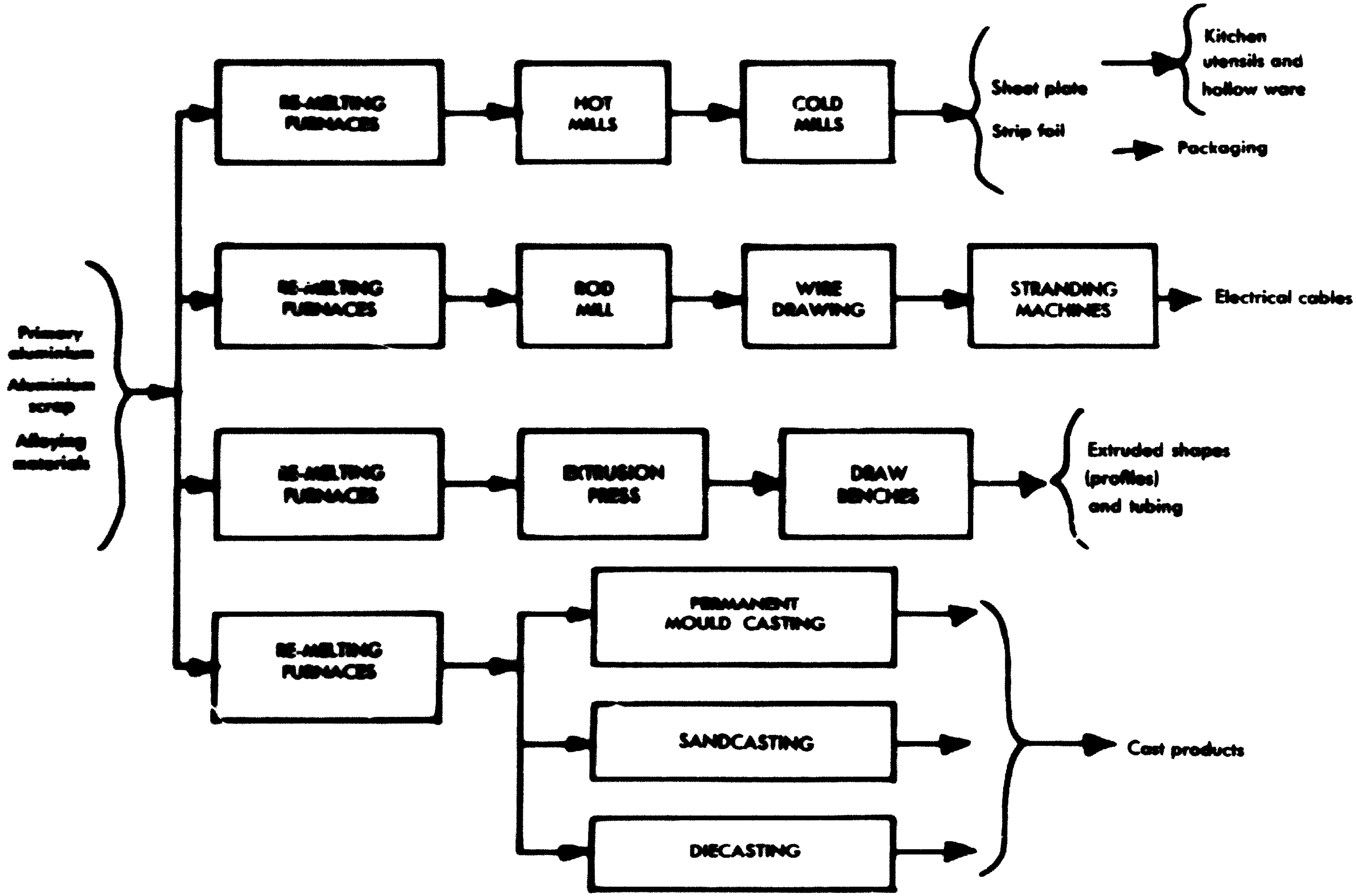
Figure III. Electrolytic aluminium reduction process



SOURCE: Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

NOTE: This flow sheet is based on the Soderberg system.

Figure IV. General flow sheet of aluminium fabrication



SOURCE: Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963 aluminium products.* In the present version, emphasis is shifted to Africa as a whole. Some references to East Africa are retained but are only incidental.

The maximum possibilities of developing the aluminium industry in Africa are currently not assured. They will become more definite with growth in economic co-operation between Governments to secure improvements in transportation, agriculture and mineral and energy development, and with the establishment of conditions more favourable for capital investment.

It is well recognized that Africa has the essential resources of bauxite and electric-power potential, and strategic location needed to become a world leader in the production of crude aluminium for exportation to industrialized countries. But as a current and prospective consumer of aluminium, Africa has been at the bottom of the list of world regions. This situation could change dramatically if African countries would join their ambitions and resources into effective programmes.

Africa has 33 per cent of the world's bauxite resources, but it mines only about 6 per cent of the world output; it has also 32 per cent of the world's high-grade hydroelectric potential, but only 2 per cent of the developed hydroelectric capacity; and 9 per cent of the world's population, but less than 1 per cent of the world consumption of aluminium.

The current and proposed aluminium smelter capacity in Africa, if fulfilled, would give the continent about 12 per cent of the world capacity. But such a development would be principally for export markets.

In 1960, the average *per capita* aluminium consumption in Africa was about two-tenths of a pound per year. It was much greater in other less developed regions and far greater in developed nations.

The two questions facing African Governments are: (*a*) how much they will supply of the anticipated growth in world demand for aluminium; and (*b*) what they can accomplish in stimulating their own aluminium consumption.

Because of the high capital requirements for primary aluminium production, it is important for African countries not having ample outside sources of capital to examine critically what stages of the industry they should develop.

Aluminium is a young industry, commercially accepted on a wide scale for barely twenty years and concentrated in the industrialized countries. But many African countries already have small factories producing aluminium utensils and roofing sheets.

Since the Second World War, one African country —Cameroon—has become a primary aluminium producer. Another—Ghana—is about to become a producer; and five countries—Angola, Congo (Brazzaville), Congo (Democratic Republic of), Guinea and the United Arab Republic—have been hoping to become producers.

Over sixty years, 1900-1960, the world aluminium production has doubled every seven years, but the rate of growth has slowed down. Even so, the production of 6.1 million short tons in 1963 is expected to double again by 1975-1980, and to double once more by 1990-2000. Such ultimate expansion will require additional annual world outputs of 90 million long tons of bauxite, 36 million short tons of alumina, 18 million short tons of aluminium and a new firm power capacity of 33 million kilowatts.

While Africa can contribute to these requirements, other countries also have bauxite and energy resources, and, in addition, the capital, conditions favourable for investment and technical and administrative personnel lacking in Africa.

The world aluminium industry is concentrated in a few private enterprises and government enterprises with which African countries must make arrangements, especially for access to markets for bauxite, alumina and ingot. Cameroon, Ghana and Guinea have made such arrangements.

Because of the reduced importance of low-cost power for locating smelters, those African countries hoping to have their power resources developed for aluminium with outside help should recognize that they must compete with other countries which use economic and political encouragements to attract the aluminium industry.

The trend is upwards in African consumption of aluminium, but it was, nevertheless, only about 51,000 tons in 1963 for the entire continent and only 6,500 tons in East Africa (including the Sudan). Southern Africa consumed 18,000 tons, one-third of the continental total, as did Western Africa; North Africa used 9,000 tons.

There are at least forty-four aluminium fabricating plants in Africa. The principal products of most plants are utensils and building sheet, made from imported ingot and sheet. For all imported aluminium, Africa spent about $36 million in 1963. Such imports will decrease to the extent that aluminium fabrication is encouraged.

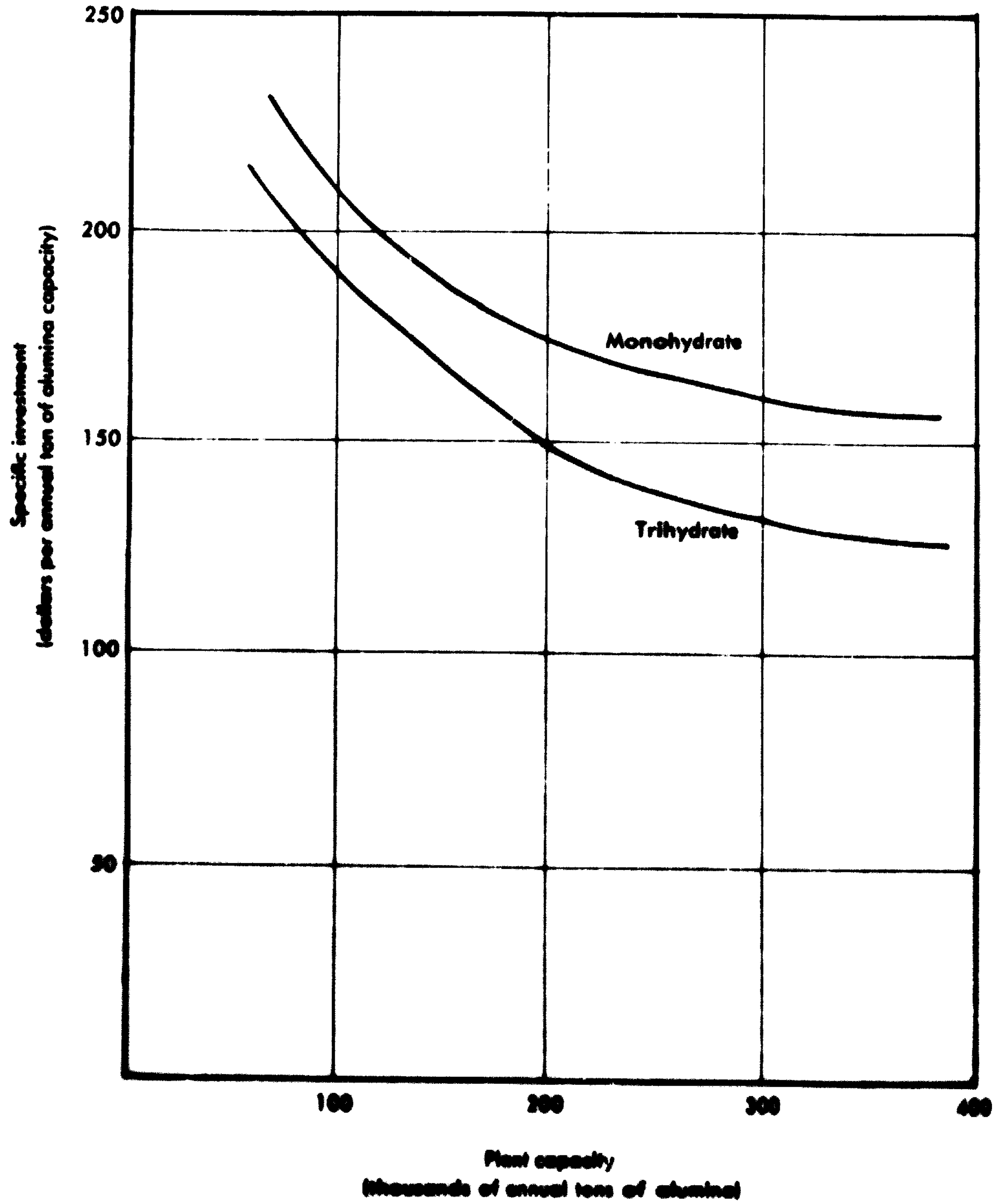
The pattern and rate of growth of aluminium consumption in Africa are affected by certain differences in African conditions, compared with those of industrial countries. These are, particularly, the low productivity of agriculture and industry, widespread disease and malnutrition, the prevalence of subsistence farming, the low literacy rate, some fifty separate political jurisdictions spread over a vast land area lacking in sufficient and economical internal transportation facilities and the long distances between urban centres.

Plans of African countries to improve conditions are not sufficient to justify confident projections of aluminium consumption. The anticipated growth of population and gross domestic product may suggest minimum projections of continental consumption by 1980 of between 75,000 and 114,000 tons. Production of primary aluminium now assured in Africa by 1980 already greatly exceeds such projections.

But opportunities for the use of aluminium in Africa could lead to much greater consumption levels. These offer room for government programmes to encourage uses where aluminium will help reduce imports of less essential goods, conserve on foreign exchange and make better use of limited domestic capital resources. The opportunities also are for aluminium to make important contributions in agriculture, food preservation, sanitation, health, transport, housing, electrification and national well-being.

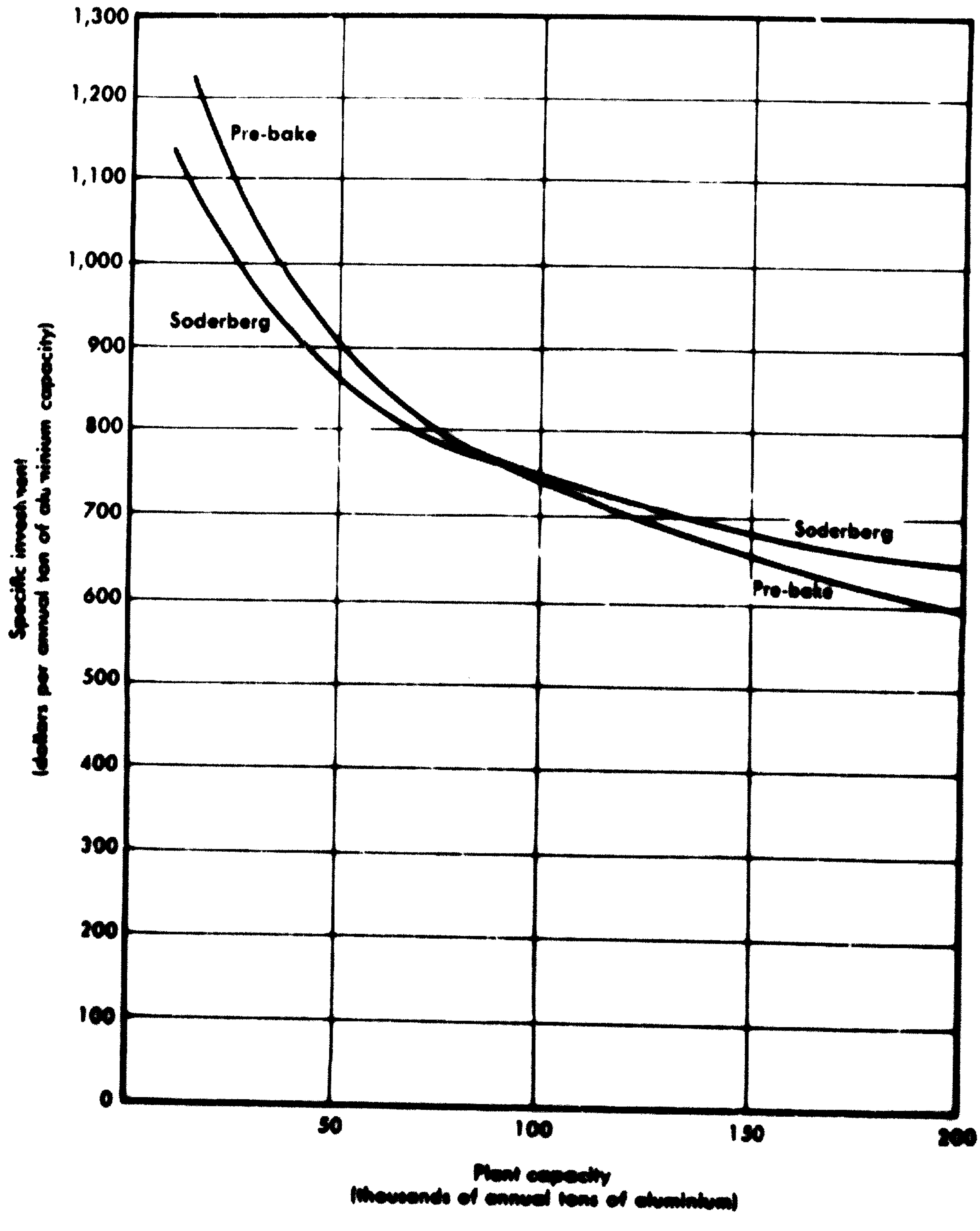
* See "East Africa and the aluminium industry: a pre-feasibility study" (E/CN.14/INR/100), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965.

Figure V. Capital cost of Bayer process alumina plants, for monohydrate and trihydrate bauxites



Source: Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

Figure VI. Capital cost of aluminium reduction plants: pre-bake and Soderberg anode systems



SOURCE: Jan H. Reimers, "Pre-investment data on the aluminium industry" (ST/ECLA/CONF.11/L.24), paper prepared for the Seminar on Industrial Programming in the Latin American Region, São Paulo, 4-15 March 1963.

ANNEX IV

Bauxite in developing countries[a]

During the period 1939-1962 world bauxite production multiplied seven times in keeping pace with aluminium production. This was possible only because of the vast bauxite deposits of the developing countries. Bauxite production in this period advanced from 4.3 million to 30.5 million tons. The following countries in the less industrialized group made the largest bauxite contributions in 1962.

Table 28. Bauxite production, selected developing countries, 1962

(Tons)

Jamaica	7,583,000
Surinam	3,256,000
British Guiana	2,744,000
Guinea	1,375,000
Greece	1,005,000
Dominican Republic	720,000
India	575,000
Indonesia	494,000
Haiti	445,000
Malaya	356,000
Ghana	288,000
Sarawak	229,000
TOTAL	19,080,000

This group of twelve countries contributed 63 per cent of the world bauxite production. Only one of them, India, also produced crude aluminium, and then only less than 1 per cent of the world supply. In Guinea and Jamaica, much of the bauxite was converted into alumina for exportation. In other words, this group of countries supported the aluminium industries of the more industrialized countries. Some of the latter had no bauxite resources, e.g., the Federal Republic of Germany, Japan, Norway and the United Kingdom of Great Britain and Northern Ireland. Others did not have enough of their own ores to supply all the needs of their aluminium industries—Italy, the Union of Soviet Socialist Republics and the United States of America. How bauxite moved between the producing and the consuming countries and the production of all countries are shown for 1961 in table 29.

It is only recently that some of the developing countries have become bauxite producers. Jamaica, now the leader, contributing about one-fourth of the world bauxite production, was not even known to have bauxite until 1942, and the first production did not begin until 1952. The discoveries of bauxite in the Dominican Republic and in Haiti likewise took place early in the 1940's and production began in the 1950's. Guinea and Sarawak did not produce important amounts of bauxite until a few years ago. Furthermore, it was not until after 1955 that the vast deposits of Australia and Guinea were recognized and substantial additional deposits were found in British Guiana, Cameroon, India and Surinam. Between 1950 and 1963, the world reserves of bauxite increased nearly four times, despite the production of this period. Exploration for bauxite has been intense throughout the world since the Second World War. Additional important discoveries may be expected in some tropical countries, particularly after political conditions become stabilized. The latest estimates of world bauxite reserves are given in annex I, table 13.

In view of the prospects for the industrialized countries to depend even more upon developing countries for bauxite, it is useful to consider what bauxite has meant to some of these countries and what policies they are following. In Africa, Ghana, Guinea and Sierra Leone are of interest. Ghana became independent of the United Kingdom in 1957; Guinea, independent of France in 1958; and Sierra Leone, independent within the British Commonwealth in 1961. In the Caribbean area, British Guiana, Jamaica and Surinam are the largest bauxite producers. Surinam is a colony of the Netherlands. British Guiana has been promised independence by the United Kingdom.[b] Jamaica obtained independence within the British Commonwealth in 1962. Australia is of special interest because of the recent recognition that it combines the largest known bauxite reserves in the world with political security and a promotional attitude of the Government towards stimulating private enterprise to build a major integrated aluminium industry to serve export markets.

I. Africa

A. GHANA

At the current time, Ghana has a very small bauxite industry, but the Government wants the industry to increase substantially as part of the combined Volta hydroelectric and aluminium project. Bauxite has been produced in Ghana since 1940 by the British Aluminium Company of the United Kingdom. The bauxite reserves are the same size or greater than those of many other bauxite-producing countries, including British Guiana, Dominican Republic, Haiti, Hungary, Surinam and Yugoslavia. Nevertheless, bauxite production in Ghana has been consistently smaller than in these other countries. One reason has been the distance of most deposits in Ghana of 80 to 100 miles from the sea-coast, whereas the deposits of the other countries have been more economically located for their markets.

In 1962, bauxite exports from Ghana were close to 300,000 long tons, valued at nearly $2 million. Employment in the industry is very small, a few hundred out of total national registered employment over 300,000 persons in a population of about 7 million. The value of bauxite exports has been less than 1 per cent of all exports and hence a negligible contribution to the gross national product.

The actual bauxite reserves of Ghana may be much greater than those thus far reported. The Government has sponsored geological explorations and since 1962 has had the assistance of technicians from the Soviet Union and from the Peace Corps of the United States of America. The preliminary reports on these explorations indicate reserves may be more than double the previous estimates.

The limited production of bauxite by the British Aluminium Company has contributed little revenue to the Government. The company obtained its two bauxite concessions under the previous British Colonial Government of the Gold Coast. These concessions run for ninety-nine years and expire in the years 2033 and 2043. No revenues from bauxite were obtained by the Government until 1958, when payments on income tax, minerals duty and land rent were $0.24 per ton. In 1960, the payments had risen to $0.42 per ton. No royalties were paid, and only the ordinary income tax applied. A small bauxite operation like that in Ghana, requiring a long railroad haul, cannot be very profitable.

Ghanaian bauxite, however, is to become much more important as a result of policies adopted by the Government in connexion with developing the aluminium industry along with the Volta hydroelectric project. A study of this development in 1953 looked forward to using Ghanaian bauxite. The project was finally committed late in 1961 with financial assistance from the International Bank for Reconstruction and Development (IBRD) and the Governments of the United Kingdom and the United States of America. Under the agreement entered with the Volta Aluminium Company (controlled by interests in the United States of America), within ten years from the time the new aluminium smelter operates, the Company is to produce

[a] This annex is revised from a portion of "Aluminium industry case study", prepared by the writer for use in a seminar of the Economic Development Institute, International Bank for Reconstruction and Development, Washington, D.C., August 1964.

[b] British Guiana obtained independence in 1966 and is now the independent State of Guyana.

