OCCASION

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

DISCLAIMER

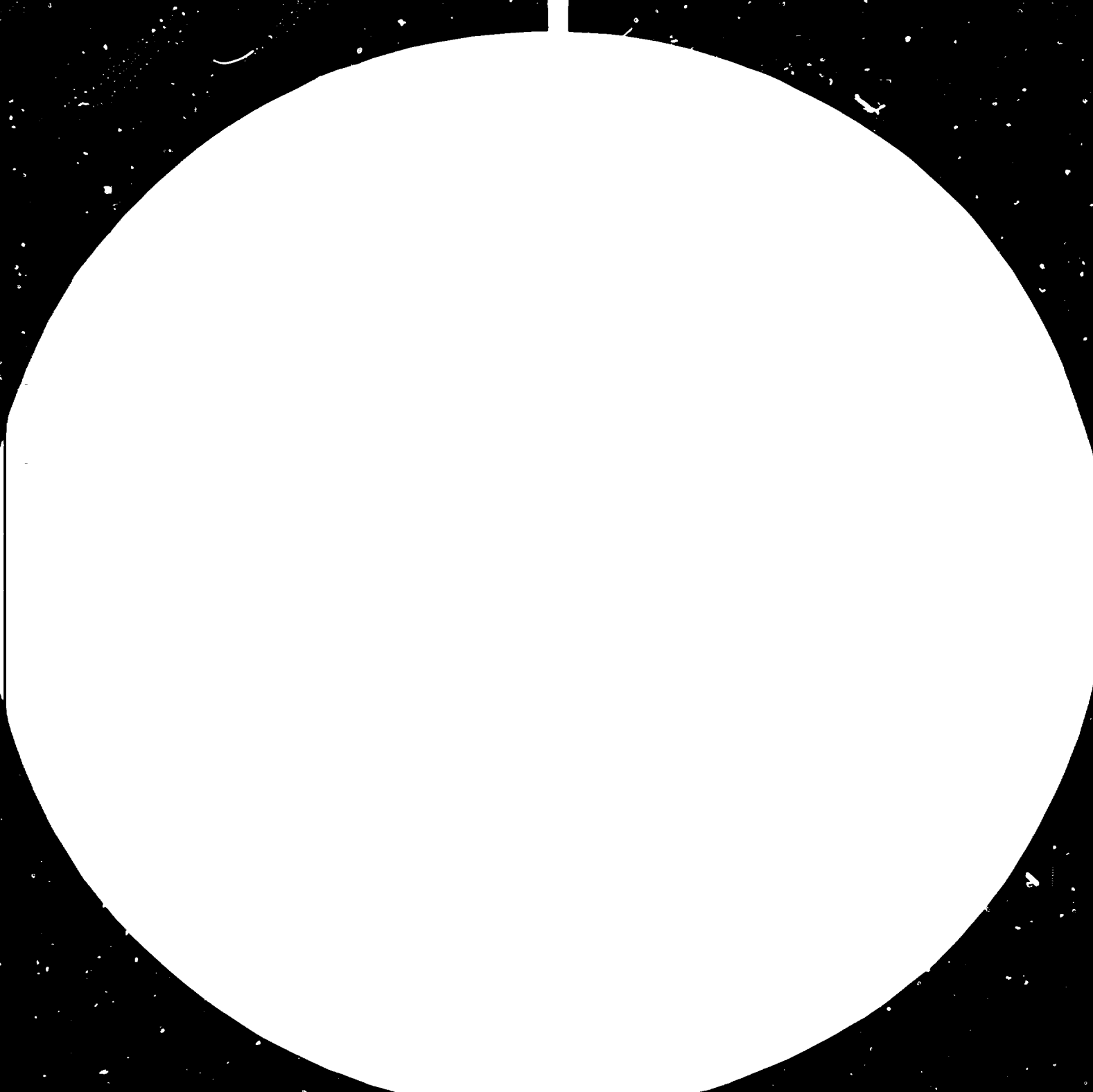
FAIR USE POLICY

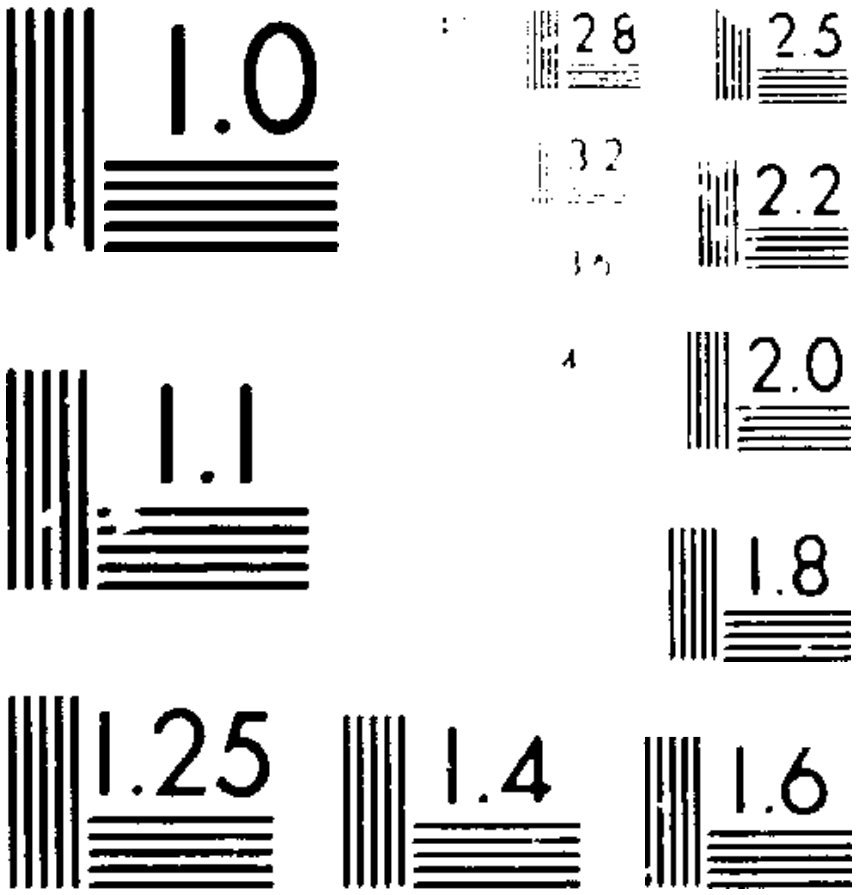
CONTACT

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

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

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




1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

11181

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.365/9
8 February 1982

ORIGINAL: ENGLISH

First Regional Consultation on the
Agricultural Machinery Industry,
Addis Ababa, Ethiopia, 5 - 9 April 1982

AGRICULTURAL MECHANIZATION AND THE DEMAND FOR AGRICULTURAL MACHINERY AND EQUIPMENT IN AFRICA TO THE YEAR 2000*

Prepared by FAO

H.E. Jahnke

* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariats of FAO and UNIDO. This document has been reproduced without formal editing.

V.82-21744

This supporting document was prepared for the United Nations Industrial Development Organization (UNIDO) by Messrs. H. E Jahnke and M. Sievers of the Kiel University* under a sub-contract by the Food and Agriculture Organization of the United Nations (FAO).

* Universität Kiel, Institut für Agrarpolitik und Marktlehre, Olshausenstrasse 40-60, 2300 Kiel 1, F. R. Germany.

Agricultural Mechanization and the Demand for Agricultural Machinery and Equipment in Africa up to the Year 2000

- an Analysis of Results and Implications of the FAO Study AT 2000 -

Table of Contents

List of Tables

Annex

List of Graphs

Abbreviations and Technical Termini

MDE	man-day equivalent
GAPS	Global agricultural production system
GDP	Gross domestic product
HP	Horse power
AT 2000	Agriculture: Toward 2000