Table 29. Production and trade of bauxite in 1961, by major countries
(Thousands of long tons)

		Exports, by country of destination											
			North America		Europe						Asia		
Area and country	*Production*	*Total*	*Canada*	*United States*	*France*	*Fed. Rep. of Germany*	*Italy*	*USSR*[a]	*United Kingdom*	*Others*	*Japan*	*Australia*	*All other countries*
North America													
Dominican Republic	701	856		856									
Haiti	263	289[b]		289[b]									
Jamaica	6,663	4,975		4,975									
United States of America	1,228	151	108		18	c	c	21	1	c	c		3
South America													
Brazil	96	2											2
British Guiana	2,374	1,606	875	506	17	25	18		44	49	20		52
Surinam	3,351	3,352	264	2,917	8	108[d]	1		3	41			10
Europe													
Austria	18	8				8							
Federal Republic of Germany	4	c								c			c
France	2,155	252				130	7		104	6			5
Greece	1,100	1,034			38[d]	402		448	57	64			25
Hungary	1,337	699				87[d]		612					
Italy	318												
Romania	68	33						33					
Spain	6												
USSR	4,000[e]	f											
Yugoslavia	1,213	915			39	650	182	40		4			
Asia													
China (mainland) (diaspore)	400[e]	f											
Federation of Malaya	410	284								4	260	10	10
India	468	99				9	18[d]		c		62	9	1
Indonesia	413	423									423		
Pakistan	1												
Sarawak	253	256									220		36
Africa													
Ghana	196[g]	196							196				
Guinea	1,739	346	208	57		76[d]		5					
Mozambique	5	f											
Oceania, Australia	26	30									30		
WORLD TOTAL	28,805[h]	15,806	1,455	9,600	120	1,495	226	1,159	405	168	1,015	19	144

SOURCE: United States of America, Bureau of Mines, *Minerals Yearbook, 1962*, chapter on bauxite.
[a] Union of Soviet Socialist Republics and the centrally planned economies of Eastern Europe.
[b] Imports by United States of America.
[c] Less than 500 tons.
[d] Imports.
[e] Estimate.
[f] Data not available.
[g] Exports.
[h] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

alumina in Ghana from domestic bauxite or, otherwise, to pay the Government an extra charge on imported alumina. At that time, probably by the year 1977, the expectation is that the production of bauxite in Ghana will more than double from recent levels because the initial capacity of the smelter, about 100,000 tons of metal per annum, will require about 400,000 tons of bauxite per annum. The Government has agreed to approve the necessary bauxite concessions. In 1962, the Government cancelled five private bauxite concessions that were not being worked, and the National Assembly passed a bill vesting ownership and control of minerals in the President. The ultimate gains to the Government from bauxite development may depend primarily upon the benefits obtained from the development of the aluminium industry.

B. SIERRA LEONE

Sierra Leone is a small developing country in which even a limited kind of mineral development is desirable. The population is about 2.2 million, supporting itself mainly from subsistence agriculture. The value of the gross national product is not reported, but exports in 1961 were valued at $70 million. The largest item was diamonds ($45 million), followed by iron-ore ($12 million). To stimulate new enterprise, tax and customs concessions are offered. Bauxite had been known in Sierra Leone since 1920, but mining did not begin until 1963. The only producer is a subsidiary of the Swiss Aluminium Company. To encourage this development, the Government granted an income-tax holiday for five to eight years and exemption from export and import duties under a concession that can run for at least thirty years. At first, the Company will pay the Government a royalty of $0.21 per ton of bauxite. Since the production in the near future is expected to be only about 200,000 tons per annum the direct revenues from bauxite will be small. At an approximate valuation not over $7 per ton, this level of exports will not materially increase the trade of the country. The Government itself investigated the original bauxite concession area, as well as additional bauxite reserves granted in the concessions to the Swiss company. To attract a small bauxite development in competition with other countries more favourably situated, the Government of Sierra Leone believed it was necessary to grant an income-tax holiday and to accept, at least at first, the quite limited revenues and employment benefits. In this policy, the Government was following the example of many other countries.

C. GUINEA

The most important bauxite developments in Africa may be taking place in Guinea, which has the largest high-grade bauxite deposits thus far discovered in the world, probably more than 20 per cent of the world reserves of all bauxite. Three different types of development have been arranged. One is a concession to a private consortium, the Company Fria, granted by the previous French Colonial Government, for the mining of bauxite and for conversion into alumina. Another is a Government-owned and operated bauxite mine on the Los Islands, based on properties taken when a concession to a private company was cancelled. The third is a partnership between the Guinean Government and a private company in the United States of America to develop the choicest deposits in the first arrangement of this kind in the world bauxite industry.

Bauxite in Guinea was known as early as 1912. The first significant mining was begun in 1952 by a subsidiary of Aluminium Limited of Canada, Bauxites du Midi. This took place on the Los Islands near the capital, Conakry. Production reached a level of 500,000 tons in 1955. Exploration by the company in north-west Guinea, in the Boké region, had disclosed the existence of very large and high-grade deposits. In exchange for seventy-five years concessions to develop these deposits the company agreed in 1957 with the French Colonial Government to mine at a level of 1.5 million tons per annum by 1963 and to produce alumina in a plant with a capacity of 220,000 tons, to be built by 1964. The company committed itself to a total programme, including a 75-mile railroad and a new port, at a cost of about $100 million. At the same time, the consortium of companies called Fria, led by the French aluminium producer, Pechiney, also obtained a seventy-five year bauxite concession in north-west Guinea by committing itself to build a 480,000-ton alumina plant. This project required construction of a 96-mile railroad, a town of 7,000 persons and a total investment of $150 million. Both the Boké and the Fria projects were committed to supply alumina for a smelter that the Colonial Government was encouraging a consortium of companies to build, along with a hydroelectric project on the Konkouré River of Guinea.

In 1958, the newly independent Republic of Guinea withdrew from the French community of former African colonies. The Government of France terminated assistance to Guinea, and plans for the hydroelectric and aluminium project were suspended. Guinea then assumed the obligations of the contracts for the Boké and Fria projects, and the Fria alumina plant went into production in 1960. In 1961, however, Aluminium Limited advised the Guinean Government that it could not meet the commitments to produce bauxite and alumina because of unsatisfactory conditions in the world aluminium industry. The Government cancelled the bauxite concessions and took over the properties, and also the mining properties on the Los Islands, after giving the company an extension of three months to try to arrange to resume under the original contract. The Government then sought to obtain new concessionnaires for the Boké resources, and operated the Los Islands project on a very limited basis with help from Hungary.

Various companies in Europe and in the United States of America made offers to the Government, which, finally, in October 1963, accepted a proposal of Harvey Aluminum, a company in the United States of America. Under this arrangement, the Government and Harvey became partners in a new bauxite company (Compagnie des Bauxites de Guinée), with Harvey having the controlling interest of 51 per cent. The Government will provide the investment of approximately $30 million for the railroad, the port and the town-site for government employees. Harvey will provide the investment for the mine, the railroad equipment, the bauxite-handling facilities and the employees' housing. Profits will be divided on the basis of 65 per cent to the Government and the balance to Harvey.

Unlike the operation of other privately controlled bauxite enterprises, this joint venture must sell bauxite to any competitors of Harvey and others. The Government restricts bauxite reserves of the north-west region for use of the joint venture, with the right to allocate concessions to other applicants if they cannot obtain from the joint venture all of the bauxite they want.

The government ownership of the railroad and port is designed to contribute to the general development of the country and to permit other commodities to move over these transportation channels. By contrast, the Fria railroad is only for use of the alumina company.

Because the Guinean economy is essentially based on subsistence agriculture for up to 90 per cent of the population of 3.2 million, the alumina and bauxite developments may make an important contribution to the country. Rough estimates of gross national product indicate about $261 million or $82 *per capita* in 1962. The value of the exported alumina was about 10 per cent of the gross national product. However, the portion of the value of the alumina paid in the country for labour and other services and goods, as well as that paid in taxes and other contributions to the Government, is not reported. The contribution in employment and income is clearly very small, but it is significant in relation to the earnings by Guinea of hard currency foreign exchange.

The Fria project was originally planned for an ultimate capacity of 1.2 million tons per annum. If this were to materialize, the contribution of alumina plus that expected from the development of the Boké bauxite deposits, would become much more important to the national economy, particularly with respect to foreign exchange to aid Guinea in its imports of goods, services and new investment.

II. The Caribbean area

Much more information is available regarding the contributions of bauxite to economies in the Caribbean area. The North American aluminium companies, which produced half of the world supply of primary aluminium in 1962, took, in that year, close to 90 per cent of their bauxite supplies from the Caribbean area and adjacent countries. Although the employment they created in bauxite and alumina production was relatively small, their contributions to government revenues were substantial in British Guiana, Jamaica and Surinam.

A. SURINAM

Surinam follows Jamaica and the Soviet Union as the third leading bauxite producer. Over most of the years since production began in 1922, Surinam has been the principal source of foreign bauxite for the United States of America because of the predominant position in the aluminium industry of the Aluminum Company of America (Alcoa). Most of the bauxite reserves of Surinam have been explored by and are under concession to Alcoa. Much smaller reserves are held by a second bauxite producer, Billiton, a company from the Netherlands. The Government has, however, discovered important bauxite deposits about 100 miles inland from the sea coast; these deposits may also be developed in future, when transportation facilities are established. In 1959, the Government, with United Nations assistance, began an aerial geological survey in order to promote mineral exploration, and it has since undertaken mineral surveys. Gold and iron ore, as well as bauxite, have been found. To make accessible one area in which the Government's explorations located possibly 400 million tons of bauxite, the Government has applied to the European Economic Community for financing of the construction of roads.

Because of the small population of Surinam (about 300,000) and its limited economic activities, bauxite has been a principal element in the gross national product, the dominating export, and a large contributor to governmental revenues (see table 30). Imports and exports have comprised about 95 per cent of the national income and bauxite about one-third of income, but about four-fifths of the value of exports. Between 1950 and 1958 the two bauxite companies contributed somewhat more than one-third of all the ordinary revenues of the Government, principally in the form of income tax and royalties. The payments by Alcoa of between $2.50 and 3.00 per ton in recent years have been the highest received by any Government from bauxite producers. The total bauxite production in the past fourteen years has varied mainly between 3 million and 3.5 million tons per annum, showing little growth since 1952.

Table 30. Surinam: revenues deriving from bauxite compared with total revenues

	Surinam Government ordinary revenue			
	From all sources	*From bauxite*	*Bauxite percentage of total*	*Surinam bauxite production (million tons)*
	Thousands of dollars			
1950	12,800	4,250	33	2.0
1951	12,800	3,920	30	2.7
1952	15,700	5,880	37	3.2
1953	16,800	6,100	36	3.3
1954	17,800	6,690	37	3.4
1955	18,800	6,950	37	3.1
1956	20,300	8,050	39	3.4
1957	27,300	9,000	33	3.3
1958	24,700*	8,630	35	2.9
1959	26,800*			3.3
1960	30,100*			3.6
1961	30,600*			3.4
1962	30,400*			3.2
1963				3.4

SOURCES: Central Bank of Surinam and United States of America, Bureau of Mines.
* Preliminary figures.

Surinam is an agricultural and wood products economy with very little other industry besides bauxite mining. The 1961 output of 3.4 million tons of bauxite was produced by less than 2,900 employees, at an average of about 1,200 tons per annum per worker. This employment, however, just about equals the number of persons who enter the labour force every year, presenting a serious unemployment problem.

The most important fact about Surinam bauxite is that it has become essential to Alcoa, the largest aluminium company in the United States of America. Alcoa does not have bauxite resources of such good quality and quantity anywhere else as favourably located to serve the company's alumina plants. But like other large aluminium companies, Alcoa also tries to avoid excessive dependence upon any one source, in the event of political or other difficulties interfering with the supply of bauxite. Therefore, Alcoa has acquired and mines bauxite in Australia, the Dominican Republic and Jamaica, as well as in the United States of America. As a result, Alcoa has increased its production of bauxite in Surinam by very little since 1952, although Alcoa's total aluminium production advanced by two-thirds between 1952 and 1962. Yet, the principal source of the company's ore is Surinam. This situation partly explains the willingness of the company to co-operate with the Government of Surinam in building a hydroelectric project and agreeing to build an aluminium smelter. This arrangement was adopted in 1958 in a contract called the Brokopondo agreement.

Other important circumstances influenced Alcoa's willingness to make this agreement. One was the possibility of Surinam being accepted, as a colony of the Netherlands, in the European Common Market, thus enabling Alcoa to sell aluminium in that market without paying import duties. A second was Alcoa's wish to obtain substantial income-tax savings under the tax-incentive laws of the United States of America, through certain changes in the corporate arrangements in Surinam. A third factor was Alcoa's interest in obtaining control over additional bauxite reserves in Surinam.

On the other hand, the Government of Surinam wanted the Brokopondo hydroelectric project built so as to obtain a share of the electric power for the country, an aluminium industry giving employment and more revenue to the Government, and the opening up of interior lands for agricultural and forest product development by means of the roads and reservoir connected with the project.

Consequently, the Brokopondo agreement laid the foundation for additional growth of Alcoa in Surinam and for important general economic development in such a small country. The contract runs for seventy-five years, at the end of which period the company will give its interest in the hydroelectric project to the Government but will retain the right to buy 90 per cent of the energy for its own use. The company was to build the project largely at its expense, although the Government would make certain contributions to costs. The company agreed to build an aluminium smelter with a capacity of 60,000 tons and agreed under certain conditions that it might build also an alumina plant at a later time. The company agreed also to make certain minimum payments of income tax and royalty which assured the Government of a payment level that is still about the highest received by any Government per ton of bauxite.

The Government granted the company bauxite rights for seventy-five years, including exclusive exploration privileges over much of the country. The Government also agreed to a new corporate tax arrangement to help the company take advantage of benefits under the tax law of the United States of America.

The hopes of the Surinam Government in regard to this agreement have so far been sustained. The company will complete the power project by 1965 and the aluminium smelter by 1965 or 1966. The company is also completing an alumina plant, probably by 1966, having made an arrangement to sell alumina to a new smelter to be built in the Netherlands, in which the Netherlands bauxite company in Surinam will have an interest. The economy of Surinam will continue to depend upon one company and one industry, but will at least be richer than if the agreement had not been made.

B. BRITISH GUIANA

Adjoining Surinam on the west is British Guiana, another small country. British Guiana is the fourth largest world producer of bauxite and the principal source of bauxite for the largest international aluminium company, Aluminium Limited of Canada. The Government depends much less upon bauxite for revenues than does Surinam. There are two producers.

The population of British Guiana is about 600,000, or double that of Surinam. The country also has little industry and depends largely upon its exports of sugar, rice and bauxite. In recent years, about one-fifth of the labour force has been unemployed. In 1960 the gross national product was about $140 million, or roughly $240 *per capita*. Half of the gross national product consisted of exports ($73 million), of which 83 per cent was accounted for by sugar, rice and bauxite. The value of the bauxite exported was $17 million, or nearly one-fourth of all exports and about 12 per cent of the gross national product. The Government's revenues in 1959 were $28 million, of which the bauxite industry contributed about $3.1 million, or 11 per cent, all in hard foreign exchange. In addition, the two bauxite companies contributed to the costs of local government through company-built communities supplying housing, electricity, medical care, schooling and other services customarily paid for by local governments from local tax revenues.

The subsidiary of Aluminium Limited, the Demerara Bauxite Company (Demba), made most of the payments for the bauxite industry to the Government, amounting to approximately $2.40 per ton of exported bauxite. For local government services, the company also contributed about $0.40 per ton. Such payments, like those of Alcoa in Surinam, have been among the highest received by Governments from the bauxite industry. These were made possible by the profitability of sales of high-quality bauxite for uses other than making aluminium and by the large scale of over-all production, generally ranging between 1.5 million and 2 million tons per annum. The other producer, the Reynolds Metals Company, made very small payments to the Government, due mainly to the limited scale of production,

29. 9. 71

The greater use of aluminium in utensils should be encouraged in order to help reduce the waste of fuel-wood in Africa. This waste contributes to widespread deforestation, soil erosion, impaired agricultural productivity, flood damage and loss of ground-water resources. Such damage is greatly affected by the use for fuel of 88 per cent of all wood cut in Africa and by inefficient ways of using this fuel, including wastage in utensils that conduct heat much less rapidly than does aluminium.

The productivity of agriculture in Africa and the increased consumption of perishable foods can be greatly helped by wider use of aluminium. Aluminium roofing on agricultural buildings, compared with other materials, has been demonstrated to give cooler temperatures and to increase significantly the output of farm animals in milk, eggs and meat for consumption. Aluminium and other insulating materials permit safe transport, storage and preservation of perishable foods for greater protein consumption, a major need in Africa. Aluminium pipe has helped to create the system of sprinkler irrigation, which is much more efficient in the use of water than conventional gravity irrigation, and it has demonstrated increases in crop output that have paid for the investment. The system is especially adapted to water and land erosion problems of Africa. It may also help to reduce the spread of the disease, bilharziasis, that now affects about one-third of the population of Africa.

The greater use of aluminium in house roofing would make for cooler and healthier dwellings. Particularly in replacing the grass roof, it would eliminate one of the shelters for vectors of disease. Aluminium is more economical, although at first it is higher priced in most countries than is galvanized iron. It gives much longer life at lower cost. Some Governments have adopted roofing programmes, and the extension of this principle to African public housing deserves careful consideration.

African government agencies concerned with investment and maintenance of public roads and railroads should also consider the promotion of the greater use of aluminium. The benefits have been proved in many countries to include reduced costs of road repair and maintenance, reduced vehicle costs of operation and maintenance and greater revenues from a larger carrying capacity per vehicle using aluminium. On the 1-metre and narrower gauge railways of Africa, including those of four East African countries, aluminium in railway cars would increase safety and would permit greater speeds and reduced costs of operation.

Electric-power generation, transmission and consumption in Africa will offer growing opportunities where aluminium has been proved to be more economical than copper. Some large power projects, railway electrification and transmission line construction across national boundaries will require co-operative arrangements between Governments.

B. Conclusions and recommendations

To promote greater aluminium consumption and manufacture, African countries will require a more consistent and constructive tariff and trade policy than currently prevails in certain countries.

It is recommended that African countries undertake a conference on the subject of aluminium development and the adoption of consistent tariff and other trade policies related to aluminium.

To encourage the justified greater uses of aluminium for benefits to African agriculture, housing, forestation, transportation and electrification,

It is recommended that the African Governments establish a permanent intergovernmental committee to formulate a programme to (*a*) determine the desirability of promoting certain aluminium uses; and (*b*) to define the policies and programmes recommended.

It is also recommended that the Governments establish an aluminium industry advisory committee from enterprises operating in Africa to supply technical help to the intergovernmental committee and that another industry advisory committee be established to represent materials competitive with aluminium, so that aluminium policies are checked against criticisms and so that makers of competing materials are encouraged to improve their products and reduce their costs and prices.

To prevent the misuse and misapplication of aluminium products as experienced in some African and other countries, to the detriment of aluminium markets,

It is recommended that the African Governments include in their programmes for aluminium, with the help of aluminium enterprises, the popularization and instruction of people on the proper ways of installing and using aluminium and the adoption of quality standards by producers of aluminium products.

It is concluded that building the aluminium industry in East Africa involves common problems for the various Governments and can only be achieved for the maximum welfare of their populations by intergovernmental co-operation in policies and programmes.

Introduction

A. Purposes of the report

The present report is derived from another report[1] prepared for the purpose of examining the possibilities in the East African subregion of establishing any of the primary stages of the aluminium industry: bauxite mining, production of alumina and production of the crude metal. In the present version, emphasis is shifted to Africa as a whole. Some references to East Africa are retained, but they are only incidental.

These possibilities are also examined from the point of view of fitting the aluminium industry within broader development goals of countries by the period 1975-1980.

It is hoped that this report may assist the United Nations Economic Commission for Africa (ECA) and individual Governments in Africa in shaping policies

[1] "East Africa and the aluminium industry: a pre-feasibility study" (E/CN.14/INR/100), paper prepared for the United Nations Economic Commission for Africa, Conference on the Harmonization of Industrial Development Programmes in East Africa, Lusaka, 26 October-6 November 1965.

towards the development of the aluminium industry, and in making decisions towards the undertaking of additional studies. Particularly, it is hoped that this report may stimulate some African Governments to investigate where the greater uses of aluminium may be justified and encouraged, as compared with other materials, in contributing to the improvement of the health and productivity of Africans and in obtaining a larger output or reduced costs in agriculture and some other industries.

This paper is preliminary and not conclusive for two reasons. First, only a very limited time has been available for its preparation, about two months. Secondly and more important, the maximum possibilities of developing the aluminium industry in Africa, as with some other industries, are currently not assured and will only become more definite with the establishment of industries more favourable for capital investment and the growth of economic co-operation between African Governments. The greater the stability and co-operation, the more rapidly will come about the essential conditions in which the aluminium industry can best thrive. The conditions include improvements in developments of agricultural, mineral and energy resources, and the internal transportation arteries of rail, road and inland waterways. Improvement in these areas will increase the demand for aluminium and the number of industries that can share with the aluminium industry the joint costs of power-stations, transport, community housing and health, and other factors of the infra-structure. The more industrialized countries of the world have demonstrated the importance of such relationships in building up their leadership in aluminium consumption.

B. Africa and aluminium

It has been increasingly recognized since the end of the Second World War that Africa has the essential resources of bauxite and the electric-power potential, as well as the strategic location, for becoming a world leader in the production of crude aluminium for exportation to the industrialized countries. But as a consumer of aluminium, Africa has been at the bottom of the list of regions in *per capita* consumption and is still regarded as being in this position in the list of those likely to use more aluminium. This low ranking reflects past experience and current circumstances, but it could very well change dramatically if the ambitions and rich resources of many African countries could be joined into effective development programmes.

1. Bauxite

Africa possesses one-third of the world's combined reserves and submarginal resources of bauxite, the basic raw material of aluminium. The largest part is found in Guinea, where the reserves represent the most important volume of high-grade ore in the world. In Western Africa also, bauxite is known in Angola, Cameroon, the Congo (Democratic Republic of), Ghana, the Ivory Coast, Mali, Sierra Leone and Upper Volta.[2] In East Africa, bauxite is found in Madagascar, Malawi, Mozambique and Southern Rhodesia, and in North Africa, in Morocco. For additional details, see annex I, table 13, which shows the world reserves of bauxite as known in 1963.

The African bauxite resources have been used but to a minor extent in relation to the world share of 33 per cent. They contributed only 6 per cent of the world bauxite output in 1963. Most of this production was converted into alumina in Guinea and shipped to European aluminium smelters and to the one smelter in Africa in Cameroon. The African share of world alumina production converted into aluminium was little more than 4 per cent. However, the role of Africa in bauxite production is likely to expand considerably in a few years as a result of new developments in Guinea and minor ones in Ghana and Sierra Leone.

2. Low-cost electric power

In sources of energy for low-cost electric power for aluminium production, Africa is outstanding in its hydroelectric potential. This potential is widely distributed in Western and East Africa. Based on recent discoveries, petroleum and gas resources are now ample in North Africa and may yet be found in economical quantities in East Africa. Coal resources in Southern Africa are also outstanding and permit production costs as low as anywhere in the world.[3] Africa likewise shares with Canada and the United States of America the possession of most of the world's known uranium and thorium reserves for nuclear power.[4]

Natural gas in Algeria has interested one aluminium company for some years as a possible source of power for a smelter. But it is the hydroelectric potential of Africa that has attracted most attention in investigations of aluminium possibilities. These have included hydroelectric projects under construction in Ghana (Volta) and United Arab Republic (Aswan), and completed projects in Cameroon (Sanaga) and Southern Rhodesia-Zambia (Kariba). They have also included proposed projects in Guinea, the Congo (Brazzaville) and the Congo (Democratic Republic of). Based on hydroelectric power, one aluminium smelter operates in Cameroon, one is under construction in Ghana, one is planned for the United Arab Republic and one has been proposed for Angola.

While the developed hydroelectric capacity of Africa was only 2 per cent of the world total in 1962, the high-grade potential (95 per cent of the time) was 32 per cent, greater than that of any other continent. It is this potential, particularly the concentration of much of it in the Congo River, and the presence of the African bauxites, that will continue to sustain the interest in greater aluminium development in Africa for years to come. Table 1 summarizes the position of African

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[2] In the present report, the subregional groupings are as follows: *Western Africa*: Angola, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Congo (Democratic Republic of), Dahomey, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta; *East Africa*: Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Reunion, Rwanda, Somalia, Southern Rhodesia, Uganda, United Republic of Tanzania, Zambia; *North Africa*: Algeria, Libya, Morocco, Sudan, Tunisia, United Arab Republic; *Southern Africa*: Basutoland, Bechuanaland, South Africa, South West Africa, Swaziland. In certain data and projections, however, the Sudan has been included with East Africa (see table 4).

[3] In this paper, reference to Southern Africa indicates the subregion, including Basutoland, Bechuanaland, South Africa, South West Africa and Swaziland. Reference to South Africa indicates the Republic of South Africa.

[4] For a full discussion, see United Nations, *Situation, Trends and Prospects of Electric Power Supply in Africa* (United Nations publication, Sales No.: 65.II.K.2.).

hydroelectric resources in the world, while the details for each African country are given in annex I, table 14.

Table 1. World hydroelectric capacity, installed and potential
(Megawatts)

Area	Approximate installed capacity, 31 December 1962	Estimated gross theoretical potential: Q 95[a]	Estimated gross theoretical potential: Arithmetical mean
North America, Central America and West Indies	61,230	90,065	270,089
South America	6,865	50,750	471,350
Africa	3,185	176,677	684,680
Asia	19,992	160,826	944,153
Australia and Oceania	3,860	18,600	143,750
Europe	85,806[b]	54,687	209,505
TOTAL	180,938	551,605	2,724,044
Africa: percentage of total	1.8	32.2	25.0

SOURCE: Lloyd L. Young, *Summary of Developed and Potential Waterpower of the United States and Other Countries of the World, 1955-1962*, Geological Survey Circular 483 (Washington, United States Geological Survey, 1964), p. 7.
[a] Available 95 per cent of the time.
[b] Including the Asian area of the Union of Soviet Socialist Republics. Most of the USSR developments are in Europe.

3. ALUMINIUM SMELTERS

In 1964, Africa had only one primary aluminium smelter. Located in Cameroon, this smelter, with a capacity of 57,000 short tons, gave Africa less than 1 per cent of the world capacity. The Volta smelter under construction in Ghana will provide about 115,000 tons additional capacity at first, beginning about 1967, and 165,000-250,000 tons, ultimately. Another smelter to produce 40,000 tons is probable in the United Arab Republic, and additional projects have been proposed at different times in the past ten years, aggregating 1,118,000 short tons of capacity for Angola, the Congo (Brazzaville), the Congo (Democratic Republic of) and Guinea. If all of these projects were fulfilled, Africa would have about 1,447,000 tons of capacity, or about 12 per cent of world capacity existing, under construction and proposed, as known in 1964. Details are given in annex II, table 19.

On the other hand, Africa is a long way from having any substantial internal markets for aluminium. Therefore, most of the capacity of crude metal now committed and practically all that has been proposed are based on the intention of meeting demands outside of Africa. The achievement of independence by African countries cannot, for some time, bring about any major change as far as aluminium exports are concerned because it will take much economic development within Africa to build up large internal markets for aluminium.

In 1960, it was estimated that Africa and the Middle East consumed the equivalent of only 29,000 short tons of primary aluminium, or less than 1 per cent of world consumption. Much of this was used in South Africa. The average *per capita* consumption in Africa was of the order of two-tenths of a pound of aluminium per annum. This is only a statistical figure, of course, and is misleading, since most Africans used no readily identifiable aluminium products. By comparison, however, the statistical average of aluminium use was much greater in other developing regions of the world, e.g., 1 pound *per capita* in Latin America and seven-tenths of a pound in Asia and Oceania.

On the basis of the import data available, a substantial increase in consumption in Africa to more than 55,000 short tons is estimated to have occurred between 1960 and 1965. The projected demand for the Middle East and Africa for 1970 of 55,000 tons, as estimated back in 1960, has now been exceeded. The *per capita* use of aluminium in Africa has improved slightly, but it still is below four-tenths of a pound per annum, at the bottom of the list of world regions, if South Africa is considered separately. The industrialized regions of the world are expected to continue to maintain their leadership in *per capita* consumption of aluminium. The summary of world consumption and projected consumption to 1970, presented in table 2, can be interpreted as posing two questions to the African Governments:

(*a*) How much of the anticipated growth in world demand for aluminium Africa will supply;

(*b*) What Africa can accomplish in increasing its own aluminium consumption as it moves to close the wide gap between it and the more developed nations in consuming a wide variety of goods and services.

Table 2. Projection of total and *per capita* consumption of primary aluminium, 1970

Region	Thousands of short tons: 1960	Thousands of short tons: 1970	Pounds per capita: 1950	Pounds per capita: 1960	Pounds per capita: 1970
North America	2,210	4,365	11.3	22.4	36.0
Latin America	94	293	0.5	1.0	2.6
European Common Market	560	1,257	2.0	6.7	14.1
Other European countries	481	854	2.8	6.2	10.1
Middle East and Africa	29	55[a]	0.1	0.2	0.3
Asia and Oceania	245	614	0.1	0.7	1.3
China (mainland), USSR and other centrally planned economies	1,040	2,750	0.6	2.0	4.4
Total world	4,659	10,188	1.4	3.2	6.0

SOURCE: Kaiser Aluminum & Chemical Corporation, United States of America, 6 November 1960.
[a] Exceeded in 1963.

It may be emphasized again that to the extent that independent African countries choose to supply a substantial part of the outside markets for aluminium, they will be following the previous pattern. There may be a difference in so far as the countries can retain within their own borders a greater share in taxes and profits of the value produced or, alternatively, obtain in exchange for aluminium more imported goods and services desired to build up the African economies. The African countries will, however, clearly depart from the previous pattern to the extent that they build up their own consumption of aluminium and, particularly, in those uses where the metal does a better job at lower lifetime cost than alternative materials. Where such uses can be developed, Governments will be promoting aluminium in the most effective ways to improve the welfare of populations and to increase national incomes.

C. A critical attitude towards aluminium by developing African countries

The primary aluminium industry requires far more capital per unit of output and per employee than most other basic industries. The large capital investment, therefore, constantly poses to developing countries the question of whether the promotion of primary aluminium production, compared with alternative needs for industrial development, represents the best use of scarce capital. This problem is more important when some of the capital must be supplied within the country and less important when much of it comes from outside sources. A critical attitude towards the stimulation of each phase of the aluminium industry is particularly justified where there may be a tendency to be carried away by the spectacular growth of the aluminium industry in this century and to fail to examine the differences in values of aluminium to developed countries and to developing countries. It may, therefore, be helpful to examine briefly in the next chapter the position that developing countries have thus far occupied in the spectacular growth of the world aluminium industry, and to consider what that position can become if this world growth continues.

I. Developing countries, Africa and the world aluminium industry

A. The growth of the world aluminium industry

Commercially, aluminium is a very young metal, new to the twentieth century. Its world acceptance on a large scale is barely twenty years old. World production was very small until the decade of the Second World War, as is shown in figure 1. In the ten years following the War, the world output of aluminium leaped ahead of copper, lead and zinc. It became the leading metal in the United States of America after iron and steel; its uses were stimulated greatly by the effects of the War.

To prepare for the Second World War and the use of aluminium in aircraft, Germany, by 1938, was the largest aluminium producer. But the United States of America rapidly caught up, went far ahead of Germany and increased its aluminium industry by six times in order to produce 100,000 aircraft in the peak year of the War. Out of this experience and the training of over 1 million workers to work with aluminium, the United States of America laid the foundation for the popularity of aluminium. This popularity then spread throughout the world. It moved to other industrial countries on a large scale and then on a very small scale to countries that for centuries had known only the older metals, particularly iron, copper and bronze. Thus, small factories are currently producing such aluminium products as cooking utensils and roofing sheets in Algeria, Cameroon, the Congo (Democratic Republic of), Ghana, the Ivory Coast, Nigeria, the Sudan and the United Arab Republic. Such products are also being produced in East African countries—Burundi, Ethiopia, Kenya, Rwanda, Southern Rhodesia, Uganda, the United Republic of Tanzania and Zambia.

At the beginning of the Second World War, eighteen countries, including the principal industrial nations, produced primary aluminium. Seven more countries then followed between 1941 and 1963. Six other countries are shortly to have aluminium smelters for the first time. At least thirteen others in Europe, Africa, Asia and South America would like to establish aluminium smelters and have taken steps through their Governments to promote interest in the ultimate construction of aluminium plants. In most of the eighteen countries established as older crude aluminium producers, plans are also being made for additional productive capacity.

The actual and possible spread of production of crude aluminium since the Second World War from the older industrial countries to the newer developing economies is shown in table 3. The actual production of crude

Table 3. Increase since 1940 in number of countries producing crude aluminium and possible additional producers

Beginning of Second World War, 1940: eighteen countries producing crude aluminium	*1941-1964: Seven new producing countries*	*1965-1967: Six countries becoming new producers*	*Thirteen countries hoping to develop production*
Canada	India (1943)	Romania (1965)	Angola
United States of America	Brazil (1951)	Surinam (1965)	Argentina
Austria	Czechoslovakia (1953)	Greece (1966)	Congo (Brazzaville)
France	Poland (1954)	The Netherlands (1966)	Congo (Democratic Republic of)
Germany	Australia (1955)	Ghana (1967)	Guinea
Hungary	Cameroon (1957)	Venezuela (1967)	Iceland
Italy	Mexico (1963)		Indonesia
Norway			Kuwait
Spain			New Zealand
Sweden			Peru
Switzerland			Philippines
United Kingdom			Turkey
USSR			United Arab Republic
Yugoslavia			
China			
Japan (including North Korea and Taiwan)			

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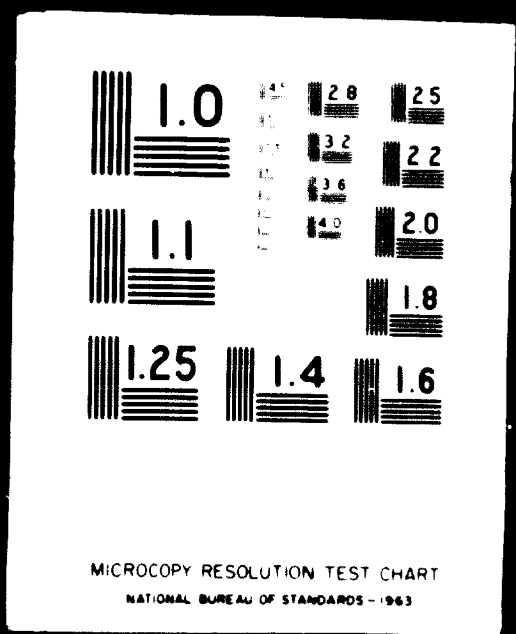

at least for an initial period, which may extend to several years, and the possibility of at least a temporary increase in consumer prices has to be faced. Even with such government assistance, if the company concerned is not one that has already established a brand name, promotion is essential. These are not insurmountable problems, but their resolution is as important as solving the physical problems of production.

C. Research

Applied research in food processing and storage is expensive and often can only be carried out in developing countries by Governments with assistance from international organizations, through bilateral aid programmes, or by foundations. Several Governments have taken the initiative, with the support of the United Nations Special Fund and FAO, to establish such applied-research institutes or pilot plants in Brazil, Chile, Ecuador, Ghana, Jordan, Peru, Philippines, Poland, Senegal, the Sudan, Syria, Turkey and certain other countries. These organizations will pave the way for the development of food industries in many countries, especially when carried out in pilot-plant operations. These offer great opportunities for the planning of food industries and the demonstration and operation of suitable modern equipment and machinery. They also provide opportunities to train local personnel, technicians, engineers and technologists, at the working, as well as the managerial, level.

Pilot-plant operations can also be used to test the markets and systems of marketing the product. They can also be used as a "test bed" for such related industries as packaging and transportation.

The establishment or expansion of a processing plant, or of research, costs money. Such investment can be public or private, or both. Private investment may be either by producers' organizations or by individual firms or investors. Public investment in this field is not ruled out, since the improvement of nutritional levels in developing countries is recognized by many of them as a problem of the first importance.

Running costs have also to be met. In the case of a factory, adequate working capital has to be available, though the annual costs will, of course, be met out of receipts from sales. The running costs of a research station are normally met by the Government, with or without outside aid, as the case may be, but in many instances, the industry contributes towards the cost of research through a special research levy or other similar means.

In planning such investments, account has to be taken of the economic basis of the operation, in terms of volume of production, capital, plant investment, market studies and supplies of manpower.

D. Labour intensity

Another vital consideration is the degree of labour intensity. Unskilled labour is relatively plentiful in many African countries, whereas capital is very scarce. It is, therefore, vital in many cases to choose a labour-intensive technique, even though much progress is unlikely with an out-of-date technique in the long run. Flexibility, as emphasized below, is important.

As is shown in table 1, a relatively small capital investment is sufficient to provide significant levels of employment for non-agricultural workers. It is difficult to define precisely the labour requirements for various sizes of canning installations because this figure is dependent upon the nature of the foods to be processed and, even more so, upon the labour costs of the area. In a developing country, where wages are usually low, a very small plant with a capacity of 50-100 kg of processed food per hour may cost only $56,000 for capital expense requirements while employing between fifty and sixty people. In regions where wages are high, equipment is available to reduce the manpower requirements so that fewer than thirty people may be able to operate such a plant.

In a somewhat larger installation, such as Plant B in the table given below, a hundred people or more may be employed to process approximately 500 kg of food per hour in a plant which costs approximately $180,000. Alternatively, more equipment may be purchased and labour requirements may be reduced to as low as forty-two people.

In a plant with a capacity of 5,000 kg of food processed per hour, minimum capital requirements will be about $600,000 with a relatively high manpower requirement of 300 people. Again, the use of more processing equipment can reduce these manpower requirements to as low as sixty to seventy men. As can be seen from the table, the larger the plant, the greater are the savings on both labour and the capital per unit of output.

Characteristics of typical food-canning plants

(Values in dollars)

	Plant A	*Plant B*	*Plant C*
Capacity (pounds per hour)	100 — 200	1,000	10,000
Capital costs	56,000 — 90,000	180,000 — 290,000	600,000 — 850,000
Labour requirements (man-years)	28 — 56	42 — 100	66 — 300
Capital per man employed	1,600 2,000 —	1,800 — 6,900	2,000 — 12,900
Capital per pounds per hour	450 — 560	180 — 290	60 — 85
Labour per pounds per hour (man-years)	.280	.042 .100	.007 — .030

This great flexibility in the choice to be made between capital investment and labour requirements occurs primarily in the area of food-crop handling and preparation. The functions of weighing, cleaning, trimming, grading, sorting, cutting, slicing, coring etc. can be performed in an entirely satisfactory manner by hand labour. However, where the situation warrants their use, highly sophisticated equipment is available to carry out the functions with only a minimal amount of hand labour.

It must be appreciated that often the choice between a capital-intensive or a labour-intensive industry is more apparent than real. The factory, whether privately or Government owned, will always seek to use the method that results in the lowest cost per unit of output, and where (as is normally the case) it has to meet competition, it may have little choice if it is to survive. Where, however, the economics of the firm show that more capital should be used, this may conflict with the balance-of-payments position of the country and the need to maximize employment.

II. Technological aspects for the planning of food products industries

Food spoilage or deterioration is due to a variety of causes. Fresh plant and animal tissues are living organisms and, therefore, many of the metabolic processes continue after harvest or slaughter. The enzymes naturally present in such tissues can cause a variety of changes, mostly undesirable. In addition, micro-organisms are present in or invade all such tissues, again causing changes which are, as a rule, detrimental. Therefore, the control of enzyme action and the prevention of proliferation and action of micro-organisms is one of the major objects of food preservation.

This desired control of enzymes and micro-organisms can be achieved by a number of means. Conditions can be created when enzymes and micro-organisms cannot function, as at deep-freeze temperatures. The enzymes can be inactivated by heat or chemicals. The micro-organisms can be eliminated by thermal treatment or by the application of chemicals or antibiotics. Removing water from food products will also prevent both enzyme action and the growth of micro-organisms. Ionizing radiation can also accomplish some of these desirable conditions. Thus, the food processor has a wide choice of methods which, jointly with proper packaging, will produce preserved, attractive, wholesome and economical foods. Some of these methods are discussed below.

Planning food and food products industries must take into account the selection of one or another technological process. Factors affecting the choice are the raw material to be processed, the facilities which are available, the quality and storage requirements of the finished product and, naturally, the economical aspects.

A. Dehydration

In dehydration, the water content of a food is reduced to such an extent that enzymes are unable to act and micro-organisms are unable to grow. In addition, deteriorative changes due to other factors are also usually retarded by a low moisture content. The amount of permissible residual water will vary from product to product, according to specific requirements and the length of storage and temperature range to which the product will be exposed between processing and consumption. In general, the moisture content of dehydrated food products is in the range of 1-10 per cent.

In addition to providing fruits and vegetable products out of season, dehydration has been extensively used in order to compensate for the variation in the seasonal production of some commodities, such as milk and eggs.

Quality (including the case of rehydration), cost and storage behaviour are the major factors determining the usefulness of dehydrated products and, therefore, the choice of the method of preservation used for a given product will depend mainly upon these considerations.

1. Sun-drying

Some fruits, e.g., peaches, apricots, figs, dates and various raisin grapes, are still sun-dried on a very large scale. However, even with these products there is a definite tendency towards the use of more controllable artificial means. Sun-drying requires several days and is followed by "curing" in sweating bins, where the moisture in the various pieces equalizes. The water content of most dried fruits is in the range of 5-20 per cent, with different requirements for various products.

2. Artificial drying

The basis of successful drying is the transfer of water vapour into a stream of air or other gases that are not saturated with water vapour. Therefore, the volume, the temperature and the relative humidity of the drying gas, and the surface of moist material exposed to heat will govern the drying efficiency. Every fruit particle has a definite attraction for moisture, which, at a given temperature and pressure, will be in equilibrium with the moisture content of the drying atmosphere. This attraction to moisture, as well as the size (surface) of the particles to be dried, varies greatly, and, therefore, most types of dehydrating equipment will be suitable for a limited number of products only.

With foods, the effect of the drying on flavour, colour, physical condition and nutritional value are further factors that must be taken into consideration. There are several methods to dry artificially fruits and vegetables; among them the cabinet drier, the kiln drier or "evaporator", the tunnel drier, the vacuum shelf drier, the drum drier, the rotary drier and the spray drier are noted here.

Often, it is expedient to use combinations of various procedures for dehydration. There are some vegetables that can be most economically dehydrated with the maximum retention of desirable properties by first using a tunnel drier to remove the bulk of the water, followed by drying in cabinet driers and, finally, by removing some more moisture in bins through which air dried by silica gel is circulated.

3. Freeze-drying

The food to be dried is first submitted to quick freezing, effected by the application of vacuum, causing rapid evaporation of water and loss of heat. The drying operation is then carried out in a high vacuum, the process permitting rapid conversion of the water from the frozen into the vapour state without going through the liquid phase. Moisture is lost from the surface of the food, leaving a porous product which greatly facilitates rehydration when the food is prepared for consumption.

Drying foods at low temperatures minimizes bacterial growth, enzyme activity and undesirable chemical changes, while damage to colour, flavour and texture is low. Freeze-dried foods do not have to thaw, but merely to be rehydrated before cooking or serving. However, freeze-drying is still an expensive procedure and, therefore, it is used mostly for specialty products or important ingredients of dehydrated soup-mixes etc.

4. Foam-mat drying

This method involves making a still foam by whipping air or an inert gas into a concentrated foodstuff in the presence of an edible foam stabilizer. The stabilized f[illegible]n is deposited as a uniform layer onto perforated [illegible]ays; the trays pass over an air blast to perforate the foam and thus greatly increase the surface available for heat transfer and evaporation of water.

This perforated mat of foamed food concentrate then passes through a drier which decreases product moisture to 2 to 2.5 per cent. Materials that have been foam-mat dried include water infusions of tea and coffee, fruit *purées* and extracts of beef and chicken. The flavour and colour of these foam-mat products are superior to those dried by other methods. The process obviously is limited to liquids and concentrates, as foaming is required. It is not suited to products sensitive to oxygen in the drying air. Volume and weight reduction of the dried food is approximately the same as with spray- and drum-dried foods.

B. Canning: thermal processing

Fresh fruits almost invariably carry or will eventually acquire micro-organisms that cause spoilage. The principle of preservation of foods in hermetically sealed containers rests on the destruction by heat of such organisms in a closed container, which prevents reinfection. Suitable containers may be made of metal, glass, plastics or other materials.

It is clear that in addition to the destruction of micro-organisms, the enzymes present in the food will also be entirely or mostly inactivated. While properly prepared canned food will keep indefinitely, as far as putrefaction is concerned, deterioration of quality and nutritive value will occur during the prolonged storage of many products.

The term "processing" as used in the canning industry means the cooking of the product in a sealed container; it is designated in terms of the temperature and time of the thermal treatment required. The processing of the canned products must destroy all organisms that are injurious to health and may cause spoilage. Complete bacteriological sterility, while sometimes attained, is not always essential in canned products, providing that conditions in the can are such that no growth of such residual organisms will occur.