R-value	Indicator of cropping intensity ($\frac{\text{ha harvested}}{\text{ha arable}}$ x 100)
Draught Factor	Proportion of total power requirements of crop agriculture in MDE met by draught animals in percent
Tractor Factor	Proportion of total power requirements of crop agriculture in MDE met by tractors in percent
Mechanization Factor	Sum of draught factor and tractor factor
Land-man-Ratio	Harvested area in hectares per agricultural labourer

1 Introduction

The objective of this study is to analyse the information underlying, contained in, and generated by the FAO study AT 2000 with respect to the quantitative and qualitative aspects of the demand for agricultural machinery and equipment from 1975 to 2000. It is thus to help guide the development of the African agricultural machinery and equipment industries in meeting the requirements of the agricultural sector.

The scope of the study is determined by the AT 2000 which provides the framework in terms of the agricultural production programmes and of the inputs of agricultural equipment and machinery to meet the work requirements. The approach of AT 2000 and the general results for Africa are summarized in chapter 2.1.

The present study focusses on equipment and machinery required in crop production, specifically hand tools, equipment for animal traction, equipment for power-driven machinery and self-propelled machinery itself (essentially tractors). Excluded from detailed consideration are machines and equipment for irrigation, land development, input and service delivery, product transport, processing and the like and equipment and machinery required in connection with animal production. Only some aggregate figures on the importance of these items are provided in chapters 2.2. and 4.1.

The region considered is Africa as contained in AT 2000. This includes 38 countries on the continent and the islands of Madagascar and Mauritius. Excluded are former Spanish North Africa, Namibia, Botswana and South Africa as well as some very small African countries and islands. Three major subregions have been defined: Northern Africa, Western/Central Africa and Eastern/Southern Africa. The rationale for this grouping is given in detail in chapter 2.3. Finer breakdowns and country by country considerations on mechanization patterns are given in chapter 3.

Chapter 4 translates the mechanization patterns as foreseen by AT 2000 into demand for packages of agricultural machinery and equipment.

Some issues related to agricultural mechanization, the demand for agricultural machinery and equipment and the consequences for an industrialization policy are discussed in chapter 5.

2 General View of Agricultural Development and Mechanization

2.1 Agricultural Development in AT 2000

2.1.1 General

AT 2000 is a study by FAO of the perspectives and policy issues of world agriculture up to the year 2000 with particular reference to developing countries. Its projection of agricultural development is based on a demand-driven model of agricultural production on one hand and on a number of informal considerations with respect to the feasibility and desirability of certain development paths. The study includes 38 countries on the African continent and the islands of Madagascar and Mauritius. These forty countries, which represent about 95 % of the total African population, are here taken as the region of Africa. The general approach of the FAO Study and the aggregate results shall be briefly illustrated for this region.

2.1.2 Demand for Food and Agricultural Products

The demand for food and agricultural products is derived from the projected population development and from overall economic growth rates. With respect to the latter two scenarios are distinguished, scenario A and scenario B. Scenario A is based on an average annual growth rate of the gross domestic product of about 7 % between 1980 and 2000 which represents views within the UN as to the likely income targets of the new International Development Strategy. Scenario B is close to a trend projection with an annual growth rate of 5 %. Between 1975 and 1980 both scenarios are based on the trend growth rate. Table 1 gives the basic figures and the derived values of per caput income for Africa. It must be noted that constant 1975 prices are used throughout the FAO study and throughout this present analysis for all extrapolation and derivation of values. Thus no changes are assumed to occur in terms of relative real prices and inflation is abstracted from.

Table 1: Population and Income Growth in Africa from 1975 to 2000 (Scenarios A and B)

Scenario/ Indicators	Year 1975	Year 1990	Year 2000	Average annual growth 1975-2000 %
Population (mio)	371.9	579.2	763.5	2.92
Scenario A:				
GDP (Bio US $)	131.3	310.5	614.9	6.37
GDP per caput (US $)	353	536	805	3.35
Scenario B:				
GDP (bio US $)	131.3	269.6	463.9	5.18
GDP per caput (US $)	353	470	610	2.24

The basic difference between the two scenarios lies in the development of the per caput income. In scenario A it moves to over US $ 800 in scenario B to US $ 610 which still represents an increase by a factor of 1.7. The differential growth rate is reflected in differences in the level of demand for food and agricultural products and in differences in the development of agricultural production.

2.1.3 Development of Agricultural Production

The agricultural production programme is assumed to respond to the development of demand. It is based for each country on an assessment of land and water resources, cropping intensities and yields. Starting with information on the base year area, yields and production of 28 crops or commodity groups on six types of land and water situations and four levels of production (technology levels) are allocated over time. A similar although cruder approach is taken for livestock production. Taking cereal output as the most universal indicator scenario A provides for an increase from 53.8 million tonnes in 1975 to 127.1 million tonnes in 2000 which corresponds with an average annual growth rate of 3.5 %. Scenario B shows a growth rate of only 2.62 % which is below the growth rate of the human population. Neither scenario deems possible an improvement of the self-sufficiency ratios for cereals or in total calory supply. Import requirements are projected to increase. Scenario A e.g. projects cereal import requirements to move up from 10.6 million tonnes in 1975 to over 30 million tonnes in 2000. The point to make here is that even the optimistic scenario does not depict a rosy future. Rather it calls for substantial efforts to make the

world a slightly better place to live in by the year 2000 as indicated by per caput food consumption that would move from 2200 kcal per day to 2700. The trend scenario highlights the fact that even at relatively high and sustained rates of economic growth the per caput availability of food and agricultural products may remain precarious.

2.1.4 Input and Investment Requirements

The input and investment requirements of agricultural development are calculated within the model of the agricultural production programme. For both scenarios they are substantial.

Table 2: Indicators of Input and Investment Requirements of Agricultural Development (Scenarios A and B)

Year/Scenario	Fertilizer 1000 MT	Pesticides mio US $	Tractors 1000	Total gross investment mio US $
Starting level 1975	1504	379	233	5975
Scenario A:				
level in 2000	7510	1096	1577	18812
average annual growth rate	6.7 %	4.4 %	8.0 %	4.7 %
Scenario B:				
level in 2000	4036	907	979	2510
average annual growth rate	4.3 %	3.6 %	5.9 %	3.0 %

For the major current agricultural inputs like fertilizers and pesticides already scenario B calls for a trebling of quantities. Tractor numbers are to quadruple. The annual gross investment in agriculture moves from US $ 6 billion to 12.5 billion. The input and investment requirements grow at a substantially higher rate in scenario A.