C. Aseptic canning

This treatment of foods that have been sterilized by a high-temperature, short-time process is receiving a great deal of attention in several countries. The high-temperature, short-time sterilizing process, in conjunction with aseptic canning, minimizes the heat damage that accompanies traditional long-time processing of food. The new method retains more of the desirable properties of foods. In addition, large containers—even 210-litre drums—can be sterilized and filled aseptically. Milk, evaporated milk, processed cheese, fruit juices and similar products processed by this method provide a more nutritious and natural-tasting product than the same foods processed by conventional canning methods.

D. Fruit juice production

Although canned (heat-preserved) fruit juices were prepared from a variety of fruits in many countries for over a century, their large-scale production did not commence until the 1930's. The heat-preserved fruit juices constitute the highest proportion of the fruit juices produced. Large quantities of citrus juices are preserved by a combination of heat and freezing. Yet, other juices are used in the canned form straight or in concentrates of all sorts, including a variety of products, for example, tomato *purée*, sauces, paste etc.

While the fruit juice industry originally utilized mostly surplus fruits and those which were unsuitable for the fresh market or processing, now most fruit juices are produced from fruits specifically cultivated for such purposes.

In producing fruit juices, the expressed juice flows through screening equipment to remove seeds and undesired suspended particles. This is usually followed by de-aeration and filling into cans, which are then quickly sterilized under hot water with rotation to ensure rapid heat penetration. Cooling follows the processing. Tubular flash-heaters are also used for some juices.

E. Cold storage

When the storage temperature is lowered, most foods will keep longer. The multiplication and growth of most micro-organisms is thereby retarded, and enzyme actions and other processes in living tissues, as well as non-enzymic reactions leading to deterioration and spoilage, progress more slowly. As a rule, however, cold storage does not stop such changes. As temperatures are again elevated, all types of reactions will again progress at increased rates. Although cold storage has been used for thousands of years, the intercontinental shipping of food, especially from New Zealand and Australia to the United Kingdom of Great Britain and Northern Ireland, provided a major impetus for the development of modern cold-storage technology.

Cold storage facilities are extensively used with a wide variety of products and under a great variety of conditions. Fruits, vegetables, dairy products, eggs, meat, meat products, fish and many other foods are held in cold storage for periods ranging from a few days to a year or more.

Although icing is still extensively used, artificial refrigeration is being increasingly applied. The art of heat removal or refrigeration is a highly specialized branch of engineering. In addition to the initial cooling and heat losses, calculations of refrigeration loads and capacities must also take into account the heat generated by living tissues. For instance, 1 ton of sour cherries at 10.6° C (60° F) will evolve 11,000-13,200 BTU of heat per ton per day. A number of other factors will also enter into the calculations of refrigeration requirements and thus into the design of refrigeration equipment. A considerable variety of different types of mechanical refrigeration and refrigerants are currently in use. Capacities of refrigerating equipment are usually expressed in terms of "ton refrigeration". A ton-refrigeration is equivalent to the removal of 288,000 BTU per day or 200 BTU per minute.

An interesting example of cooling of produce for transport is practiced with lettuce in the United States of America. The loaded truck or railroad car is put into a huge chamber, where sufficient vacuum is created to cause rapid evaporation of the water on the surface of lettuce leaves. The dissipation of heat by the heat of evaporation is sufficient to reduce the temperature of the lettuce throughout the load effectively to the level required for long-range shipment.

For best storage, most products require a specific, often narrow, temperature range, a given humidity and perhaps atmosphere control also. The variations in all these requirements are great. Atmosphere control is important from the standpoint of odours, as well as the presence of gases. Some products emanate gases, which influence the storage behaviour of the same product, as well as that of other commodities. Artificially introduced gas atmosphere is often used for the storage of foods. At times, such desired gases are produced by the food and are then kept at specific concentrations.

Most fruits and vegetables keep best at 0° C (32° F), but the optimum storage temperatures for some products, e.g., lemons, grapefruits, cucumbers, tomatoes and potatoes, are somewhat higher. Often the optimum storage temperature (and other conditions) for a given crop, such as bananas, will change with the maturity.

Milk and cream must be held under refrigeration at all times and are usually kept near 0° C (32° F). Even at this temperature, these products will keep only for a few days unless they are pasteurized and cooled before being put into cold storage. In pasteurization, the number of micro-organisms in the milk is greatly reduced and the pathogenic organisms are killed.

Fresh meats are highly perishable and, therefore, must be cooled immediately after slaughter and kept just above the freezing-point until used. Some meats become more tender during ageing. Cold and freezing storage facilities of all sorts are extensively used with meats and meat products.

Fresh fish is even more perishable than meat, and the current tendency is to ice or refrigerate fish immediately upon catching. Salted and smoked fish will also keep better at lower temperatures and are often kept under refrigeration.

Eggs are usually kept at 0° C (32° F) where, under proper conditions of humidity and control of air movement, they will keep for many months.

A great variety of other foods and food products are kept in cool storage. Of these, wines, various chocolate products, yeast and nut meats may be mentioned.

F. Freezing and frozen storage

Whereas cold storage will only retard the three major types of detrimental changes in foods, those of microbial, enzymic and non-enzymic origin, freezing will often arrest these changes and, in some cases, slow them down to such an extent as to allow storage of the product. However, in order to assure better storage behaviour of plant foods, it is often desirable to inactivate some of the enzymes present in the tissues. It is clear now that such thermal inactivation of the enzymes by "blanching" will usually destroy only certain enzymes while others will survive. The roles played by different enzymes in the deterioration of frozen foods is not clearly understood at the current time.

In many cases, the freezing of a food, such as meat, will cause no objectionable physical changes or will be even beneficial in certain respects. In other instances, the alterations resulting from freezing and thawing will be objectionable. Most such changes seem to be caused by the formation of ice crystals in the tissue and by the irreversible disturbance of colloidal tissue components. More rapid freezing will result in the formation of smaller ice crystals and thus in less disturbance of tissue organization. As far as flavour, odour and colour are concerned, the changes caused by freezing are usually less marked than when the same foods are canned. On the other hand, there are many products, which, by their very nature, must be prepared by a given method. Tomato juice, for instance, usually lacks the typical flavour associated with this product if it is prepared without heat treatment and then frozen, rather than processed by heat in the usual manner.

Syruping or mixing with sugar is used with many fruits in order to assure better quality in the frozen product. This is the case with apples, strawberries, raspberries, peaches, apricots and cherries, which make up the bulk of frozen-fruit pack. In order to prevent oxidative discolouration of sliced peaches, addition of ascorbic acid to the syrup is now common practice. Most vegetables are blanched before freezing; sulphuring is used only with fruits and to a very limited extent.

The rate of freezing will depend upon the efficiency with which heat is removed from the product to be frozen. The first phase of the freezing process consists of chilling the product to its freezing-point. During the second phase, the actual freezing, the temperature of the commodity remains practically constant. The third phase is the lowering of the temperature of the frozen product to that required for its storage, which is usually considerably below the freezing-point. The first phase is usually easily accomplished because of the relatively large temperature difference between the warm food and the refrigerating medium. The amount of heat (plus latent heat of fusion) that will have to be removed during the freezing process will vary from as low as 22 BTU/lb for dried beef to 124 BTU/lb for milk and 144 BTU/lb for water. Fruits and vegetables are in the range of 100-134 and fresh meats in the range of 66-100 BTU/lb. Thus, the rate of freezing of different products will vary considerably when the same equipment is used for different foods. Although for some time it was believed that quick freezing generally resulted in products of higher quality, it is now clear that this is seldom the case. Under certain conditions, however, rapid methods of freezing have advantages over slow freezing. First, quality deterioration might occur in a product during the first phase of the freezing process, during which the temperature of the product is reduced. Secondly, the output per unit of investment is usually higher in equipment capable of quick freezing.

There are three main direct-contact freezing methods, with many variations: freezing in still air; blast freezing; and immersion freezing. There are also several indirect-contact freezing methods, among which is quoted the multiple-plate freezer. There are additional freezing methods, as, for instance, by floating the product in a blast of cold air. New techniques are continuously proposed to meet special product requirements and to attain greater production economy.

G. Dehydro-freezing

This is a process in which the product is partially dehydrated before or during freezing. This procedure has certain advantages over both dehydration and freezing. For instance, the rehydration and thawing processes can be combined by placing the dehydro-frozen product in boiling water. The storage space required for dehydro-frozen products is less than that needed for the directly frozen commodity. The practical possibilities of this new method seem to be limited as yet because of the higher cost of processing.

The methods used for the preparation of fruits and vegetables for freezing are essentially the same as those applied in canning. Blanching is required for most vegetables in order to ensure sufficiently long storage life.

H. Preservation by salting and fermentation

The proportion of salt present in a food product will determine, to a great extent, the type of micro-organisms that will grow in it. In addition, the presence of salt will also influence the extent of the changes that the micro-organisms will be capable of producing. Although salt has been used in food preservation for hundreds of years, its action is not clearly understood. Among the suggested explanations are that salt exerts a poisonous action on certain organisms, that it makes moisture unavailable to micro-organisms, that it will prevent bacterial growth by plasmolysis of the cells and that it destroys bacterial protoplasm. Whatever may be the mechanism of salt action, the fact remains that salt, especially in combination with acids, has a selective action on micro-organisms. This effect is extensively used in the manufacture of pickles, sauerkraut and many other products. Such dairy products as butter and cheese, as well as great variety of fish and meat products, are also salted.

There is little doubt that most fermented foods were discovered by accident, and there seems to be even somewhat more uncertainty concerning the mechanisms involved in their production than in the case of the preservation methods discussed previously.

I. Preservation by chemicals

Sugar and salt have been utilized since ancient times as chemical food preservatives. In general, one qualifies as chemical preservative any substance capable of inhibiting, delaying or stopping the fermentation, acidification or other forms of deterioration of foods, and substances which are able to mask any sign of putrefaction in food. But the possibility of masking with the preservative the unsafe condition of the food has obliged the public-health services in various countries to control in the most drastic way the utilization of chemical preservatives.

As examples of such preservatives, one may note the use of sodium nitrate, potassium nitrate, acetic acid, lactic acid, vinegar, glycerine, alcohol, benzoic acid, sorbic acid and sulphur dioxide. There are many other chemical preservatives used for a variety of products.

J. Preservation by antibiotics

Even though the use of antibiotics could be theoretically effective for the control of the spoilage agents of foods, the health authorities in several countries have objected to its utilization because of the secondary effects which the antibiotics can produce on the eventual consumers of the foods. For instance, the use of Subtilin has been suggested in the canning food-industry as a supplementary means to weaken the bacterial resistance to heat. It would be possible to get a sterilized food with a relatively short heat treatment. At the current time, such processes are not allowed in commercial practice.

During recent years, antibiotics have been utilized to delay deterioration of fish. For instance, 1 to 4 parts per million of aureomycin have been incorporated in the ice with which the fish is preserved. Furthermore, 2 parts per million have been incorporated in the sea-water in which the fish is kept while still in the boat. The fish is also dipped for a minute in solutions which contain 50 parts per million of aureomycin before making use of ice preservation. These methods have shown very good preservative effects and are used now in commercial practice.

K. Preservation by irradiation

In order to be useful as a practical technique of food preservation, any new method must have some definite advantages. It will have to provide a cheaper procedure or a better product, or be useful in instances where other ways of preservation cannot be used. Whereas these requirements are clear, their assessment is not always easy and can be usually accomplished only by systematic development work followed by extensive testing under practical conditions. This certainly is the case with the use of ionizing radiations for food preservation.

The principles of preserving foods by exposing them to ionizing radiations are now fairly well understood. As expected, there is a great variation in the response of raw food materials to radiation. Even within a certain type of food—fish, for instance—the effects of irradiation, beneficial or objectionable, vary greatly. This is not surprising, since a strictly analogous situation existed in the development of canning, freezing, dehydration etc. and led first to the selection of foods for which a certain technique was applicable and later to the testing and production of new varieties of plants and strains and breeds of animals and fish. Generally speaking, very little of this selection has been done with preservation by irradiation, the work thus far having been mostly restricted to the kinds of foods where irradiation shows practical promise of usefulness.

The radiation preservation of foods, as it is currently understood, is based mainly on three modes of action. First are the physiological influences on plant foods, for instance, the prevention of sprouting of potatoes and onions. Secondly there are the benefits of the irradiation in inhibiting the growth of micro-organisms or destroying them altogether. Unfortunately, there is great variation in the susceptibility of micro-organisms to radiation. Enzymes, viruses and toxins seem to be comparatively resistant to radiations, and their destruction or inactivation often requires radiation dosages of such magnitude that undesirable side-effects on flavour, colour etc. make the practical use of irradiation difficult or impossible. The third group of major useful influences is the killing or sterilization of insects, leading to the great promise of food disinfestation by ionizing radiations. There are many other isolated instances when preservation of foods or their desirable modification can be accomplished by radiation.

There are two major types of sources of ionizing radiations which are currently considered as useful for food preservation. These are the electron accelerators of various kinds and the radio-active isotopes, the latter being usually derived as by-products of reactor operations. Both types have advantages and disadvantages. Electron accelerators are expensive and intricate machines and are able to deliver radiation of low penetrating power. Therefore, in their use, the food or food container must not be more than a few centimetres thick, and, even so, irradiation may have to be done from two sides. As a result, it is difficult to attain a uniform dosage delivered throughout the package or product. On the other hand, the machine can be turned on and off, and does not need extensive shielding during transport or when not in use. Further, there are instances when shallow penetration is an advantage, as, for instance, in the irradiation of some fruit for the destruction of mold spores or spoilage organisms occurring on the outer surface.

In the use of radio-active isotopes—usually Co^{60}—extensive shielding is necessary, and the power of the source is continuously decreasing due to the comparatively short half-life of this isotope. On the other hand, the gamma rays produced have substantial penetrating power, making the irradiation of large packages, whole hams etc. possible.

There are some foods where sufficient background information is on hand to allow practical testing. Important promising products are: potatoes; dehydrated fruits; fresh fruits; marine pro'ucts; meat and meat products.

Two important points must be strongly emphasized. First, food preserved by radiation dosages now used or thought of for this purpose will not make the food radio-active. All foods possess some natural radioactivity of exceedingly low levels, which, however, are now often higher than before on account of atmospheric atomic explosions. The second important point is that thus far there is no indication that irradiated foods are in any way "cancerigenic" or that they contain new harmful constituents. The "wholesomeness" of irradiated foods have been more thoroughly investigated during the past twenty years than that of any other type of food. The use of some irradiated food-products has now been permitted in a few countries, but it is likely to take a few more years before this new method of food preservation is used on a large scale in commercial practice. There are several possible applications, for instance, the disinfection of cereals, dried fish and dried fruit, which provide methods of great potential use to the developing countries.

L. Storage

It is only during the last twenty or twenty-five years that serious attempts have been made in the developed areas of the world to handle and store crops and processed produce in ways which minimize deterioration. There is, therefore, a tremendous challenge to ensure that in the developing areas of the world also, storage facilities are improved. It is often not sufficiently realized how great the damage can be in the form of high losses, including decrease of quality and other important drawbacks, such as loss of nutritive value, as a result of faulty storage. The little information available on the quantitative aspects of food losses was mentioned previously.

In dealing with storage problems in developing countries, it should not be forgotten that most of the knowledge on modern storage techniques and facilities derives from countries in temperate zones and has, therefore, only limited application under the climatic conditions prevailing in tropical countries, especially in the monsoon areas.

For the right application of modern storage techniques, it is necessary to understand the main causes of losses and quality deterioration during storage. They can be divided into two main groups: (*a*) moisture and temperature; and (*b*) insects and rodents.

While the damage done by insects and rodents is more or less obvious, the influence of too high moisture and temperature on deterioration during storage is an indirect one leading to: (*a*) such biological changes as respiration and germination of seeds; (*b*) chemical changes by oxidation and hydrolysis; and (*c*) microbiological spoilage by moulds and bacteria.

High humidity during storage and too high a moisture content in the stored produce can also lead to a combination of microbiological and chemical processes resulting in spontaneous heating and, at times, combustion. In addition, excessive moisture and temperature of the stored produce create favourable conditions for insect activity.

Two methods of storage are used: in sacks; or loose in bulk in a variety of containers. The advantages and disadvantages of sack and bulk storage may be summarized as follows. Storage in sacks provides flexibility of storage, is partially mechanizable; allows only slow handling with much spillage; demands low capital cost but high running costs; and the loss from rodents is potentially important. On the other hand, bulk storage is inflexible, mechanizable, allows rapid handling but little spillage; requires high capital cost but low running costs; no rodent losses need to occur.

From the main causes of losses and deterioration follow automatically the main essential features of storage buildings: they must be watertight; they must not allow the entry of rats and mice; and they must assist rather than hamper the control of insect pests.

The building design should also specifically control the entry of moisture, as:

(*a*) Moisture introduced during construction;

(*b*) Moisture entering the store from outside by rain penetrating the walls and through the roof, or by water or water vapour rising from the ground through floor and walls;

(*c*) Moisture condensed from water vapour in the air at night. The design of a storage building should also take into consideration the temperature conditions which will be obtained under the prevailing climatic conditions.

The scope of this paper does not permit a discussion of constructional details, but a few important points might be mentioned shortly, viz., the importance of selecting a good site and having good foundations; careful selection of damp-proof materials for damp-proof courses and vapour barriers; and floors of well-cured concrete, the surface treated with a hardener. There is a wide variety of materials suitable for walls and roofs, which will give satisfactory results if carefully selected and properly applied.

Storage of produce in bulk is carried out in a range of types of containers and buildings, but commonly takes the form of storage in baskets or bins, especially constructed for the purpose. Above-ground bins are usually constructed on a plinth and consist of wicker-work and mud, metal (aluminium being popular), local brick or concrete. The efficiency of these bins depends upon the effectiveness with which insect infestation can be controlled, the degree of water damage which occurs and the ease with which they can be erected efficiently under local conditions. The principles of construction are, more or less, the same as already mentioned for sack storage buildings. If of suitable construction, a bin is automatically rodent- and weather-proof, and insect pests are readily controlled. It might be mentioned here that extremely interesting work is being carried out at the Haile Selassie University in Ethiopia on the satisfactory construction of grain silos.

III. Selected food and food products industries

A. General information

In the previous chapters, some of the economic factors and technological aspects relating to the food-processing industry have been briefly described. What now is the actual purpose of food processing? Disregarding the final preparation of food for eating, i.e., stewing, grilling, baking etc., the purpose of food processing can be broadly divided into the following three categories.

1. Conversion of raw materials into more edible or semi-processed produce

The most important process in this category is the milling of food-grains. Although the grain itself can be used as human food, its nutritional properties can be utilized much better if the grain is converted into flour and the outer shell removed. Processing of this kind also includes the extraction of sugar from sugar-cane or sugar-beet, extraction of oil from oil-seeds and the pounding of cassava and other tubers. In all these cases, wastage is reduced and, at the same time, by-products for other utilization as food or feed can be obtained.

2. Food processing as a means of preservation

Since most perishable products are harvested within a very short period during the year, but are confronted with a more or less continuous demand throughout the year, the food-processing industry has the task of preserving these products. Numerous ways of doing this are available, ranging from such primitive methods as salting and smoking to the most advanced types, e.g., food radiation preservation and accelerated deep-freezing. The method to be used will depend largely upon economic factors, the basic principle being that the cost of processing should be more than balanced by the reduction in losses. Preservation is of particular importance for fruits, vegetables and milk. Closely related to preservation, although not in itself a processing method, is the proper storage of food products.

3. Food processing as a means of meeting consumer demand

This category is directly related to the standard of living of the consumer population. The higher the standard, the higher the demand for further processing. For example, the butchery trade aids in utilizing the carcass in the best way to meet consumer demand by separating the various cuts and qualities of meat, which, incidentally, also leads to highest returns from the market. The preparation of food-mixes also falls into this category.

Obviously, it is very difficult to give any clear-cut distinction of food processing for the various types of food since the third category often overlaps with the first and the second. However, an attempt has been made to group the various commodities under the headings given above.

B. Wheat and bread

The major economic trends in the field of commercial flour-milling in recent years have been the tendency towards surplus milling capacity in developed countries and the spread of modern mills in developing countries in the last decade or so, especially in tropical countries which produce no wheat, or only very little. As the mills in those areas have been frequently established with the active encouragement and support of Governments, protective measures were introduced to safeguard their operations. As a result, several countries, hitherto flour importers, have switched permanently their purchases from flour to wheat grain, with adverse effects on the level of world trade in wheat flour.

The main reason behind the spread of commercial flour-mills in developing countries in recent years has been the desire: (*a*) to stimulate the economic growth by diversifying and modernizing the local industry, and providing new employment opportunities; (*b*) to meet the rapidly rising consumption requirements for wheat products out of domestic production, thus saving the foreign-exchange expenditure on flour imports in the first place and on wheat imports in the longer run; and (*c*) to meet the problems of storage and transport of imported flour under tropical conditions.

These objectives, however, must be carefully weighed against the following general considerations: (*a*) modern automatic flour-mills are highly capital intensive, with modest requirements particularly for unskilled labour (e.g., the ratio of capital investment per man employed in the milling industry in the United States of America is around $110,000 or more, which is one of the highest ratios in any industry); (*b*) there may be problems in developing markets for by-products of milling, which account for 25 to 30 per cent of the volume of wheat milled; (*c*) because of the low general productivity levels in most developing countries, almost any new industrial undertaking requires special measures of government protection, which tend to perpetuate themselves, and flour-mills have been no exception in this respect (e.g., in those countries where because of anti-inflationary policy (Libya) or for social reasons (Costa Rica), imports of flour have been recently de-restricted, this has led to the closing down of the mills, through their inability to compete with low-cost imports); (*d*) flour-mills require a continuity in the supply of wheat—hence the necessity for adequate storage facilities; and (*e*) the scarcity of capital in developing countries, which generally handicaps industrial development, has been an impediment also to the flour-milling in some countries.

The existing commercial flour-milling capacity in most developing countries appears to be somewhat over-extended. It is fully (or nearly fully) utilized in only a few countries (e.g., the Sudan, Turkey and the United Arab Republic), with several other countries working at below one-half of their annual capacity (e.g., Brazil, Colombia, Honduras, Lebanon, Libya and Mexico) and many others at less than three-fourths. Substantial excess capacity exists also in developed countries (both among exporters and importers) because of the stagnant consumption of wheat as food and the shrinking export outlets for wheat flour, but in contrast to this position, the under-utilization of capacity in developing countries reflects primarily the supply bottle-necks (i.e., the shortage of wheat and the scarcity of working capital).

Moreover, the information relating to commercial mills does not give the full picture of the over-all milling capacity in existence in developing countries.

In wheat-producing countries, there has always been a traditional milling industry, and although some of the primitive mills (usually cottage-sized units using stone grinders and located in villages) are being progressively modernized, small primitive mills still represent a substantial share of the total milling capacity in many countries.

The large majority of commercial mills in developing countries are privately owned and controlled, and they are often financed fully or partly from abroad. In non-wheat-producing countries, newly established mills are generally concentrated near the main population centres (i.e., near towns), while in wheat-producing countries, their location is more widely diffused, with a fair proportion of the total capacity placed in or near the main wheat-growing areas.

An important corollary of the expansion of the flour-milling industry in developing countries has been the creation (or extension of wheat food and food products processing industries (e.g., bakeries, paste plants and other specialty manufacturing enterprises) in a large number of countries, associated with a declining use of flour in individual households, the setting up of live-stock-feed plants in some countries (e.g., Ghana, Libya and Nigeria) and the creation of a profitable export trade in by-products of milling, such as the steady increasing shipments of bran from the Philippines to Japan; exports from Senegal to Denmark, Guinea and the United Kingdom; and Nigerian exports to the United Kingdom.

Two most significant technological developments in wheat utilization during recent years include: (*a*) turbo-milling or air-classification of flour; and (*b*) mechanical dough development.

Turbo-milling or air-classification of flour is, in principle, the separation of flour into fractions of different protein content by means of a vortex classifier using centrifugal force in an air medium. During normal milling of flour, the endosperm cells are broken apart. Upon further milling of the endosperm pieces, some of the starch and protein are separated into discrete pieces; the protein chunks are irregular in shape and small in size (mostly below 20 microns), while the starch pieces are round and usually larger. The flow-dynamics properties (size, shape and specific gravity) of the different particles permit separating into size ranges where protein matter is enhanced or depleted in the material. Since turbo-milling is new, the limits of its possibilities are not known, but at the current time, flours rich in protein (above 20 per cent) and flours low in protein (below 6 per cent) are beginning to appear on the market. On a laboratory scale, flours of more than 35 per cent protein have been produced. Research is currently under way to determine the effect of other particular materials than protein, such as enzymatic activity (primarily diastase) and colour, which appear in higher concentration in the particle size fraction below 20 microns after air-classification, on bread-making. In view of the existing knowledge of enrichment of flour with selected amino acids and vitamins, flours prepared by turbo-milling may be enriched with amino acids and vitamins to produce high-protein food suitable for infant and child feeding. These possibilities, however, require further investigation.

Mechanical dough development might be defined as the expenditure of sufficient mechanical energy within a mass of dough to bring about, within a few minutes, such structural changes as would otherwise occur only after several hours of fermentation. Mechanical dough development can be achieved by one- and two-stage continuous mixers, batch-mixers and continuous sponge plus development units.

It is recognized that some of the above-mentioned new developments in cereal technology have their widest application in the technologically advanced countries. To assist member nations, FAO is now preparing to embark on a comprehensive bread-improvement programme for countries in the Southern Mediterranean and Near East regions. At the current time, surveys of the individual countries are being made to assess the magnitude of the needs regarding bread improvement. Based on the results of these surveys, it is expected that plans will be defined and implemented regarding:

(*a*) The establishment of regional grain, flour, and bread laboratories to provide the required chemical analysis and technological evaluation;

(*b*) The establishment of model commercial bakeries to introduce improved, but locally applicable methods of bread-making; and

(*c*) The establishment of training courses, on a regional basis, to train bakers, technicians, mill operators, analysts and foremen.

C. Rice

There are two conflicting issues underlying the decisions regarding the expansion of rice processing in developing countries. First, most of the traditional rice-producing countries appear to have a theoretical excess of milling capacity in physical terms; secondly, much of this capacity consists of crude or out-dated machinery on a small scale, which may or may not require replacement, depending upon the economic circumstances of particular countries and localities. In India, for example, the government policy is to protect the hand-pounding industry, which gives more nutritious undermilled rice and provides ten times more employment for the same quantity processed. At the same time, the larger commercial mills play a crucial rôle in the marketing and distribution of rice, and the Government has decided to try to dominate the industry by establishing a large number of publicly owned modern mills during the Fourth Plan. Here, the main motive is to give the Government a firmer grip on the entire marketing system. In many countries, for example, the Republic of Korea, the processing facilities are very small and require modernization, but the Government prohibits new construction because the current capacity is considered excessive. Similarly, Madagascar is closing down several of its obsolete rice mills, even though production is rising. At the same time, Ceylon wishes to erect more modern types of mills but lacks the capital resources, while Burma is establishing quite a number of modern mills.

In short, there is no simple relationship between a given increase in production and the extra milling capacity which will be required. This has to be assessed very carefully, country by country, and will depend upon the structure of the market and the capital resources of the country.

As regards international trade, virtually all rice exports are in the form of milled rice or husked rice.

This contrasts with the pre-war position, when a substantial proportion of paddy was exported from the Far East to Europe. Today, European processing of imported rice is limited to the final polishing stage of husked rice. Husked rice receives preferential tariff advantages so as to protect the European milling industry in the Federal Republic of Germany and the United Kingdom, but only about 5 per cent of world trade is in this form, and this is not an important policy issue. In any event, a large part of such exports originate from the United States of America.

Processing at commercial level through medium- or large-scale mills is only justified when there is enough concentration of paddy production to keep a large installation running throughout the year. The setting-up of such mills usually involves high capital investment, but it does not really involve great technical problems, since modern processing equipment and the relative techniques developed in the industrialized countries can easily be transferred with minor adaptations into any area.

As rice is the only food-grain consumed in the whole state, modern milling facilities are of great advantage, especially if such mills have paddy-drying and storage facilities, so that the moisture level of the paddy can be adjusted when necessary, thus reducing the amount of broken grains. Furthermore, such mills will separate the bran from husk and brokens so that this valuable by-product can be further utilized.

By considering this commodity in greater detail, losses appear to be severe at various levels. They begin when the crop is still standing in the field, and continue until the product has reached the table of the consumer. Some countries are reporting 30 per cent losses of the total production; other countries are reporting even higher figures, up to 50 per cent, but, in general, the figures are unreliable and very rough since no attempt has ever been made to assess in a scientific way the amount of rice which is actually wasted, including a heavy loss in quality from a nutritional point of view.

A good part of the grain may go to waste during milling, and this may be determined by two different factors: the bad quality and poor adjustment of the milling machinery; and the previous infestations or deterioration which made the grain unfit for milling. A proper moisture content prior to milling also has considerable influence on the quality and quantity of the end-products.

The reduction of rice wastage during the pre-processing stage does not require any appreciable capital investment. As pointed out on several occasions by the International Rice Commission, it requires applied research activities on a pilot basis to be conducted under the leadership of experts. The purpose is to determine such simple measures as the opportune harvesting time, good harvesting techniques, proper threshing and improved methods of drying, which can be both natural or artificial. Once the improved techniques have been developed the programme must be extended through training and demonstration in order to disseminate the improved methods among the farmers.

The storage also requires some applied research work, since the current knowledge of modern techniques is derived from industrial countries, which are mainly in the temperate regions of the world. This knowledge has only limited application under tropical conditions, particularly in the monsoon areas, and it is therefore necessary to conduct experimental research activities within such areas to ascertain local requirements.

Central storage involves less research work since there are various examples of modern, large and efficient storage facilities installed under tropical conditions to provide enough data for similar initiatives. On the other hand, central storage requires organizational effort because a large installation must be operated by skilled personnel, and it also requires appreciable capital investment.

D. Sugar

The total sugar production of Africa, as reflected in the statistics, is about 3 million tons, of which almost half is exported as raws, mainly from Mauritius, Réunion and some other countries. There is, on the other hand, a substantial volume of imports, partly in the form of refined sugar, with the result that the total sugar consumption of Africa is about 3.2 million tons, or about 11 kg *per capita* per annum. Actual consumption might be slightly higher, as the above-mentioned other sources, e.g., palm sugar, are not included in this figure. At any rate, as the consumption *per capita* per annum in Africa is only about a quarter of the consumption in the United States of America and about a third of the consumption in Europe, there seem to be great future possibilities for the increase in sugar consumption and for the expansion of the production for the local market. Whether there are also possibilities for the expansion of sugar exports is another question.

By-products of the sugar industry include alcohol from molasses, cattle-feed from sliced beet and paper from crushed cane; these are beyond the scope of this section. The present note is confined to the sugar-refining industry.

The bulk of sugar enters trade in the form of raws. Bulk handling, which is possible for raws, cuts costs, while importing countries with sugar industries prefer to use their own factory capacity for refining (the economic size of a refinery is considerably larger than that of a factory producing raw sugar). There is, therefore, little scope for extending refining among exporters in Africa. The bulk of shipments from Mauritius and Réunion are raws; Madagascar exports a small proportion of refined sugar to countries on the mainland, and Ugandan shipments to Ceylon are in refined form. The Congo (Brazzaville) and the United Arab Republic export refined sugar to adjacent countries with which they have historic connexions, and Ethiopia has developed a trade in refined sugar with countries of the Middle East.

The development of refining industries in importing countries is already under way in Africa; it has been developed, for the most part, as an adjunct to the domestic cane or beet industry. Morocco is an exception —a domestic sugar-beet industry is currently being developed, but two-thirds of the imports of sugar have been raws, refined locally. Domestic sugar-beet production in Algeria has ceased, but a proportion of imported sugar still comes as raws for domestic refining. The bulk of the sugar imported into the United Arab Republic is now raws and is refined locally, supplementing domestic production. Despite the recent development of cane cultivation in the Sudan, however, imports of refined sugar still continue. Kenya processes raw sugar from Uganda and the United Republic of Tanzania, but it still has to import refined sugar from elsewhere. Tunisia has increased the proportion of sugar imported in raw form, while Libya plans to replace three-quarters of its imports of refined sugar by raws to be refined in the country. Ghana and Nigeria, which so far have depended upon imports of refined sugar, have plans to develop sugar-cane production and may eventually be able to use their refining capacity to process imported raws.

Under the sugar plan of the French Community, the territories of West and Equatorial Africa were supplied with refined sugar from other members of the Community, particularly France; the quantities imported into the Ivory Coast and Senegal are substantial, but no plans to establish a domestic industry have been reported.[3]

In case the establishment of a modern sugar industry may not be economical, consideration should be given to the processing of non-centrifugal sugar, which can be carried out in smaller and inexpensive plants (gur, jaggery). FAO has been giving assistance to such operational field projects in Africa, and elsewhere, partly with gifts of equipment supplied under the Freedom from Hunger Campaign.[4]

The essential difference between the simple method of making non-centrifugal sugar and the modern methods of processing centrifugal sugar is that in the latter case the juice is concentrated under vacuum, therefore at a much lower temperature, and that crystals and molasses are separated in centrifugals. For the rest, the various stages are performed much more carefully and on a much larger scale.

A modern sugar factory with its expensive equipment is only economic for higher capacities of many hundreds and even thousands of tons of cane per day. This requires a good organization of cane transport to the factory, by car or by rail, and good roads. In some developing countries, such a regular cane transport is difficult because of lack of good roads or rail facilities. Sometimes, the chosen solution is then sugar manufacture in two stages. Juice extraction from cane takes place in various local mills, and only the juice is transported to the central boiling-station. Sometimes the juice is concentrated in open pans to syrup or to non-centrifugal sugar; in the latter case, the crude sugar is dissolved again in the central plant and recrystallized. Such a central plant is then called a refinery, but it usually differs in methods and also in the quality of the final product from the proper refineries that refine centrifugal raw sugar.

While such a system might be a temporary solution for transport problems over greater distances, it is less efficient, from a technical point of view, than a modern central sugar factory.

From a technical point of view, the sugar industry is rather an "old" industry, as the basic principles of "modern" sugar manufacture, as extraction by a mill-train, clarification methods, use of filter presses, multiple effect evaporation, sugar boiling in vacuum etc., were invented long ago and are partly more than a hundred years old.

Machinery is, of course, steadily being improved and being made more efficient, with a general trend to make all processes continuous. Juice extraction from cane has, in the mill-streets, always been a continuous process, but extraction from beets in diffusion batteries was originally done in batches and has only in recent years been developed into a continuous process. Continuous processes have also been introduced for the clarification of the juice, for its subsidation and filtering. Juice evaporation in multiple effects has always been continuous, as has sugar drying. Centrifugals are usually still working in batches, but the trend here is also towards continuously working separators. Continuous and automatic sugar-boiling from syrup to massecuite, the dream of many a sugar technologist, is, in spite of many attempts, still an unsolved problem.

In the chemical field, the modern plastic ion-exchangers have introduced a new principle, which, by the removal of "molasses-forming" Na and K cations, makes it possible to reduce drastically losses in molasses. Other trends are the introduction of automatic-control instruments, with the ultimate aim of complete automation.

E. Fruits and vegetables

In determining whether to establish processing plants for fruit and vegetables (or for any other commodity), Governments must have some knowledge of the market outlook, both domestic and foreign. Generally speaking, consumption of processed fruit and vegetables is currently confined mainly to high-income countries. In many of the countries of the African and Near East regions, even fresh fruit and vegetable production is geared to the export market and there is ample room for expansion of domestic consumption of the fresh product before cultivating a taste for the more expensive processed items. It would seem, therefore, as experience in North and West Africa would appear to indicate, that processing establishments in developing countries would have to aim primarily at the export market.

Data on trade in processed products are extremely limited, but available statistics indicate that demand for processed fruit and vegetables in the high-income countries of Western Europe, in particular, has been expanding rapidly and at a considerably higher rate than has trade in fresh fruit and vegetables. For example, imports of orange juice, expressed in terms of fresh fruit equivalent, have more than doubled (from about 350,000 tons to 700,000 tons) during the past four to five years, and it is estimated that the demand for citrus juices will be sharply accelerated. Similarly, the trade in canned peaches, canned pineapples and processed tomatoes has shown a steadily increasing trend, and, no doubt, there is a potential outlet, although probably more limited, for the other tropical fruits, such as canned mangoes, lychees, papaws, passion fruit, tropical-fruit salads etc. Blending of tropical-fruit juices with more common types of juice may, however, show further outlets, especially for sophisticated markets, but this subject requires further investigation.

The first prerequisite for any processing establishment is, of course, an adequate supply of the fresh product. In West Africa, for instance, the pineapple

[3] W. N. Lewis, Report on Industrialization on the Gold Coast (Gold Coast Government, 1953).

[4] See Food and Agriculture Organization of the United Nations, "FAO's relations with industry through the Freedom from Hunger Campaign" (E/CN.14/AS/IV/3), paper prepared for the Symposium on Industrial Development in Africa, Cairo, 27 January-10 February 1966.

200,000 to 400,000 tons per annum, and the absence of taxable profits at this level.

Bauxite production was begun in British Guiana in 1917, requiring the construction by the Demba company of a complete town in an entirely undeveloped area 60 miles from the sea-coast. In 1960, the population of the area around the town was about 12,000 and employment for the company, about 2,000. The community is isolated from the population centres on the sea-coast and enjoys higher quality schooling, housing, medical care and recreation, and higher wage rates. It illustrates a condition found in other developing countries where enterprises of this type frequently introduce improved levels of living to a small part of the population, making a sharp contrast to those of the rest of the population.

The Government of British Guiana has been deeply concerned with the need to improve the national economy through diversification. The Government has engaged in a limited amount of study of bauxite resources on government lands, which constitute most of the country, and has had technical assistance from the United Nations, the United Kingdom and the United States of America in other surveys, including the hydroelectric potential. The political conflicts within the country had caused the Reynolds company to refrain from enlarging its very limited scale of production, although another causal factor may well have been the adequate bauxite reserves held by the company in other countries. The same political frictions did not keep the Demba company from making substantial additional investments to enlarge production. One factor in this case is the profitable and substantial international market served by the company for uses of the high-grade British Guianan bauxite in making abrasives and refractory products. The company meets much of the world demand for these grades of bauxite. Another factor has been the importance of the company's investment, about $70 million in 1961. This included a $36 million alumina plant completed that year, having a capacity of 230,000 long tons per annum.

This plant was the result of a contract made with the Government of British Guiana in 1957, then under direct rule by the United Kingdom, following the suspension of both the constitution and the previous Jagan Administration of 1953. This contract was adopted the same year as a similar one with the French Colonial Government of Guinea, but in the case of Guinea, the alumina plant was never built; and in the case of British Guiana, it was completed. One reason for the difference in outcome is that the bauxite in British Guiana had already been long established by the parent company in Canada as a major source of its bauxite and represented a large investment already made. Another reason is that the additional investment required in British Guiana was much less than that required for Guinea. Still another reason was that the British Guiana contract offered a five-year income-tax holiday as an inducement, along with temporary exemption from import duties. The arrangement assured the company of additional bauxite concessions along with the existing concessions for a period of seventy-five years. The Government was guaranteed minimum income-taxes from bauxite during the five-year tax holiday on the alumina plant and also obtained higher royalties. The Government expected to obtain the benefits of an increase in employment of about 700 persons and greater revenues from taxing alumina operations, owing to the greater profitability of converting a ton of bauxite into alumina instead of exporting it for conversion elsewhere.

British Guiana, like Surinam, enjoys the position of supplying bauxite primarily for the North American aluminium market, the largest in the world. The two countries also serve the two largest private aluminium producers in the world. The only larger aluminium enterprise is that of the Soviet Government itself. Both countries have high-grade bauxite, suitable for profitable uses aside from conversion to aluminium. Both have additional bauxite reserves inland from the coast that could be developed, provided transportation becomes possible at low cost, or provided low-cost power becomes possible from water-power, petroleum or gas if discovered, or atomic-energy installations. Surinam will shortly have an integrated primary aluminium industry. British Guiana may have one some day, provided the condition of suitable power is met, as well as the condition of internal political stability. In both cases, the bauxite-alumina-aluminium industry is unlikely to provide a significant amount of employment, as compared with agriculture and forest products, although the industry should continue to make important financial payments to the Governments.

C. Jamaica

The small island of Jamaica in the Caribbean has the distinction of becoming, only eight years ago (1957), the largest producer of bauxite in the world. The Colonial Government's Department of Agriculture, through soil tests, actually discovered the presence of bauxite during the years 1938-1942. Interest in the bauxite began as a matter of national defense with the United Kingdom Government and then with Aluminium Limited in 1942, when the German submarine campaign sank many bauxite ships moving from Surinam and British Guiana to the United States of America. Tests showed that Jamaica bauxite was different in chemical and physical characteristics from the South American type and could not be used in existing alumina plants, but the bauxite was acceptable, provided alumina plants were designed or modified to process it.

Aluminium Limited was first in Jamaica, but it was quickly followed in 1944 by Reynolds. The Canadian company asked the Government to nationalize the bauxite reserves on private lands in order to facilitate mining and to reduce problems that might arise with landowners. In 1946, the Government moved to nationalize the bauxite and thereby also obtained the right to claim royalty. Following the end of the Second World War, Kaiser Aluminum came and also found bauxite in Jamaica. All three companies purchased private lands and acquired bauxite reserves estimated at some 600 million tons. The Government of the United States of America further stimulated events by making loans in 1950 for the Jamaican development to the Canadian company and to Reynolds. While the companies from the United States of America prepared to mine bauxite and ship it to alumina plants in the region of the Gulf of Mexico, the Canadian company began construction of an alumina plant in order to save on the transportation costs by moving 1 ton of alumina instead of 2.4 tons of bauxite. The companies in the United States of America did not have the same incentive to build alumina plants in Jamaica, because of a tariff imposed on imported alumina by the United States of America and the fact that the alumina capacity they already had could be adapted to the Jamaica bauxite. The first bauxite was exported in 1952 and the first alumina in 1953, and within five years, Jamaica had become the world's largest producer of bauxite. The Canadian company steadily expanded the capacity of its alumina plant and then built a second plant. In 1957, the American Metal Climax Company obtained a bauxite concession and, being unable to develop it within the terms of the lease, sold it to Alcoa, which began production in 1963. The Harvey Aluminum Company also has a lease on bauxite lands, but it is currently inactive in Jamaica.

The three companies in the United States of America have invested over $60 million in the bauxite developments, and the Canadian company, over $100 million. One of the companies has launched a $30 million expansion programme. When completed, the total investment of the bauxite-alumina industry will be about $200 million, most of this in foreign currency. The approximate current annual production capacities are about 7 million long tons of bauxite for exportation and 850,000 short tons of alumina, also for exportation. These quantities are enough to support nearly one-third of the 1963 world production of 6 million short tons of aluminium. All of the Jamaica bauxite exports go to the United States of America and contributed about half of the aluminium production of that country in 1963. Nine-tenths of the Jamaican alumina goes to Canada and Norway.

Jamaica has a population of about 1.6 million, forming a relatively high density on the island's 4,400 square miles. In 1960, the labour force was about 650,000 persons, with one out of seven unemployed. The country has been politically stable. One contributing factor has been the influence of British law and methods of government supporting the growth of political democracy since the United Kingdom granted the adult right industry is geared to the processing sector, but in North Africa and the Near East, the processing sector, to the extent that it exists at all, is regarded as purely residual, to be used only to absorb surplus quantities of fresh fruit. For instance, Moroccan citrus juice factories have been consistently operating with considerable excess capacity. This is because of the low price paid by the processors. Farmers are naturally most reluctant to deliver high-quality table-fruit to the processors, except as a last resort, and it would seem, therefore, essential to base a processing industry on an assured supply of low-cost varieties suited for processing.

The question of varieties needs some elaboration, as varieties suitable for the fresh market are often not suitable for processing purposes, particularly for juicing. For manufacture of citrus juice, for example, suitability depends generally upon juice content of the fruit combined with the sugar content. In the case of oranges, bitterness can be a problem; and, for this reason, as well as for their low juice content, navel oranges are generally unsuitable for processing. Another undesirable quality is the formation of precipitate in the juice, which is largely a characteristic of juice from blood oranges. Oranges of the common *blonde* or the *shamouti* varieties are also unsuitable because of low sugar content, lower juice yield and flat flavour. On the other hand, the "Valencia" variety generally possesses the ideal requirements for processing. Similar considerations apply to other fruits and vegetables.

Labour supply, fuel and power facilities etc. are also limiting factors. For obvious reasons (shortage of capital and skilled labour, for example), processing techniques must be simple. For instance, developing countries may not be in a position to manufacture frozen concentrates, but could produce hot-pack fruit juices. However, even for a hot pack plant, establishment costs are fairly high (the machinery would have to be imported), and, for this reason, the importance of operating at full capacity needs again to be stressed. Cans and other components would also probably have to be imported.