2.1.5 Development Strategies and Mechanization

The production estimates and programmes elaborated by FAO are normative in the sense that they describe what could and should be accomplished if the development goals are accepted. They result from strategy choices. In the case of crop

production the main strategy choices concern area expansion versus intensified land use, the cropping patterns and alternative technologies for increasing yields and the associated choices of input mixes. In analogy the main strategy choices in livestock production refer to numeric herd and flock growth versus productivity increases, the species composition of the livestock population, the choice of the livestock product (e.g. meat versus milk) and the technologies for productivity increases. These strategy choices are partially reflected in aggregate indicators as shown in Table 3 for the development of crop agriculture in scenario A.

Table 3: Indicators of Agricultural Development Strategy for the Case of Crop Agriculture in Scenario A

	1975 level	2000 level	Increase % p.a.
Arable land (mio ha)	219.9	283.4	1.0
Cereal area	27.5 %	32.4 %	n.ap.
Cereal yield (kg/ha)	890	1380	1.8
Irrigated area (1000 ha)	4957	9775	2.8
Cropping intensity	0.53 %	0.65 %	n.ap.
Mechanization factor[a)]	17.9 %	19.7	n.ap.

a) Proportion of total power requirements in man-day-equivalents met by animal draught and by tractors.

Table 3 shows that concious decisions are assumed to be made with respect to the cropping pattern (increasing the area under cereals), yield development as opposed to area expansion, irrigation development versus non-irrigated agriculture, increase of the cropping intensity and the like. One of the strategy choices concerns the role of mechanization. While this is of major interest for this present paper it must not be overlooked that mechanization is part and parcel of the overall agricultural development strategy a country opts for. To characterize mechanization within the framework of overall agricultural development is the major aim of the sub-regional analysis in section 3. Before this section can be embarked upon the components of mechanization and the determinants of mechanization shall be discussed on the aggregate level.

2.2 Components of Agricultural Mechanization

2.2.1 General - Objective and Delimitation of Mechanization

Mechanization is not given a clear-cut definition in the AT 2000 study. The objective of mechanization is the attainment of agricultural development goals through the substitution of capital for labour. Mechanization refers to the process of introducing mechanical-technical progress into agriculture. This is opposed to the introduction of biological-technical progress which generally substitutes capital for land (improved seed, fertilizer, pesticides) and is referred to as intensification. The effect of mechanization is labour-saving while that of intensification is land-saving but this statement is incomplete. Thus mechanization may allow crop area expansion and therefore have a positive employment effect. It may also increase the productivity of the land (improvement of soil preparation, reduction of harvest losses, improvement of harvest quality). Some biological innovations on the other hand like herbicides may have their major effect on labour productivity. Another distinguishing feature of agricultural mechanization is the degree of mobility of the capital goods used. Hand tools, draught animal equipment and tractors are mobile and assist agricultural hand labour a characteristic of which is its mobility. A storage shed on the farm or livestock housing is neither mobile nor has it a direct labour replacing effect and can only be included in a very wide definition of mechanization. A further differentiation can be made according to the farm enterprise (cropping versus livestock production), according to on-farm and off-farm mechanization and according to whether labour is replaced in current agricultural operations or in bringing land into agricultural production (clearing, establishing irrigation structures etc.).

The availability of information in AT 2000 necessitates the limitation of this present analysis to crop mechanization proper. This refers to the assistance of current on-farm field work in cropping by machinery and equipment. Other forms of mechanization shall also be examined for their implied demand for machinery and equipment, but this examination has to remain cursory.

2.2.2 Crop Mechanization and the Power Model of AT 2000

The power model of AT 2000 is part of the agricultural production programme, but in some respects it is an "add-on" and not a fully integrated component. It encompasses the estimation of total power requirements of crop agriculture

and leads to estimations of the use of different sources of power. A common denominator for all power inputs into crop agriculture, man-day equivalents (MDE), is used which allows to compare the use of different sources of power and to depict the process of substitution over time. The MDE represents the average amount of work which an adult male can accomplish in a day's time. This is a pragmatic unit; there is no further formal link to e.g. working hours, units of energy expended or the like. The maximum utilization rate of human labour for cropping is put at 250 days. In this sense 250 MDE can be regarded as a man-year.

Power requirements for the base year are determined within the agricultural production programme. For each country there exists a data bank for the base year covering 28 crops/commodities, 6 soil and climate types and 4 technology levels. This yields 672 production activities and thus power requirement subtotals. For the base year total power requirements according to the production activities actually employed can be calculated by aggregation over all crops, soil/climate types and technology levels.

The production activities contained in the agricultural production programme for the years up to 2000 imply changes in the total requirements and in the sources of power which result from

- expected expansion of total crop area
- changed cropping pattern
- changed utilization of soil/climate types,
  and
- expected change in the technology level.

The substitutional relationships between the different power sources over the analysis period constitute the essence of the power model. The total power requirements are entirely met from three sources: Human labour, animal traction and tractor work. The contribution of the different sources to the total power inputs is estimated in steps which include the following considerations

- allowance for a minimum input of human labour which is always necessary irrespective of the degree of mechanization;
- the exogenous projection of the draught animal population and the substitution of hand labour at the rate of 104 MDE per draught animal in 1975, 118 MDE in the year 2000;
- the estimation of tractor numbers as a function of labour costs and of capital costs; for both determinants per caput income is taken as a proxy; the substitution rate of tractors for hand labour is assumed to drop as the mechanization level increases;

- the estimation of the hand labour input as a residual;
- the consolidation of the outcome and its adjustment for plausibility.

The different steps of this calculation are given in more detail in Annex 2. The starting point of the power model is the total power requirements, its result the allocation of the three different basic sources of power to meet the requirements. The power model thus yields the number of tractors, draught animals and of agricultural workers required for the production programme. The transmission of this physical allocation into monetary units, i.e. required monetary inputs, net investments and replacements is carried out with the help of mechanization packages. Each of the three basic sources of power is characterized by a standard mechanization package. These are the same for all African countries with the exception of the tractor unit for Egypt, Libya and Sudan. They remain unchanged throughout the analysis period.

The tractor package or tractor units looks as follows:

Number	Item	Unit value (1975 Prices) US $
1	45 HP tractor	5460
1	3-bottom mouldboard plough	2100
1	tandem disc harrow	940
1	seed-box	940
1	trailer	1560
	total	11000

For Egypt, Libya and Sudan a combine harvester is added for every seventh tractor unit raising the average value of a tractor unit to US $ 16000.

US $ 11000 (or 16000) in constant 1975 prices constitutes the net investment or the purchase cost of a tractor unit for the first time. The useful life of the whole package is put at 8 years, i.e. after 8 years the whole package is replaced at the same cost. Gross investment is made up of net investments and replacement costs.

The animal traction unit is assumed to consist of two draught animals. The investment costs, which are not broken down any further, are made up of two components

- the costs of rearing and training an animal; they do not relate to agricultural machinery or equipment and are put at US $ 400 per animal; no depreciation or replacement allowance is made implying that the salvage value (slaughter value) of the animal accounts for the cost of replacement;
- the cost of equipment for two animals is put at US $ 325; for this equipment a useful life of 10 years is assumed after which it is replaced at the same cost.

The package of human labour is an agricultural worker with hand tools. These hand tools are not further differentiated. The package can be assumed to vary with farming systems and soil/climate types. Their purchase cost is put at US $ 10, their useful life at 5 years.

2.2.3 Other Forms of Mechanization

Only crop mechanization has been considered by AT 2000 in some detail as a process of labour substitution. Other forms of mechanization are presented in the form of capital requirements for various aspects of agriculture. They also contribute to the total demand for agricultural machinery and equipment but quantification of the amounts and specification of the items is not possible. The following groups of agricultural development in part represent mechanization components:

- Land development in a wide sense which includes development of rainfed land, development of partially and fully irrigated land, soil and water conservation, flood control and drainage and the establishment of permanent crops.
- Capital requirements of livestock production.
- Off-farm capital requirement for storage, marketing, transporting and processing.

Table 4 gives details of capital requirements for land development.

Table 4: Composition of Capital Requirements for Land Development

Component	Unit costs	Quantity applied to	Depreciation charge	Foreign exchange component
Land development for rainfed agriculture	US $ 50-600/ha	as calculated by GAPS	-	10 %
Irrigation development				
- full	US $ 2000-4000/ ha (3560)	as calculated by GAPS	2.8 %	38 %
- partial	US $ 1000-1800/ ha	as calculated by GAPS	2.8 %	38 %
Soil and water conservation	US $ 100/ha	25 % of rainfed area in 2000 (1975 negligable)		
Flood control and drainage	US $ 300/ha	20 % of flooded in 1975, 50 % in 2000	-	30 %
Permanent crops establishment	US $ 1000/ha	as calculated by GAPS	4 %	5 %

The estimated foreign exchange component largely reflects that component of land development that constitutes a demand for machinery and equipment.