The establishment of efficient marketing channels is another obvious pre-requisite. Although global prospects for processed fruits and vegetables are favourable, the market is, nevertheless, highly competitive, and it is important to know where the market is and how to obtain a share of it. In this connexion, developing countries might encourage firms with experience in the production and marketing of processed fruit and vegetables to invest capital and to help supply the necessary technical and commercial knowledge.

The final determinant of profitability depends, of course, upon the price obtained, balanced against costs of production and marketing. It should be possible to estimate prices or a range of prices likely to be obtained on any given market and to work back from there to the production point. Proximity to markets is obviously not as important for processed products, as there is no question of deterioration *en route*. Nevertheless, transport costs are still significant. It is a little difficult to see African and Near Eastern countries exporting large quantities of processed vegetables, although canned tomatoes could be a notable exception. However, for canned fruits and especially fruit juices (notably citrus and pineapple), prospects are more promising, provided projects are carefully thought out and well integrated, and marketing and distribution channels are well organized. This sector of industry is a good example of the close relationship that has to be created between agriculture and industry, as, otherwise, a profitable operation will not be the result.[5]

It may be interesting to mention that many Governments of the regions are still thinking in terms of shipping fresh fruit and vegetables under refrigeration to Western Europe, rather than processed products. The idea of cold chain transportation attracts countries which are not too far distant (a symposium on the subject was held in Beirut from 20 to 28 September 1965). For more distant areas, however, shipping of processed products would be the best possibility.

F. Nuts

The most important edible nuts of the trade (not considering here coconuts and cocoa beans) are, in alphabetical order: sweet almonds, *Prunus amygdalus;* Brazil-nuts (paranuts, butter-nuts, castaneas), *Bertholettia excelsa;* cashew-nuts, *Anacardium occidentale;* sweet chestnuts, maroons, *Castanea spp.;* filberts and hazel-nuts, *Corylus spp.;* hickory nut, pecan nut, *Carya spp.;* kola-nuts, cola-nut, *Cola acuminata* and other *spp.;* macadamia nut, Queensland nut, *Macadamia ternifolia;* Pistachio nut, pistache, green almond, *Pistacia vera;* walnut, *Juglans spp.*

With the exception of the cola, none of these trees is a native of Africa, many preferring a cool or temperate climate, but some have been introduced successfully in Africa, e.g., almonds and chestnuts in North Africa, pecan nuts in Natal and cashew-nuts in East Africa and also in many countries of West Africa. The production of cashew-nuts in Africa is estimated at about 100,000 tons. For cola-nuts, the estimate for West Africa is 50,000 tons, of which 5,000 tons are grown in Nigeria.

There are many less known nuts in Africa which have only local significance as edible nuts, some of them, however, being exported as raw material for the production of "vegetable butters".

Edible nuts are marketed either "unshelled" or "shelled" ("kernels"), and are graded according to country of origin, to size (large, midgets, medium, chipped etc.) and to damage (wholes, halves, splits, pieces, broken etc.).

For unshelled nuts, processing consists of cleaning and grading. For the production of kernels, the nuts have to be shelled, which is usually not an easy processing operation, as damaging of kernels has to be avoided. Quite a number of very specialized machines are on the market. For example, for almonds, the green hulls are removed with almond huskers, while the hard shell is cracked with special almond hullers. Almonds are further blanched by removing the skins in a blanching machine after scalding. Similar machines exist for peanuts, Brazil-nuts and other nuts. Further processing depends upon the use of the nuts and can consist of slicing or stripping, splitting, nibbing, grinding etc., and also of roasting, dipping, coating and similar confectionery treatments. For all such treatments, suitable modern equipment is available.

[5] See Food and Agriculture Organization of the United Nations, "The economic significance and contribution of industries based on renewable natural resources and the policies and institutions required for their development" (E/CN.14/AS/III/1/7).

Some nuts pose special processing problems, as, for example, the removal of the husks of the macadamia nuts, for which special equipment has been developed. Extremely difficult is the cracking of some palm nuts, such as babassu nuts and cohune nuts, which are too hard for direct eating (just like palm kernels) and are used for oil extraction. They have, however, no significance for Africa.

A serious problem for Africa is the processing of cashew-nuts. Here, the difficulty is caused by the peculiar form of the kidney-shaped nuts and by the fact that the shells contain the cashew-nut shell liquid, which consists of anacardic acid and cardol, which are very aggressive substances for the human skins. Shelling meets, therefore, the double problem of avoiding damage to the kernels and of preventing spoilage of the kernels by the phenolic shell liquid. It is, therefore, still mainly done by hand after previous roasting of the nuts and is a dirty and cumbersome work requiring special skill. Lack of a simple mechanical processing device has hampered greatly the expansion of cashew-nut production in Africa.

In the last few years, not less than three mechanical and partly automatic cashew-nut processing plants have been developed in Italy, and the first plants have been installed in the United Republic of Tanzania. These plants operate on a large scale and require considerable capital investment.

G. Cassava food products

There are quite a number of products that can be produced from cassava tubers, food as well as food products, and others for technical applications. These products have the advantage that they are durable and can be stored, while cassava tubers in unprocessed form have to be consumed within a day. In Africa, however, the only durable product from cassava is *garri*, and it is only processed by housewives in their kitchen. The large producers of durable cassava products (more commonly called tapioca products), for local consumption as well as for exportation, are in Asia, viz., Indonesia and Thailand.

The more common cassava products are:

(a) *Products utilizing portions of, or the whole root:* food products (usually for local consumption):

(i) Cooked roots; cooked and fermented roots (Indonesia);

(ii) Farinha, a granular, slightly fermented and slightly roasted product (South America), similar to *garri*;

(iii) *Garri*, a fermented and gelatinized product (Ghana, Nigeria);

(iv) Couac or cassava bread, similar to farinha, but more intensively roasted (South America);

(v) *Landang* or cassava rice, also similar to *garri*, but coarser, consisting of pellets (Philippines).

(b) *Products utilizing only the starch from the roots:* food products (for exportation and local consumption):

(i) Tapioca flour, pure cassava starch;

(ii) Baked products like seeds (sago), pearl, flake etc.;

(iii) Starch syrup or glucose, made from tapioca flour;

(iv) Mixed food products, such as "tapioca macaroni".

The main need for Africa, as a large producer of cassava, is the processing of cassava to durable and marketable products, for local consumption as well as for exportation.

For the local market, durable food products are most important, such as the typical African product, *garri*. Processes have been worked out for the mechanical manufacture of *garri*, especially in Nigeria. Next to *garri*, the manufacture of tapioca flour in small scale, and medium size factories should be considered, with the flour to be used for such products as sago, tapioca macaroni, tapioca biscuits, as an admixture to baker's flour and for various other food products.

For export, tapioca chips, tapioca meal and tapioca flour should be considered, but competition with such countries as Thailand is only possible if such export products can be manufactured at a sufficiently low cost. To this end, in the first instance, the production methods in the field have to be improved, better varieties should be introduced and other cultivation measures be taken in order to increase the yield of starch per acre.

Once a sufficiently cheap raw material is available, tapioca flour for exportation, according to standards of the United States of America, should be produced in modern factories, while chips and meal can be produced with simple equipment and small investment.

H. Oil-seeds

Practically all commercially important oil-seeds are grown in Africa, such as ground-nuts, cotton seed, oil-palm kernels, sesame, sunflower seed, coconuts, linseed, soya beans and even rape-seed, the latter only in relatively small amounts in Ethiopia. However, the share of Africa in the world production of oil-seeds is still rather a modest one. Of a world production of some 86 million tons of above-mentioned oil-seeds, Africa produces less than 8 million tons, therefore less than 10 per cent. However, the significance of Africa for the supply of the rest of the world is much greater than this figure indicates because most of the African oil-seed production is exported. As a supplier, Africa is the second largest exporting region of the world, next to the United States of America.

The various oil-seeds are of widely differing significance for Africa. Africa is the largest producer of oil-palm products with about three-quarters of world production, mainly from the oil-palm belt which is so typical of the west coast of the continent. Of ground-nuts, another important oil-seed, almost one-third of world production is grown on African soil. The African share of world sesame production is about 20 per cent, while of the other oil-seeds, less than 10 per cent of the world total is produced in Africa.

Production of oil-seeds within the countries of Africa varies greatly, of course. A large producer is Nigeria, producing about half of all the palm kernels of Africa and about one-third of all the ground-nuts. Of the African soya beans, in total only about 40,000 tons, Nigeria produces 70 per cent and is still expanding.

The second largest producer of palm kernels in Africa is the Democratic Republic of the Congo, with 16 per cent of the total African production, and the second largest ground-nut producer is Senegal, with almost 20 per cent of the African ground-nut production. About half of all the African sesame seed is produced in the Sudan, and about half of all the cotton seed in the United Arab Republic. Of linseed and rapeseed, Ethiopia is the main producer.

A very high percentage of the oil-seeds produced in Africa is exported, either as such or in the form of oil. Fat consumption *per capita* per annum in Africa is in general, rather low and consists—as far as vegetable sources are concerned—partly of fruit oils as, e.g., olive oil in Morocco, Algeria and Tunisia, and palm-oil in most countries of West Africa. Palm kernels have the character of a by-product of palm-oil processing and are therefore considered as a kind of cash crop.

Thus, in spite of rising consumption in Africa, the high ratio of exports to production of oil-seeds has allowed a rising trend in the volume of exports.

The share of oils in the total exports of oils and seeds is slowly increasing. For example, in Senegal, where a substantial crushing industry was established during the Second World War, about 50 per cent of the ground-nut exports are currently in the form of oil and cake. The ground-nut oil exports of Nigeria are smaller than those of Senegal, but the crushing of ground-nuts has increased slowly but steadily, and most of the oil is exported. In the Democratic Republic of the Congo, crushing of palm kernels for oil for both the domestic market and exportation, was encouraged during the 1950's, and exports of oil rose from 25 to 85 per cent of the total (including kernels, in terms of oil).

Apart from the small share of oil-seeds consumed as such, all oil-seeds must be processed. This is, technically speaking, a fairly simple process of extraction of the oil by pressure or by the use of solvents and its subsequent refining, if meant for human consumption. More advanced forms of processing include the improving of the oil-cake for human consumption. This is not yet commercially important. Oils (and such fats as tallow) also become the main ingredients of soap and of margarine.

Since both oil-seeds and their processed forms of oil and cake or meal can be stored or shipped quite satisfactorily and because their weight and bulk are approximately the same in both processed or unprocessed forms, there is technical freedom of choice as to the location of processing. (The fruits of oil-palm and olives are exceptions).

When oil-seeds are to provide food or feeding-stuffs for local consumption, they must normally be processed within the producing area. There are, however, large exports of oil seeds from developing countries, chiefly to Western Europe and Japan. Some developing countries (e.g., Argentina, Ceylon, Nigeria, Philippines, Senegal and Turkey) already process substantial quantities of oil seeds, but the bulk of exports from developing countries in this commodity group are exported as raw materials.

1. Problems and advantages

Problems encountered in processing more of these raw materials within the exporting country include:

(*a*) Competition from industries in importing countries protected by tariffs on processed imports, e.g., European Economic Community tariffs for oil imports from third countries are to be from 3-15 per cent, while oil-seeds enter duty-free;

(*b*) The unstable world market price, which processors in importing countries can offset more easily (by blending or switching between different kinds of seeds) than is possible in developing, exporting countries;

(*c*) The processing machinery is fairly expensive and must be mostly imported, and the processing tends to be capital rather than labour intensive;

(*d*) Need for a high level of technical and organizational skill in management;

(*e*) Substantial capital is required.

The advantages of processing in producing countries include:

(*a*) Export income is increased by the value added in processing;

(*b*) It provides more flexibility in choice of markets, e.g., the oil and the cake may go to different markets;

(*c*) In addition to the processing itself adding to the industrial base and employment of the country, it allows the establishment of associated industries, particularly soap and margarine, based in large part on local raw materials;

(*d*) The availability of oil-cake is useful in the development of a livestock industry.

With regard to the advisability of developing countries processing more of their oil-seeds for export, there is currently absolutely no consensus. Data are lacking on the comparative costs of processing in producing, as against importing, countries. The typical rates of return on the investments are not known. It is not clear whether a viable processing industry whose products are exported is generally possible in a developing country without direct or indirect government support.

2. Work in progress

Because no comparative study is available, FAO has undertaken an investigation. The FAO Study Group on Oil-seeds, Oils and Fats has asked that it be given a high priority. The International Association of Seed Crushers is expected to contribute information. The scope of the study comprises the economic aspects of the location of oil-seed processing, and it will include both general analysis and case studies. It will be presented to the session of the Group by approximately May 1966.

I. Meat

1. Africa

The African continent is relatively rich in livestock, among which cattle (about 112 million head) and sheep and goats (about 250 million head) are the most important. In most of the African countries, the productivity of livestock is relatively low because of primitive husbandry, poor feeding and widely spread animal diseases. The distribution of livestock is, moreover, very uneven, as in some areas, livestock raising, particularly cattle raising, is limited either by the prevalence of disease or the lack of water. There are, therefore, rather well-defined meat deficit and surplus areas on the continent.

At the current time, trade in live animals is the major means of bringing about a better balance of supply and demand for meat on the continent. While, in some cases, further investigations would be necessary to determine whether investments in meat-processing facilities or improvements in the trade channels for live animals would yield the higher economic returns, it is generally agreed that under current conditions, the trade in live animals involves serious economic losses resulting from the loss of animals, the reduction of weight suffered through the long journeys involved and the fact that when live animals are traded internationally the income from the "fifth" quarter accrues to the importing countries. The lack of meat-processing facilities also prevents some of the potential exporters from reaching more distant markets, or those outlets which might be open for processed meat products only. From the point of view of the supply of the internal markets of the countries under consideration, the current methods of trading and of handling of meat are wasteful and unhygienic, and result in considerable losses of income for the producers, as well as in higher prices to the consumers.

Meat processing is a chain of activities involved in the transformation of the live animal into dead meat for various end-uses. It can be a relatively simple operation, but it can also become a highly complex industrial process requiring substantial capital and technical and management skills. It is, therefore, possible—and, in most of the developing countries of Africa, desirable also—to consider the problem of investment in meat processing in regard to the whole range of technical facilities where improvements might lead to significant economic gains. For example, the establishment of slaughter-slabs or primitive slaughter-houses, where offals and blood could be saved, the meat inspected and the hides and skins flayed and cured properly, could already result in substantial gains that would fully justify the relatively small investment required.

The factory type of central *abattoir* providing for large through-puts, the fullest utilization of by-products and manufacturing facilities should be considered as the final stage in the development of meat-processing industries in countries or areas where large numbers of slaughter stock are available for distribution in major consuming centres or for exportation. Since from the point of view of international trade, it is the large-scale factory type of *abattoir* that is of primary importance, the remarks below pertain mainly to facilities of this type.

Thus far, the greatest progress in building up a meat-processing industry has been achieved in East and Southern Africa (Kenya, Madagascar, the United Republic of Tanzania, Zambia and Bechuanaland). Statutory bodies, such as the Kenya Meat Commission, which control large segments of the internal meat trade and have a monopoly on exports and imports, have contributed greatly to the development of the meat industry in these parts of Africa. Ethiopia also possesses a few meat factories, which were established mainly by foreign capital. In recent years, a number of other countries began investing substantial sums in slaughter-houses and processing plants. Notable advances are being made in this respect by the major livestock-producing countries in West Africa.

Meat-processing facilities in most of the above-mentioned countries were established mainly with the aim of producing exports to more developed countries outside Africa. Intra-African trade in (dead) meat is still relatively small, although it is expanding rather rapidly.

(a) *Advantages and problems*

The African livestock potential, the importance of livestock for the economies of many countries and the expected strong growth of demand for meat in Africa and in other areas, are all factors favouring investments in the meat industry within the region. The advantages resulting from further investments in meat-processing facilities include:

(*a*) Export income is increased not only by the value added in processing, but also through the additional export income, import savings resulting from the domestic processing of the by-products of slaughtering;

(*b*) Processing facilities will open up new, more distant and larger markets, among which Europe may be the most important, and will make the exporting countries less dependent upon their traditional outlets for live animals;

(*c*) Apart from the contribution of this industry proper to the industrial base of the country, investment in meat-processing industries would make it possible to establish related industries for the processing of hides and skins (tanneries, leather and shoe manufacture etc.) or the manufacture of blood-meal, bone-meal, meat-meal, meat extracts and other products.

The problems facing further improvement in meat-processing facilities include:

(*a*) Scarcity of technical and management skills and capital;

(*b*) Reluctance of livestock owners to sell and the resistance of established traders and distributors against changes that would be required in the traditional patterns of livestock marketing and distribution channels;

(*c*) Lack of co-ordination between the countries concerned in their development planning for the livestock and processing industries;

(*d*) The disease problem is still serious in many African countries and represents one of the greatest obstacles to entering foreign markets for frozen meat;

(*e*) The industrialization of slaughtering creates a transport problem and necessitates some kind of preservation. Refrigeration is one solution, but it has to be realized that the cold chain, once begun at the *abattoir*, has to be continued unbroken to the consumer. Preservation by salting, smoking and drying is mainly applicable to the domestic supply. Canning is of major importance where exports are concerned;

(*f*) Competition from traditional exporters of meat is strong both in quality and price.

The advisability of investing in the large-scale, factory type of *abattoir* will depend largely upon the availability of export markets. In some instances, however, the size and growth of the domestic market alone might justify such investments, particularly when there is scope for import substitution. It has to be stressed that the experience with such investments, in certain instances, underlines the importance of careful pre-investment surveys embracing the size of markets, as well as the possibility of obtaining supplies of livestock.

(b) *Work in progress*

The FAO, as part of its programme of work on the commodity problems of the developing countries, has recently completed a study on the problems of African meat trade. This study will be followed by further, more detailed investigations of the economic aspects of meat production, consumption and trade in Africa.

2. Middle East: Arab States

As most of the Arab States in the Middle East are net importers of meat, in the form of live animals, a modern meat industry would serve only the internal market. At the current stage of economic development (with the exception of some of the major cities) and meat distribution patterns, it seems that investments in the large-scale factory type of *abattoir* could not be economically justified. The current phase of development in these countries requires the organization and modernization of municipal slaughter-houses and their provision with refrigeration facilities and equipment for the utilization of by-products.

J. Poultry and eggs

1. The poultry industry in Africa and in the Arab States of the Middle East

Poultry is kept practically everywhere in Africa, and poultry products are important sources of animal protein in the diets of both urban and rural consumers. As in the case of other livestock, a major problem is to increase productivity through breed improvement, better husbandry practices and disease control. Since poultry are highly efficient converters of feed-stuffs into human food, have a high ratio of multiplication and are adaptable to a wide range of climatic conditions, investments in the development of local poultry industries appears to be one of the most promising means of increasing, at a relatively fast rate, the supplies of livestock products in Africa. As incomes grow, the demand for such products is expected to increase more rapidly than the demand for food in general. Although the consumption of eggs and other poultry products is hampered in some countries by existing taboos and customs, these obstacles can be overcome relatively easily, as has been demonstrated in several countries, and much could still be done to encourage the consumption of poultry products in both the urban centres and the villages.

Progress is being made in almost all African countries to develop the poultry industry; however, in contrast to the development of beef production, the promotion of poultry meat production in African countries aims primarily at the provision of the domestic markets, mainly in the larger cities, which, in many cases, are supplied partly through imports. In development programmes for this sector, attention has been paid generally to the improvement of both backyard poultry-keeping and large-scale broiler and egg production.

On the whole, the experience gained so far in these undertakings suggests that over the greater part of the developing areas of Africa, improvement of the local backyard poultry industry would be the most economical means of increasing supplies of poultry meat and eggs. This may not be the most efficient form of production, but advantage could be taken of food waste around houses and villages at little or no cost. Productivity could be greatly increased by simple measures designed to improve feeding, management and disease control. A further consideration is that, in contrast to the development of large-scale, commercial production units, investment in the development of the poultry industry at the village level is one of the most effective means of bringing about relatively rapid increases in farm incomes. Moreover, such development projects provide good opportunities for the introduction of co-operative production and marketing schemes.

As, in some African countries, the urban development, higher incomes and better standards of living are creating demands for products of better quality and in greater quantity than could be produced by the backyard poultry industry, there seems to be considerable scope also for intensive, large-scale poultry production, particularly around the major consumer centres. One of the drawbacks currently is the high cost of production in intensive, large-scale units relying mainly on concentrates. The high production costs and the resulting high prices of the products of these units, which are sometimes twice as high as the prices of backyard eggs and poultry, are caused partly by the large proportion of expensive, imported feeds in the rations. Therefore, one of the quickest ways to reduce production costs is the provision of cheap, locally produced, balanced rations. The provision of the required modern equipment for feed manufacturing would be a suitable subject for bilateral aid or various forms of international assistance. Such large-scale units also require modern egg-grading machines and improved egg packaging. The advantages of buying such equipment and of introducing better packaging and cold-storage facilities must be appraised in terms of potential benefits.

In areas where there are surpluses of eggs, the freezing or drying may sometimes be given consideration. Here again, however, the cost of the plants and their operation, as well as the quantity and quality of the raw material and the end-products, together with the prospect of marketing, need careful examination. In the United States of America, an egg-drying plant is considered to be economic if it is able to handle some 270 kg (600 pounds) of egg contents per hour and can be operated for at least 100 days per year.

Poultry production is of particular importance in the Middle East, where, for religious reasons, pork products are not eaten, and the possibilities of cattle and sheep raising are restricted on account of the extreme climatic conditions and the lack of animal feed. Remarkable advances in egg and broiler production have already been made in Iran, Jordan, Lebanon and Syria. The expansion was due, to a large extent, to the widespread production and the use of vaccines against such conditions as the Newcastle disease, which can wipe out a vulnerable poultry population. The most urgent requirements now are for improvement and development in the feed industry and in marketing systems.

K. Dairy products

1. General problems

The economic growth of developing countries requires the development of dairy industries in order to supply safe milk as a protein-rich food primarily for the populations of rapidly growing cities and new industrial settlements. The Governments of such countries are faced with various problems in their decisions for making a sound economic basis for efficient milk schemes. At the current stage of economic growth in developing countries, the following issues have to be solved:

(*a*) The dairy industry should receive a higher importance in the allocation systems of economic planning policy of developing countries than occurs at the current time. The dairy industry has often been treated as being of low significance in that it works for the domestic consumer market without earning additional foreign exchange from the world market, as do many other industrial and agricultural products.

(*b*) The expected market conditions will provide indications of the type of plant and its product pattern. Roughly there are three types of plant: the urban milk plant; the plant in a rural area supplying surplus milk to an urban centre; and the plant located in an area—a so-called "milk pocket"—having large surpluses. The question is to choose the right machinery for the through-put.

(*c*) The location of the plant is another very important factor, particularly in connexion with transport costs. On the one hand, it must be within easy reach of the producer, due to the perishable nature of milk; while, on the other hand, the urban plant should be placed fairly close to the consumer. Thus, the distance from the plant to its market also depends upon the type of plant;

(*d*) The labour force must be adequately qualified. The most modern techniques can only be applied if the labour force is trained in the handling of dairy plants;

(*e*) The quality of the raw milk is important. The technological problems of processing must be studied on the background of the composition and stability of the raw milk, bearing in mind that the industry should promote those milk products which have heaviest local demand, i.e., yoghurt, ghee and various types of cheese;

(*f*) The foreign-trade policy. The development of the domestic dairy industry should be promoted, but without undue protection, i.e., imports of cheaper dairy products should not be prevented.

There is no doubt that the most advanced industrial milk-processing techniques can be adapted to developing countries. However, it is important, from an economic point of view, to select the technique and plant best suited to local conditions, rather than to adopt the most advanced industrial technique, which may not, in many cases, be economically justifiable.

Because of the shortage of domestic capital and technical inexperience, the assistance of foreign capital and the training of experts should be sought through international agencies and bilateral agreements with either Governments or private foreign dairy firms.

2. Development of the dairy industry in Africa

There are 112 million cattle in Africa, and 128 million sheep—approximately the same as in Europe; goat numbers are almost seven times those in Europe. Sheep and goats are kept primarily for meat and skins, and milk production from cows (9.7 million tons) is only one-thirteenth of that in Europe. Both cattle numbers and milk production have remained at the same level for the past five or six years.

In terms of milk equivalent, the annual *per capita* consumption in Africa is only 45.2 kg (Oceania, 487 kg). However, some countries in Africa have shown considerable development in the dairy sector. Kenya is a particularly good example. Here, the Government plans to expand milk production considerably, especially of condensed and powdered milk and ghee, and butter for foreign trade.

FAO and the United Nations Children's Fund (UNICEF) have played an important role in the dairy development of Kenya, and also of Ethiopia and the United Arab Republic. On the basis of the current achievements of a plant in Addis Ababa that was assisted by FAO and UNICEF, a proposal has been made for a new processing plant. In the United Arab Republic, development began in 1952.

3. Development of the dairy industry in the Near East

The number of cattle, sheep and goats has increased only slightly since 1958/1959, and the same is true of milk production. Low-yielding milk animals are thus also a problem in this region. It must be expected, however, that an improvement will take place in line with the development of the dairy sector.

The consumption situation is better than in Africa, even though, at 127 kg, the annual *per capita* consumption is below the desired level, from a nutritional point of view.

Development in the dairy industry is progressing. A new dairy built a few years ago in Baghdad reached full capacity in such a short time that it had to be immediately expanded. Since 1957, when the first modern plant was erected in Teheran, many others have been established, some producing also reconstituted and "filled" milk. Production of these two types of milk is an interesting feature of the dairy industry in developing countries, very often helping a plant with fluctuating supplies to work at a constant pace.

4. Work in progress

The FAO has made a number of surveys of joint FAO/UNICEF milk conservation projects; largely on the basis of these, FAO is currently preparing a study for the Committee on Commodity Problems on the economic impact of dairy development in developing countries.

IV. Processing of protein-rich food

Because of the vast needs for additional low-priced sources of protein, much attention has been focused in recent years on the development and production of inexpensive protein concentrates from various products, which up to now have been inadequately exploited, but which could be used as human food if carefully processed. Such protein concentrates have recently been developed in a number of countries from such indigenous products as oil seed meals, presscakes and fish-flour.

Most oil-seeds are rich in protein of good quality. Some of them, e.g., soya beans, contribute significant amounts of protein to the diets eaten in some countries. Protein-rich foods made from soya beans by traditional fermentation and other treatments have been used for many centuries in China, Japan and other countries of the Far East, and commercial production of such traditional domestic products is now being carried out with some success in Japan.

In Indonesia, a spray-dried extract of soya bean and sesame is now commercially produced and widely used. In Brazil, a new protein-rich product based on heat-processed full-fat soya beans is being introduced in the market with the support of the Government. Cotton-seed flour, processed either from presscake or from solvent-extracted meal, has been used in food mixtures in Central and South America for some years.

Many of the main oil-seeds are grown chiefly in the tropical and subtropical areas where protein deficiency is most serious. However, although part of the production of such crops as coconuts, ground-nuts, soya beans and sesame seed is consumed in the producing countries, the bulk of these potential protein supplies for human and animal use is exported in the form of whole oil-seeds or oilcake. In those few countries where a significant amount of these crops is processed locally to meet the growing domestic demand for fats and oils, the protein-rich presscake is generally used as fertilizer, animal feed or fuel, or even wasted altogether, while it could be processed for human nutrition.

A number of difficulties have had to be overcome in the development of such products. It is essential that they should appeal to the consumer, that they should be nutritionally satisfactory supplements to existing dietary patterns, and also that they can be introduced into existing marketing channels in such a way as to reach consumers who are not otherwise getting enough protein. In the case of oil-seed presscakes, another difficulty is that commercial feed-grade oilcake is not usually suitable as a raw material from which to produce human food. Special processing equipment is often necessary and also careful selection of the raw material. Consequently, edible protein concentrates from oil-seeds tend to cost several times as much as commercial feed-grade oilcake, though they remain a relatively cheap source of protein.

Ground-nut flour, processed from defatted ground-nuts, is also being introduced in human feeding, though a recent setback has been the discovery that, as a result of infection by the mold *Aspergillus flavus*, ground-nut crops and products frequently contain toxic substances known as aflatoxins. How to eliminate or minimize infection during harvesting, transport and storage is now being investigated. Such products should not be used as human food until they have satisfactorily passed certain biological tests which have been devised.

A mixture of one part of ground-nut flour with three parts of millet flour has been introduced in markets in Senegal, and in Nigeria, the Government has sponsored the commercial production of a food supplement consisting of three parts of ground nut flour and one part of dried skim milk. In India, a project is under way for the manufacture of a food for weaning and for pre-school age children based on ground-nut flour, dried skim milk and wheat flour. Development work is taking place in a number of countries for the utilization of the proteins of other oil-seeds, such as sesame, sunflower seed and coconut.

Much research has also been carried out in the development of processes for the production of low-cost fish protein concentrates suitable for human feeding. Commercial-scale plants for the production of edible fish protein concentrates have been installed in Chile, Morocco, Sweden and the United States of America, though most are not yet in full operation. Fish sausages are a good and cheap source of protein and are in commercial production in Japan and other countries in the Far East.

The protein concentrates that have been brought into use in recent years have been developed in line with a set of principles for the establishment of their safety and nutritional suitability for human feeding drawn up under the joint FAO/WHO/UNICEF programme on protein-rich food which guided the early research. It was recommended that the production process should not be kept secret and that it should be not only commercially feasible, but also suitable for use in developing countries. Prior to testing on human subjects, the products should be fed to more than one species of animal to establish their safety and nutritional value. They must have a high protein content, and the quality of the protein must be such as to provide a useful supplement to protein-deficient diets. Finally, the nutritional value of the product must be confirmed by actual feeding to human subjects.

To guide producers of such protein concentrates and to ensure the safety and nutritional suitability of these new foods, "processing and quality control guide-lines" have been proposed for each type of product by the FAO/WHO/UNICEF Protein Advisory Group. These guide-lines cover such questions as the quality of the raw material, processing conditions, chemical composition, protein quality and its assessment, sanitary conditions (microbiological status and insect and rodent contamination), physical form and packaging. They have been accepted by both Governments and private concerns involved in the production, development and promotion of protein concentrates.

Protein concentrates from such sources may be treated so that they are flavourless and odourless for inclusion in staple foods, in order to augment the protein consumption of needy populations. In countries where major staple foods are processed on a large scale before they are marketed, government legislation could go a long way to increase protein consumption and prevent protein malnutrition by insisting on the inclusion of a suitable amount of such tasteless products. Alternatively, protein concentrates may be so processed that they retain their distinctive flavour and sometimes odour, and as such, they are often attractive to the consumer who uses them as a form of "relish" to be added to his food.

V. Processed-food marketing

The trend of food marketing in the last twenty years is moving towards consolidation, with fewer and larger individual concerns; towards greater integration of the different stages of marketing; and, broadly speaking, towards a more direct flow of food products from the farm to the consumer.

This marketing evolution has given a tremendous stimulus to the improvement of processing and packaging of food products. Hundreds of new products have shown up in the market, the convenience processed-foods appeared, and new types of package designs, labelling and materials are now ensuring the protection of processed and fresh foods.

The most important change in the retailing of food products has been the rise of the supermarket as the modern method of selling foods to the consumer. Pre-packaging self-service and one-stop shopping have been displacing gradually other sorts of food retailing in the developed countries.

A supermarket is a large, departmentalized, one-stop food centre with relatively complete lines of dry groceries, fresh produce, fresh meats, dairy products, frozen foods and canned foods. It carries a large variety of brands and foods in each line. The groceries, at least, are dispensed by self-service, but all other departments tend in the same direction.

The swing towards self-service could not have occurred without corresponding developments in the industries that deal with the pre-packaging and processing of foods. Moreover, the processed-food industries have been obliged to modify and adapt their products to the requirements of the self-service principle ruling the supermarkets. In other words, there is a substantial link between the food industries and the chain of supermarkets.

Consequently, the development trends of food industries in Africa must ultimately be matched by the establishment of modern and efficient chains of markets, containing the essential elements that created the "supermarket system" for the purpose of a suitable marketing of processed-food products.

VI. Utilization of wastage and by-products

There are very few agricultural products which can be completely consumed without leaving behind some wastage or by-products. A characteristic sign of highly developed food-processing industries is the optimum utilization of these residues. In developing countries, however, by-products and waste of agricultural products processing are often not yet sufficiently utilized.

For the industry, the major reason for such action is an economic one; practically all waste materials and by-products have some market value. The major problem for the industry is to find the break-even point between cost of assembly, further processing, storage and marketing of these products and their returns. This complex is generally of decisive influence upon the economies of scale of a food-processing unit. For example, economies of scale in rice mills are practically non-existent. It is, however, only in the larger mills that separation of rice bran and its further processing into bran oil is economic and feasible. Similarly, drying of liquid skim milk after butter production pays only after the minimum quantities necessary for economic utilization of equipment have been reached. Processing and overhead costs for small-capacity roller or spray driers are higher than for larger equipment.

A particularly important example and one of specific relevance to African conditions is the utilization of the "fifth quarter" in the butchery trade. In small-scale conventional slaughtering processes, the blood, tail, some intestines and glands, hoofs and hide are either thrown away or used in an uneconomic way, e.g., use of hides for human consumption. When fully utilized, these parts are of considerable value and allow for lower pricing of those portions of the animal which are of greater use for human consumption; it has been calculated, for example, that in Northern Nigeria, the potential market value of the hide, hoofs, horns, blood, tail and bones of an animal of 770-lb. slaughter weight account for about £2.10s.0d., out of a total value of the animal after slaughter of £35.18s.0d.

A second aspect of utilization of waste and by-products is the conversion for human consumption or feed of currently under-utilized products. By far the most important aspect in this field is the production of unconventional vegetable protein food, primarily from the residues of oil extraction, i.e., oilcakes. There are numerous other examples in the processing of fruits and vegetables where such by-products as peelings, cores, pomace, stems etc., can be used for the manufacture of a wide variety of products like pectin, jelly, juice, confectionery, vinegar and essential oils. In rice processing, the bran, before being used for animal feed, can be extracted by solvents, yielding an excellent oil suitable for human consumption.

A. Animal feed contributing indirectly to human nutrition

There are various agricultural by-products and waste products already in use, but much more of such raw material could be converted if animal feed and fodder industries were given more serious attention. For example, oilcakes can be used for chicken feed, and the fresh pulp from cassava processing is fed to pigs. Rice bran is such a valuable feed-stuff that some countries have prohibited its exportation. Some apparently wasteful processing techniques in developing countries are only economic if combined with chicken or pig farms, e.g., the primitive extraction of coconut oil from fresh coconuts by rasping the meat, pressing it out and boiling and settling the obtained "cream". Another example is the mechanical oil extraction from soya beans, which, without first-class equipment and proper chemical control, leads to a loss of oil in cake of about half of the total oil in beans, but which is often economic because of the high value of the cake for feed (and also food) purposes.

The modern trend is the establishment of mixed-feed plants in developing countries, producing valuable feed from all kinds of by-products in modern installations where they are automatically cleaned, disintegrated, mixed, formed into pellets etc.

Not all the waste-product problems of developing countries have been solved yet; up to now no profitable utilization has been found for the shells of ground-nuts, for the husks of rice, or for date culls, pineapple bran etc.

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to vote in 1944. In 1962, Jamaica achieved full independence within the Commonwealth. Another factor has been the ability of much of the population to live on a subsistence level on small farms. All but 3 per cent of the 160,000 farms (1961) are smaller than 25 acres, and two-thirds are less than 5 acres. About 37 per cent of the labour force is employed on farms.

The bauxite companies have acquired ownership or mining rights on approximately 250,000 acres of lands, mostly agricultural, or about 390 square miles. This represents about 9 per cent of the land area of Jamaica, but almost one-seventh of the cultivable acreage in farm lands. Only a fraction of the companies' land holdings will actually be mined, but the remainder was acquired for related purposes and as part of private lands that had to be purchased in order to obtain the portion having bauxite. The bauxite companies are among the largest landowners in this small country. Consequently, the Jamaican Government has imposed regulations on the companies to protect the agricultural capacity of the country. Mined-out areas must be restored to their original productivity and may not be left as open sterile pits, as is the case in some other countries. The bauxite companies likewise operate agricultural enterprises on some of the farming lands they own, either directly or through tenants. One of the companies has acquired substantial farm lands to transfer to farmers in order to induce them to sell their properties. The companies have likewise improved breeds of cattle and introduced new grasses and other methods of land improvement. Consequently, the benefits of the bauxite-alumina industry to the country are greater than those related solely to its own products.

Among other benefits to the country are the technical training schools two of the companies have installed to upgrade the skills and earnings of their workers. The companies have not found it necessary to build communities, but all four companies had to build private ports. Two also built their own short railroad lines, but one company uses the Government's railroad. The private transportation facilities of the companies have not limited the country's other trade because the island is small and enjoys at Kingston one of the major harbours of the world.

Originally, the Jamaican bauxite concessions provided for nominal income-tax payments by the companies from the United States of America, based on the assumption that Jamaican bauxite had a low value. In 1957, however, the Government renegotiated the tax arrangements for twenty-five year terms resulting in a fivefold increase in unit payments by the companies, from the United States of America, attaining a level close to $2.00 per long ton in royalty and income-tax. The production of alumina, on the other hand, has yielded considerably more revenue to the Government in relation to the amount of bauxite consumed. This revenue has been between two and three times per ton of bauxite converted into alumina, as compared with a ton of bauxite exported.

The over-all effects of the bauxite alumina industry upon the Jamaican economy have been one of the outstanding features of the past fifteen years. Not even in existence in 1950, the industry in 1962 contributed 49 per cent of the value of exports and 18 per cent of the Government's revenues. Its share of gross national product was much less, only 9 per cent, and its share of employment was only 1 per cent (5,400 out of some 570,000). Mining, prospecting and alumina production employed 3,400; agriculture, 1,100; and other activities, 900. Wages and salaries paid were 1.6 per cent of gross national product and averaged $2,100 per employee, well above earnings in most other employments. The financial support that the industry gave to the Government helped the Government to borrow long-term funds in London and New York for development programmes. The relative significance of the industry to the over-all Jamaican economy is indicated in table 31.

Table 31. Major contributions of the bauxite-alumina industry to the economy of Jamaica

Year	Exports (thousands of long tons)		Bauxite-alumina values				Contributions to government revenues[a]		
	Bauxite	Alumina	Production (factor cost, millions of pounds, current prices)	Exports (millions of pounds, f.o.b.)	Percentage of gross national product	Percentages of exports	Total government recurrent revenues (Millions of pounds)	Payments by bauxite alumina companies (Millions of pounds)	Percentage of total government revenues
1952	265	2	1.6	0.4	2	2	n.a.	n.a.	n.a.
1953	1,203	29	2.5	n.a.	2	n.a.	n.a.	n.a.	n.a.
1954	1,998	106	4.6	n.a.	4	n.a.	n.a.	n.a.	n.a.
1955	2,529	184	6.3	n.a.	5	n.a.	n.a.	n.a.	n.a.
1956	2,575	207	8.1	10.4	5	27	n.a.	n.a.	n.a.
1957	3,641	436	16.1	21.5	8	43	n.a.	n.a.	n.a.
1958	4,799	373	16.5	21.7	8	46	28.6	4.6	16
1959	4,197	399	15.6	20.4	7	45	31.1	4.1	13
1960	4,147	665	18.9	27.5	8	49	34.2	5.9	17
1961	4,975	703	20.0	30.0	8	49	36.9	6.1	16
1962	5,987	628	22.1	30.2	9	49	40.1	7.3	18

SOURCES: Jamaica Ministry of Development and Welfare, *Five Year Independence Plan, 1963-1968 (1963)*; annual economic surveys of the Central Planning Unit; and Jamaica Commissioner of Mines.
NOTE: n.a. indicates information not published.
[a] Fiscal years ending March 31 of subsequent year.

Compared to Surinam and British Guiana, Jamaica is fortunate in the diversification of its economy, even though the land area of Surinam is twelve times greater and that of British Guiana is nineteen times greater. Mixed manufacturing has become the largest economic sector, followed by agriculture and mining. The tourist industry is fourth. The country is less dependent than Surinam and British Guiana upon exports of domestic products, which constitute only about one-fourth of the gross national product. The leading exports, other than bauxite and alumina, are sugar, bananas, small manufactures, and canned and fresh citrus products. In 1962, the gross national product was about $710 million, or $430 *per capita*. These figures, as with other countries, do not indicate the relative income distribution among sections of the population. In Jamaica, the families of small farmers, many workers and the unemployed obtain considerably less than the *per capita* income. The basic problems of Jamaica rest in the restricted resources of the small island, the growing population and rising popular expectations. As stated in the Government's Five-year independence Plan, "The Jamaican situation is a classic demonstration of the race between development and discontent".

The outlook for the bauxite-alumina industry in Jamaica is favourable for an indefinite period. The bauxite resources of the companies will sustain current and expanded levels of production for possibly seventy-five years. Although the country has lost opportunities to obtain additional bauxite producers, due to concentration of the best reserves in the hands of

four companies, these companies are the four largest and serve the most profitable markets of the world. The industry is tied closely to the aluminium production of Canada, Norway and the United States of America, and to fixed investments in alumina plants designed for the Jamaican ore. Production costs are among the lowest in the industry. Transportation costs of bauxite to the United States of America are low, less than $2 per long ton, owing to the use of large ore-carriers and the short distances. The possibilities for additional alumina plants are restricted in the near future by plans of the companies to expand in other countries. The industry illustrates in Jamaica an outstanding case of bauxite helping a small developing economy.

III. Australia

Only since 1955 has Australia been recognized as possessing the largest economically accessible deposits of bauxite known in the world. Although bauxite was found in Australia as early as 1899, the explorations of deposits in northern and western Australia since 1955 by private companies have indicated that the country has over one-third of the world's commercial deposits. As a result, the Government of Australia hopes the country can become a world supplier, preferably of alumina rather than bauxite, and possibly aluminium as well, on a major international scale.

The Government had joined with the State of Tasmania in the ownership of very small alumina and aluminium plants placed in operation in 1955. The bauxite was imported rather than produced in the country. The uneconomical alumina and aluminium plants (13,000 long tons of ingot capacity in 1955) were protected by import restrictions to permit the sale of the metal above the import price. This enterprise was turned over in 1961 to the control of private enterprise by the Government, which sold its two-thirds interest to a company, Commonwealth Aluminium Corporation (Comalco), owned by the Kaiser Aluminum Company and an Australian mining company. The Government of Tasmania retained its interest. Comalco had agreed in 1957 with the Australian State of Queensland to develop a very large bauxite concession, conditionally also an alumina plant, and, after twenty years, to build an aluminium smelter if requested by the State or else to forfeit one-third of the bauxite concession. This contract reflected the liberality of mining concessions in Australia, running for eighty-four years.

Comalco has moved to enlarge the high-cost Tasmanian enterprise into an economical one with a capacity of 55,000 long tons and to develop the bauxite deposits of Queensland. The company announced plans for building a 122,000-ton smelter in New Zealand to use low-cost hydroelectric power, but this plan was upset when the Aluminum Company of America joined in 1961 with other Australian mining interests to build an integrated industry, including a bauxite mine, an alumina plant and a smelter. The Australian aluminium market is currently smaller than the output of Comalco and Alcoa, but is expected to consume the supply in a few years.

Both Alcoa and Comalco are now producing bauxite, Alcoa for its alumina plant and Comalco for the Tasmanian plant and for exportation to Japan. Alcoa also exports some of its alumina to a new aluminium producer in Japan. Late in 1963, Comalco joined with Canadian Aluminium Limited and the French company, Pechiney, to construct in eastern Australia the largest private alumina plant outside of North America, with a capacity of 600,000 long tons. This plant will use Comalco's bauxite from northern Australia. It will replace the uneconomical alumina plant in Tasmania and will supply alumina for export. The combined capacity of this plant and that of Alcoa—800,000 long tons—will far exceed the market in Australia for many years. Hence, Australia will become a major exporter of both bauxite and alumina. With the currently committed alumina capacity and a possible continuation of bauxite exports to Japan, in a few years Australia may be producing almost 2 million tons of bauxite per annum from these two companies alone.

The Australian Government has, however, placed other bauxite concessionnaires under pressure to become alumina producers also for the world markets. This pressure raises a conflict between the desire of companies to obtain a firm hold on Australian bauxite and a practical time-schedule for world markets to be able to absorb the alumina. In 1963, the Government terminated a bauxite lease held by a British affiliate of the Reynolds Metals Company because the company would not definitely commit itself to build another alumina plant in Australia. The Government is seeking candidates who will agree to build an alumina plant with at least a capacity of 300,000 tons and, ultimately, a smelter. Swiss Aluminium is interested, as are other companies. In 1963, the Government also issued bauxite leases to the French company, Pechiney, requiring that company to begin exporting bauxite in 1965 at a rate of not less than 250,000 tons per annum and to submit within three years a proposal for developing another alumina plant.