The capital requirements of livestock production are less easy to translate into a demand for agricultural machinery and equipment. It is clear that herd growth which can be looked at as an investment requirement must be excluded. For a proportion of incremental meat and milk production investment requirements of US $ 4000/tonne of meat and US $ 300 per tonne of milk are assumed but no specification given. For a proportion of incremental pig and poultry meat production housing costs are included at US $ 500 per piggery and US $ 4 per bird again without further specification. Feed costs are included in the aggregate of working capital for current inputs and cannot be separated out. Only grazing land development could conceptually be interpreted for a machinery content but AT 2000 limits grazing land development to negligeable proportions in Africa.

There remains the substantial component of off-farm capital requirements. This includes dry storage for non-perishable products, cold storage for perishable products, the establishment of market places, transport of market production and processing which is differentiated according to crops (cereals, oilseed, sugar, fruit and vegetable, cotton, ginning and other processing). Table 5 shows the composition of the capital requirements for these components.

Table 5: Composition of Capital Requirements for Storage, Marketing, Transport and Processing

Component	Unit costs US $	Quantity applied to	Depreciation charge	Foreign exchange component
Dry storage[a]	93/MT	incremental production of non-perishable crops plus 15 % for bufferstocks	2 %	30 %
Cold storage[a]	1000/MT	1 % of year 2000 volume of fruits and vegetables	20 %	40 %
Marketing[b]	150000/unit	20 % of cereals in 1975 rising ot 25 % in 2000[c]	2 %	20 %
Fruit and vegetable marketing	20-50/MT[d]	50 % of total product	2 %	20 %
Transport	150/MT	40 % of additional produce between 1975 and 2000	-	60 %
Cereal processing	71/MT[e]	for all additional human consumption and 25 % of cereals fed	5 %	80 %
Oilseed processing	100/MT[e]	80 % of all output as calculated by GAPS	8 %	80 %
Sugar processing	1320/MT[f]	all cane minus unspecified allowance	6 %	85 %
Fruit and vegetable processing	127/MT[e]	1 % of domestic consumption plus exports in 1975	8 %	85 %
Ginning	300/unit[g]	all additional cotton production as calculated by GAPS	5 %	80 %
Other processing[h]	-	-	-	-

a) Excluding storage of livestock products. b) Establishment of market places for cereals and other non-perishables. c) The quantity handled per market place is not given. d) 20 US $ for fruits, 50 US $ for vegetables. e) Per MT of annual capacity. f) Growth rate for domestic consumption 1,5 times that of urban production; growth rate for exports 6 % p.a. g) One unit has an annual capacity of 400 MT of seed cotton. h) The sum of all other processing costs is increased by 10 %.

Quantification and specification of the capital requirements are insufficient to examine the implied demand for machinery and equipment except on the level of aggregate values. Irrespective of this it appears difficult to include the establishment of market places and of storage structures in the notion of mechanization. Off-farm transport and processing by their nature may more closely correspond with the notion of mechanization but they take place outside the agricultural sector. The use of lorries, trains and ships to transport grain or the establishment of a ketch-up factory do not represent agricultural mechanization. It should be noted that the OECD delimitation of agricultural investment in fact leaves out off-farm transport and processing altogether.

For conceptual reasons as well as for lack of specification the 'other forms of mechanization' cannot be dealt with in further detail. In terms of their relative importance for overall investment requirement they will continue to be given attention (section 4.1.).

2.3 Determinants of Crop Mechanization

2.3.1 General

Different patterns of mechanization are projected for the different African countries. This is partly the result of formalized relationships e. g. between the rate of tractorization and overall economics growth, partly it reflects informal judgements on factors like the existing level of mechanization, the land-man ratio, the prevailing farming systems, farm size and other factors. In the following the more important of these factors are identified and discussed with respect to their role for mechanization. This discussion provides the basis for the sub-regional view of mechanization patterns in the following section. The various predictors and indicators of mechanization for each individual country are given in Annex 3.

2.3.2 Existing Level and Type of Mechanization

Existing mechanization is a derived determinant of mechanization paths for the future that summarily reflects forces that have been operating in the past. Beside the forces like economic growth, natural environment and farming system

and population pressure, which are discussed separately below, the existing level and type of mechanization also reflects historical and institutional factors like colonial settlement in the past or the existence of a dualistic pattern of agriculture with large mechanized holdings alongside traditional hoe farming.

North Africa is the region that shows by far the highest starting level of mechanization. Both animal traction and tractors account for a substantial portion of total power input reflecting the colonial history, the characteristics of sub-tropical farming but also relatively high economic growth rates in the past. Egypt constitutes an exception: High population pressure, small field sizes and the predominance of intensive irrigated farming have kept mechanization at a relatively low level.

Africa south of the Sahara by and large shows a low degree of mechanization and is still essentially the region of the hoe and the headload. Differences do exist:

- Some countries in the East and South have been exposed to European agriculture which is reflected in the fact that tractors do play a role (most notably Kenya, Zimbabwe, Angola, Mozambique and Zambia).
- Ethiopia is the country in which animal traction is indigenous and has traditionally played an important role both in the highlands and the lower lying regions.
- In the other African countries south of the Sahara animal traction constitutes an introduction of the colonial era. These introductions generally date back longer in eastern and southern Africa and are there reflected in a greater importance of this form of mechanization.
- In West and Central Africa the semi-arid zone has been the scene of expanding animal traction in the more recent decades. The Sahel countries therefore show higher draught animal populations than the other countries.

Given the existing level and type of mechanization the major forces influencing mechanization development in future are economic growth, the natural environment and the prevailing farming systems and population pressure.

2.3.3 Economic Growth

Given the differences in the starting levels overall economic growth is a major determinant of the rate of further mechanization. As an indicator the per caput income projected for the year 2000 may be taken (Annex 3), since this reflects the relative costs of labour and capital and therefore the decisions concerning their substitution. Again North Africa stands out as a sub-region on average attaining the highest income levels. This can be expected to drive mechanization further and to favour tractorization more than animal draught. North Africa is in fact the sub-region where the draught animal population is expected to decrease in absolute numbers.

The Sahel countries stand out as the country group with the most modest income prospects. According tractors remain relatively unimportant. This also holds for a number of individual countries in other sub-regions like Central African Republic, Rwanda, Burundi and Malawi.

Economic growth can also be expected to influence the mechanization pattern over time. Minimum income levels must be reached before mechanization plays a substantial role for a country as a whole. In a number of countries these minimum levels of about US $ 400 per caput are not reached before about 1990. It is only after that period therefore that mechanization really sets in. This aspect is dealt with in more detail in section 4.

2.3.4 Natural Environment and Farming System

The natural environment and, partly as a result thereof, the prevailing farming systems have a considerable influence on the mechanization pattern. Under conditions of lower rainfall the natural vegetation is less dense, clearing is less of a problem and cereals predominate in the cropping pattern, all factors which favour mechanization. At the same time land preparation becomes more of a constraint; mechanization which allows the timely preparation of large areas with the onset of the rains plays an essential role for production development. Irrigation is important in the drier areas and may have particular requirements with respect to mechanization. As rainfall increases the difficulty of clearing

the natural vegetation, a prerequisite for mechanized farming, increases. The root and tuber crops and the tree crops that predominate lend themselves less easily for mechanization. At the same time the soil fertility problems associated with permanent farming become more serious. Traditional farming methods e. g. systems of shifting cultivations have a relative advantage under these conditions and are not easily replaced by modern methods.

Linking considerations of natural environment and farming systems to countries and country groups is more easily done for northern, western and central Africa than for eastern and southern Africa. North Africa represents the low rainfall subtropical environment with the typical characteristics of rainfed agriculture and the importance of irrigation. The West/Central subregion falls into the group of semi-arid countries, the Sahel countries, and the other countries in which the high rainfall situation prevails. Nigeria is an exception in that it extends across rainfall gradients from the very humid in the south to the semi-arid in the north. In eastern and southern Africa ecological heterogeneity even within one country is more the rule than the exception. An important additional ecological zone is the highlands usually defined as areas over 1500 m a.s.l. or areas in which the average daily temperature during the growing period is less than 20° C. Some of the highland areas have been strongly influenced by European type agriculture (Kenya, to a lesser extent Tanzania). Crops from the temperate zone like wheat and barley which are easily mechanized can be grown here. On the other hand the highlands show the highest population densities, the topic of the following section.

2.3.5 Population Pressure

The land-man ratio or the cropping intensity may be taken as indicators of population pressure. In Table 6 a land-man ratio of less than unity, i. e. less than one hectare of harvested area per agricultural labourer has arbitrarily been taken to reflect high population pressure. Such high population pressure takes at least three different forms which becomes apparent if one compares Egypt with countries like the Sahel countries or Somalia on one hand and Rwanda and Burundi on the other which all have land-man ratios of less than one. Interpretation of the figure for Egypt must take into account that almost all area is irrigated with correspondingly higher yields. In dry countries of the Sahel and Somalia the bulk of the rural active population is engaged in