The eagerness of foreign private enterprises to seek Australian bauxite, even under conditions that may require commitments to build alumina capacity ahead of the demand, is due to a number of conditions. First, there is the abundance of good-grade bauxite, economically minable and transportable by sea. Secondly, there is the political security of an investment in Australia, as compared with recent uncertainties in Africa, the Caribbean area and South America. Thirdly, there are also the decreasing reserves of bauxite controlled by some companies within Europe and the need to obtain additional long-term supplies. Fourthly, there is the very low burden of payments to the Australian Government under the income-tax law and royalty regulations. Such payments may be less than $1.00 per long ton of bauxite, compared with double and nearly triple this figure in the Caribbean area. Fifthly, there is the economy of shipping bauxite or alumina in vessels with capacities of over 30,000 tons at a very low unit cost, compared with costs of land transportation. Sixthly, there is the general expectation of the world aluminium industry that market growth will, in a reasonable time, require much more bauxite and alumina production. Finally, Australia does have some low-cost power potentialities, including coal and hydroelectric projects that can support aluminium smelters for export markets.

The effect of all these factors is to place Australia in a very favourable position at the current time. Australia now has the vote of confidence of the French, Swiss and North American aluminium companies which had, only eight years ago, looked confidently towards Africa for additional ventures into bauxite, alumina, hydroelectric power and aluminium smelters. The mineral resources of Australia are essentially under-developed also. Its population (including New Zealand) of 18 million is only one-tenth that of the United States of America, while land area is nearly 90 per cent that of the United States. The Australian *per capita* income of nearly $700 (1961) is only one-third that of the United States of America, but nearly twice that of Jamaica and more than nine times that of Guinea. The less industrialized countries now face the competition for the bauxite and alumina industries from Australia, which has a combination of political stability, a moderate tax burden and favourably located bauxite of good grade of the order of one-third of the current world reserves.

ANNEX V

Patterns of aluminium consumption: developed and developing countries

I. United States of America

The aluminium industry in the United States of America, being the largest and most diversified in the world, offers a standard of comparison to which other developed countries may look and against which the developing countries may check their own circumstances. The diversity of uses of aluminium in the United States of America and the economies in many applications are not matched in other countries, although a few have done better in developing certain uses.

Today, developing countries may leap over certain stages of the aluminium market development that first built up the aluminium industry in the United States of America and still follow in a general way that sequence of uses. Many countries today are similar in broad characteristics to the United States of America in 1900, when 60 per cent of the population lived on farms and in rural areas; the railroad and the horse-drawn vehicle were the main forms of transportation; electricity was just coming into use; and there was no automobile, truck, or aircraft industry. The uses of aluminium were small, about 3,000 short tons, or just about where some countries currently are. Consumption in the United States of America was concentrated in kitchen utensils, electrical conductors, military articles, small boats, powder and paint, as a reducing agent for other metals and in lithographic printing-plates replacing heavy stones. As the pattern of development extended, the household uses continued, but they expanded to include modern appliances as well as utensils. Electrical conductors, aircraft and military uses became very important, as did automobiles, trucks and ships. But the extensive diversification of industrial and consumer fields took aluminium with it into thousands of applications. This broad trend is summarized in table 32, which shows that by 1963 the two fields of building construction and transportation used almost half of the total aluminium supplies, in equal proportions. The automobile became the largest user in the transportation class.

Table 32. Sequence of development of principal uses of aluminium in the United States of America, 1900-1963

1900: Consumption about 3,000 short tons

- Kitchen utensils
- Military articles, including water-canteens, castings for torpedo-boats
- Marine uses, including small boats
- Instruments and apparatuses for scientific use
- Wire for brushes, baskets, egg-beaters and electrical conductors
- Foil, bottle-caps
- Powder and paint
- As reducing agent for other metals
- Lithographic printing-plates

1914-1918: First world war: Consumption about 66,000 short tons in 1918

Military uses

- Aluminium dust for explosives
- Soldiers' equipment
- Bombs, fuses, flares, grenades, ammunition, cartridges
- Aeroplane engines, castings and air-frame tubing

Non-military uses:

- Automobile parts
- Utensils
- Deoxidizing agent for steel making
- Electrical conductors

1920-1939: Consumption about 203,000 short tons in 1939

- Automobile parts
- Electrical conductors
- Machinery parts
- Electrical apparatuses and appliances
- Aircraft and marine engines
- Utensils
- Iron and steel making

Second World War: Consumption about 1,053,000 short ton sin 1944

- Aircraft and other military and naval uses

1963: Consumption (shipments, including exports, 3,213,000 short tons)

	Percentage
Building and construction	24
Transportation	24
Electrical and communication	11
Consumer durables	10

Table 32 (continued)

	Percentage
Other end-uses	9
Packaging	8
Machinery and equipment	7
Exports	7

SOURCE: Based on Charles C. Carr, *Alcoa, An American Enterprise* (New York, Rinehart & Company Inc., 1952); Donald H. Wallace, *Market Control in the Aluminium Industry* (Cambridge, Mass., Harvard University Press, 1937); The Aluminium Association, *Aluminium Industry Annual Statistical Review*, 1963, pp. 18-19; Kaiser Aluminum & Chemical Corporation; and James E. Rosensweig, *The Demand for Aluminium: A Case Study in Long Range Forecasting* (Urbana, Ill., University of Illinois Press, April 1957).

II. Western Europe and Japan[a]

The patterns of aluminium consumption in Western Europe and Japan differ somewhat from those in the United States of America. This is clearly shown in a comparison of *per capita* consumption in various countries for 1960 (see table 33). Out of eleven consumption classes, building construction was the leading use of aluminium in the United States of America, but led elsewhere only in Austria, Belgium-Luxembourg and Switzerland. In other countries, the leader was transportation and vehicles, except for packaging, which was first in Denmark, and electrical applications, which were first in Japan. Although in 1960, the United States of America had double the over-all *per capita* consumption of aluminium of nine western European countries, for certain uses, the figure for the United States was equalled or exceeded in some countries, e.g., for mechanical engineering in the Federal Republic Germany and in Switzerland; for packaging in Denmark, the Federal Republic of Germany, Norway and Switzerland; for building construction in Austria; and for domestic and office appliances in Norway.

III. Developing countries[a]

In developing countries, the uses of aluminium tend towards the essential, frequently beginning with utensils and roofing sheet. Where electrification is proceeding, aluminium is favoured for outdoor conductors, as it is less costly than copper. India illustrates the aluminium cycle of a country moving towards industrialization under government planning since 1951, favoured by a national policy to displace with domestic production of aluminium the long-established position of imported copper in utensils, other household uses and electrification. Foil for packaging tea and utensils were the principal original markets for aluminium in India. Aluminium consumption in India in 1948 was about 13,000 tons and has since grown at a compound rate of 11 per cent each year. Kitchen utensils were the largest market for aluminium until 1954. Electrical conductors then took first place under a national programme of electrification and, together with utensils, absorbed about two-thirds of consumption in 1961.

Consumption of aluminium in India in 1961 was estimated as follows:

	Tons
Electrical conductors and appliances	19,000
Cooking utensils	11,000
Transport (marine, land and air)	6,000
Packing and canning	4,000
Building and construction	2,000
Miscellaneous	2,500
	44,500

SOURCE: S. R. Bhandari, "The Indian aluminium industry", *The Eastern Metals Review* (February 1963).

[a] This section adapted by permission of the Bonneville Power Administration, United States of America, Department of the Interior, from a contribution by the writer to a report pending publication, "The aluminum industry of the Pacific Northwest" (1965).

Table 33. Primary and secondary aluminium end-uses: per capita consumption, 1960
(Kilogrammes)

	Austria	*Belgium-Luxembourg*	*Denmark*	*Federal Republic of Germany*	*France*	*Italy*	*Netherlands*	*Norway*	*Switzerland*	*United Kingdom*	*Europe nine countries total*	*Japan*	*United States*
Vehicle-making and transport equipment	0.8	0.1	0.5	1.8	1.5	1.1	0.2	0.6	0.6	2.1	1.4	0.4	2.3
Mechanical engineering	0.8	0.1	0.3	0.9	0.4	0.2	0.2	0.2	1.3	0.5	0.5	0.4	0.9
Electrical engineering	1.3	0.1	0.1	1.1	0.7	0.2	0.3	1.2	1.1	0.7	0.7	0.5	1.1
Building and construction	2.9	0.3	0.5	0.5	0.3	0.3	0.4	0.3	1.3	0.6	0.5	0.1	2.6
Chemical, food and agricultural appliances	0.2	0.1	0.4	0.2	0.1	—	—	0.1	0.1	0.1	0.1	0.1	..
Packaging	0.6	0.1	1.0	0.7	0.5	0.3	0.4	0.7	1.0	0.6	0.5	0.1	0.7
Domestic and office appliances	0.3	0.2	0.2	0.3	0.5	0.2	0.6	1.3	0.5	0.7	0.4	0.4	1.2
Powder-consuming industries	0.1	—	—	0.1	0.2	—	—	—	—	0.1	0.1	—	—
Iron, steel and other metal-producing industries	0.2	—	—	0.4	0.2	0.1	—	—	—	0.3	0.2	..	..
Metal industries n.e.s.	—	0.1	0.2	0.5	0.1	0.3	0.4	—	0.8	0.3	0.3	0.1	0.4
Miscellaneous	—	0.2	—	0.5	0.4	—	—	0.4	0.1	0.7	0.3	0.2	0.3
TOTAL	7.2	1.3	3.2	7.0	4.9	2.7	2.5	4.8	6.8	6.7	5.0	2.3	10.3

SOURCES: Organisation for Economic Co-operation and Development (OECD), Non-ferrous metal statistics, November 1961. Light metals statistics in Japan, Market Research Department of a major producer in the United States of America Compiled by Bache & Co., *The North American Aluminium Industry* (New York, March 1964), p. 8.

Plans of the Indian Government will continue this distribution of uses, holding down building and construction to one of the smaller uses. The latest target of the Government is a primary capacity of 308,000 tons by 1971, indicating a fivefold increase over 1963.[b]

In Brazil, the population of 75 million consumed in 1961 about as much aluminium as the 436 million of India. The pattern was similar, utensils being first and electrical conductors next. Transportation was third (automobiles, trucks and buses). Packaging was fourth (tubes and containers for pharmaceutical and cosmetic products, and foil for the cigarette, food and drink industries). The pattern of the 1960's is not expected to change much, as consumption is projected to increase about 62 per cent between 1961 and 1967.[c]

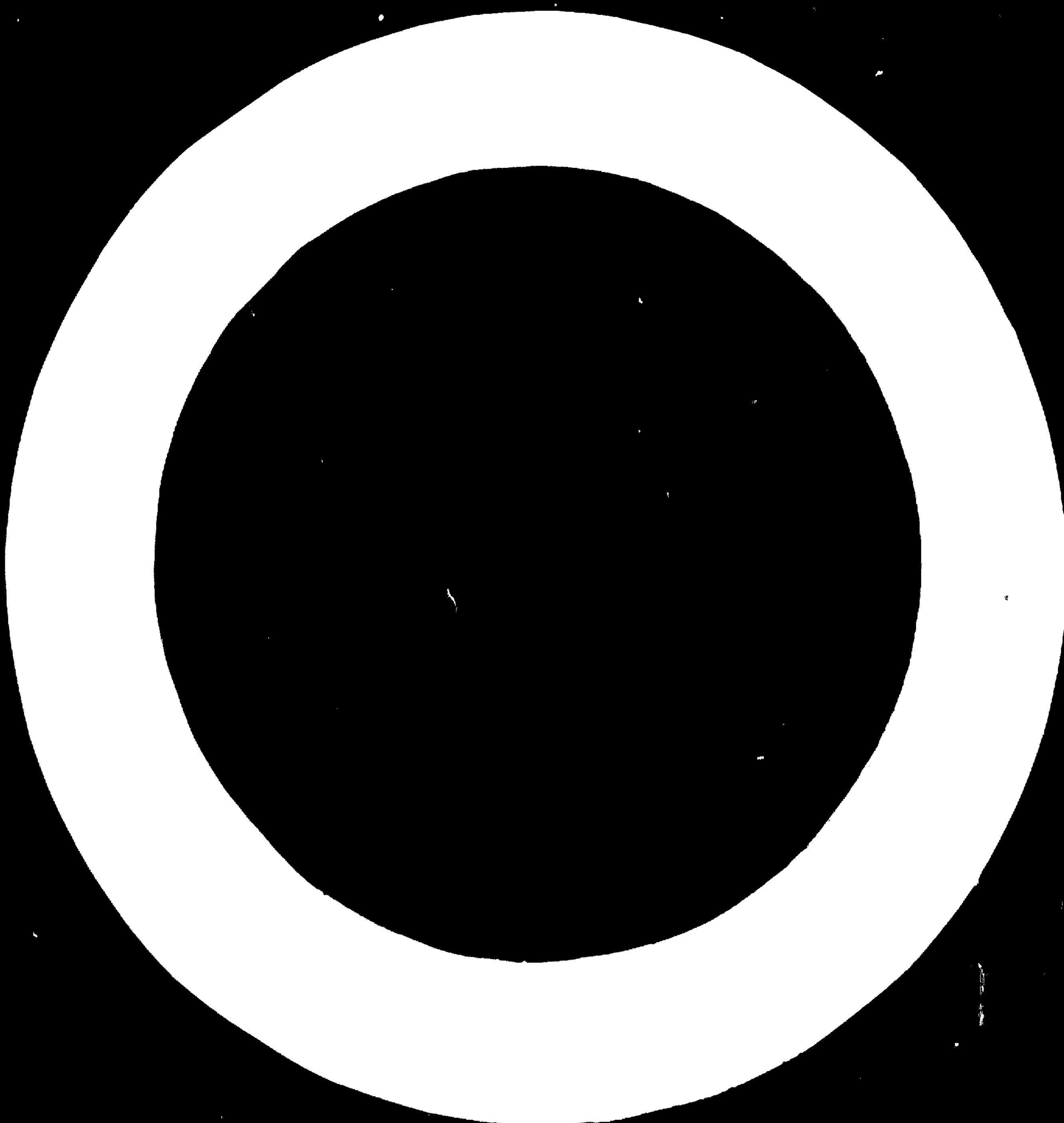
A different kind of aluminium economy is illustrated by China (Taiwan), where a population of 11 million consumed 7,000 tons in 1960, or about 1.5 pounds *per capita*. Building and construction, mainly roofing sheets, absorbed about 40 per cent of the consumption; the electrical industries, about 20 per cent; utensils and household supplies, about 15 per cent; and packaging material, about 10 per cent. Transportation used about 6 per cent. Consumption was expected to double by 1965, with the greatest relative growth occurring in transportation and packaging.[d]

All developing countries have one advantage over the more developed countries in that they can immediately adopt certain uses of aluminium because of improvements in alloys and technology which were not available to other countries in the early stages of aluminium development. Outstanding are building sheet products as used in Africa, which only came into widespread use in the United States of America after 1950. Irrigation pipe and fittings made of aluminium are in the same technical category.

[b] *Mining Journal* (London) (14 August 1964).

[c] National Bank for Economic Development (Brazil), *The Brasilian Aluminium Market, 1946-1967* (Rio de Janeiro, September 1963).

[d] United Nations, *Bauxite Ore Resources and Aluminium Industry of Asia and the Far East*, Mineral Resources Development Series No. 17 (United Nations publication, Sales No.: 63. II.F.2), pp. 45-46.



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8. FOOD AND FOOD PRODUCTS INDUSTRIES

Food and Agriculture Organization of the United Nations

CONTENTS

I. General considerations

During the last twenty years the food-processing industry has expanded rapidly in the developed countries in response to increased demand. Similarly, in the developing countries, an increasing awareness of institutional needs, the introduction of new tastes and, above all, the greater convenience in handling, storage and preparation, all backed by rising personal incomes, are resulting in an increased demand which may be expected to continue. At the same time, Governments, aware of the needs for industrialization, appreciate the opportunity that this trend offers. Thus, all factors point to a continuing expansion of this industry in these countries.

Economists have forecast an increase of 154 per cent in the food-processing industries in developing countries between 1958 and 1975, a few selected figures being: Middle East, 319 per cent; Africa, 224 per cent; Asia, 209 per cent; Latin America, 102 per cent.[1]

A good example of the food industries in the national economy of some developing countries is that of Chile, which produces some 2,330,000 tons of processed foods per annum, i.e., about 290 kg *per capita*. The growth rate of the food industry was 5.2 per cent per annum during the period 1959-1964.

Efforts are already being made by the developing countries to replace purchases of processed food from abroad and hence to reduce their expenditure on foreign exchange, by producing these goods locally. The major proportion of imported processed foods is in the form of canned foods.

This new trend in demand is also linked with the growth of urbanization, which usually means a change in attitudes towards food preparation, and a change in tasks. Urban women are less willing and, when employed, unable, to spend the time involved in preparing unprocessed foods in the traditional manner.

The principal determining factor, however, is the rise in the standard of living, which is usually accompanied by a growing preference for not only better quality foods, such as meat and milk, but also processed products.

A. Benefits resulting from a well-developed food industry

Parallel with import substitution goes the export drive. Certain of these industries, once established, find it possible to build up an export trade, particularly to their neighbours. It is essential, if the new industry is to succeed, for the cost and quality of the product to be competitive. This is indispensable so far as exports are concerned, though for internal sales some measure of protection is usually given.

[1] These figures include food, beverages and tobacco manufacturing. The latter is a relatively small factor. Taking the United States of America as an example, tobacco represents only 7.67 per cent of the total figure, according to Peterson and Tressler, *Food Technology the World Over* (Westport, Conn., Avi Publishing Company Inc., 1963).

The advantages of an expanding food-processing industry, however, are not confined to an improvement in the balance of payments.[2] They include employment in the industries themselves and in other related industries, and a general contribution to the economic growth of the country. In addition, there are reduced losses of food (once processed) during storage, transportation and distribution, and a better utilization of by-products or waste products which otherwise tend to be lost. Another advantage lies in the contribution which processed products can make (since more easily stored and transported) to evening out the seasonal fluctuations in the prices of unprocessed or partly processed foods, reducing geographical maldistribution of food and helping to lessen the food shortage in years of bad harvest. Lastly, they can contribute to an improvement in the health of the population by providing a wider range of nutrition throughout the year, especially if stress is laid on increasing protein supplies.

Naturally, the problem of building up a food-processing industry in developing countries is different from that in developed areas. On the marketing side, not only are personal cash incomes lower, but concentrations of the population represent a smaller proportion of the total population. This tends to raise the marketing and promotion costs. There is no question but that in many countries, the small, scattered internal demand has been the major handicap to introducing a good processing industry.

The major differences, however, consist of the far more formidable difficulties which have to be encountered by developing countries in setting up the industries. The lack of managerial and technical skills is a well-recognized impediment in the development of food industries in most developing nations, but it is possible to overcome this if resolute governmental action is taken, as was done in Kenya, which has built up a sizable export trade in canned foods. Training abroad in modern industries is useful, but the requirements and facilities are usually so different from those in the developing nations that, more often than not, such exposure does not quite accomplish the desired results. Therefore, in establishing food and food products industries, it is essential to provide local or regional training facilities. The Food and Agriculture Organization of the United Nations (FAO) is active in the creation of such regional food-technology training centres as, for instance, the International Training Centre in India, supported by the Canadian Freedom from Hunger Committee; the Tropical Centre of Food Research and Technology in São Paulo, Brazil; the Institute of Food Science and Technology in Santiago, Chile, supported by the United Nations Special Fund; and several other centres in Africa, the Near East and Latin America. Help is also provided by staff sent to the country, in the case of foreign-owned plants, by the owners.

There are, however, serious material complications as well. It is not sufficient, for example, merely to note and to set up a factory to process a seasonal glut of produce in a particular commodity. A successful operation is usually much more complex. The basis for a commercial processing plant is the regular availability of raw material. The security of supply at a reasonable price in relation to the end value of the product and the quantity and quality of the deliveries for an extended period are the most important factors, but, under current conditions of agricultural production in the developing countries, these pre-conditions are often not fulfilled. Variation in yield due to poor-quality seed, adverse weather conditions, diseases etc. often restrict the availability of the produce even for the fresh market. The absence of regular supplies and the failure to conform to standards can lead to high production costs. In order to assure a dependable supply of raw materials, the processor may contract with farmers or establish his own production units, where he can grow the produce specifically designed for processing. Raw-product requirements for the production of optimum-quality processed products have been established during the last twenty-five years. For each product and for each type of process, such as canning, freezing or dehydration, specific requirements have been formulated and must be met. Shape, size, texture, colour, flavour, odour, acidity, viscosity, maturity, specific gravity, soluble solids, total solids, vitamin content etc. are all factors for which standards have been established. It requires careful planning in plant breeding and cultural practices to produce a raw fruit or vegetable suitable for canning, freezing, dehydration or concentration. In several African countries, a beginning has been made at experimental stations or universities to develop and evaluate varieties suitable for processing, but much more remains to be done.

In this connexion, for some commodities the improvement of storage facilities is vital, especially in tropical climates. Such an improvement is, of course, useful in other connexions, for example, price stabilization, but it also facilitates the smooth flow both over time and in quality and amount of raw materials to the factory (for further details on storage, see chapter II, section L).

There are a number of other infra-structural requisites. These may be summarized as follows:

(*a*) An adequate transport system (often non-existent in many African countries) to bring raw products, raw materials, machinery, equipment, packaging material etc. to the factories, and to carry the finished products to the markets;

(*b*) Supplies of fuel, power and water in adequate quantities and at economically suitable cost;

(*c*) Adequate chains for marketing and retail outlets for the distribution of the products;

(*d*) A banking or credit system to provide working capital;

(*e*) Facilities for the building of industrial premises, storage facilities, laboratories, offices, housing etc.;

(*f*) A reasonably efficient Government, providing adequate support for managerial, technical and sales personnel.

B. Marketing

Finally, the marketing problems must be stressed again, as well as the fierce competition that characterizes this complex of industries. It is not enough to have a good product at a competitive price—it has still to be sold. Examples of costly failures abound where this has been forgotten. Almost invariably, government assistance in the form of tariff protection is necessary,

[2] See Food and Agriculture Organization of the United Nations, "The economic significance and contribution of industries based on renewable natural resources and the policies and institutions required for their development" (E/CN.14/AS/III/1/7), paper prepared for the Symposium on Industrial Development in Africa, Cairo, 27 January-10 February 1966.