livestock husbandry. In countries like Rwanda and Burundi but also Kenya, Malawi and Madagascar a low land-man ratio can be taken as an immediate indicator of high population pressure on traditional agriculture. This situation prevails in much of the highland areas in East Africa but also countries like Malawi. Such high pressure on the land with concomitant fragmentation of the holdings, rural underemployment and low levels of productivity and income reduces the prospects of mechanization to negligeable proportions. The general pattern that is predicted for Africa by AT 2000 implies a widening of the land-man ratio as a result of crop area expansion and increasing cropping intensities on one side and increasing urbanization on the other. The maintenance of land-man ratios that are significantly above unity and the achievement of a widening of the ratio necessitate a degree of mechanization since the capacity of land labour in terms of the area that can be worked is strictly limited. It is recalled here that the production elasticity of power for Africa as a whole for the period 1975-2000 is estimated at 0.7 i. e. in order to achieve a one percent increase in production the power requirements increase by 0.7 percent. In order to achieve the desired growth of production part of the increased power requirements have to be met by mechanization in spite of localized situations of high population pressure (see section 4.1.).

2.3.6 Synopsis

A summary of the predictors for agricultural mechanization is given in Table 6 for subregions, countries and country groups. While a formal analysis of the relationships and differences is not possible the country-by-country examination of the predictors (see Annex 3) suggests that the inter-group differences are larger than the intra-group differences. The groupings therefore appear to be a reasonable approximation of real-world differences in the mechanization patterns. The different mechanization patterns are presented in more detail in the following section. The tables of Annex 3 provide the data for the individual countries.

Table 6: Determinants of Crop Mechanization Patterns

	Northern Africa		Western and Central Africa				Eastern and Southern Africa					
	Egypt	Other North Africa	Sahel	Nigeria	Other West Coast	Central	Ethiopia	Kenya	Other East	South	Madagascar	Mauritius
Existing tractorization[a]	M	H	L	L	L	L	L	M	L	M	L	M
Existing draught[b]	H	H	M	M	L	L	H	H	M-H	M-H	H	M
Income in 2000[c]	LM	LH	L	H	V	V	L	M	L	M	L	H
Climate[d]	ST	ST	TA/TS	TS/TH	TH	TH	HL/V	HL/V	TS	TS	TS	TH
Share of cereals[e]	M	H	H	H	M/H	L/M	H	H	M/H	M/H	H	L
Irrigation[f]	100 %	6.8-16.7%	0-6.8%	-	negl.	-	-	2.0 %	low	low	31.0 %	28.0 %
Land-man ratio[g]	L	H	M	M	L/M	L/M	L	L	L	L/M	L	M
Draught in 2000[g]	M	M	M-H	L	L	L	H	M	M-H	M-H	H	L
Tractorization in 2000[i]	H	H	L	M	L-M	L,M,H	L	M	L-M	M-H	L	M

a) Tractor factor in 1975 over 15 % = H, 5 - 15 % = M, below 5 % = L.

b) Draught factor in 1975 over 15 % = H, 5-15 % = M, below 5 % = L.

c) Over US $ 1000 = H, US $ 500 - 1000 = M, below US $ 500 = L; according to scenario A, V = varied.

d) Subtropical = ST, tropical arid = TA, tropical semi arid to sub-humid = TS, tropical humid = TH, tropical highlands = HL, V = varied.

e) In 2000 of total harvested area over 50 % = H, 30 - 50 % = M, below 30 % = L.

f) In percent of arable land.

g) Hectares of harvested area per agricultural worker over 3 = H, 1-3 = M, below 1 = L.

h) Scenario A, draught factor over 15 % = H, 5-15 % = M, Below 5 % = L.

i) Scenario A, tractor factor over 15 % = H, 5 - 15 % = M below 5 % = L.

3 Crop Mechanization Patterns[1)]

3.1 Northern Africa

Northern Africa is the region that shows by far the highest starting level of mechanization reflecting in part the history of dualistic agriculture but also the higher income level in this region and the farming systems that are conducive to mechanization. Both tractors and animal draught are important in their present contribution to total power input. For the future mechanization in this region can be pretty much equated with tractorization. Draught animals are predicted to decrease not only in relative importance but also in absolute numbers in all countries but the Sudan. Table 7 shows major determinants and indicators of mechanization in the region.

Table 7: Determinants and Indicators of Mechanization of Crop Agriculture in the Northern African Countries in 2000
(Scenario A)

Country	GDP per Caput (US $)	Land-man Ratio (ha/man)	Tractors in Use (1000)	Draught Animals (1000)	Draught Factor (%)	Tractor Factor (%)
Algeria	1920	2.48	39	15	7.8	65.3
Morocco	850	1.94	28	59	15.2	18.2
Tunisia	710	3.83	19	9	9.2	58.8
Egypt	740	0.65	14	37	8.4	17.1
Libya	10500	43.41	9	3	4.3	87.1
Sudan	620	1.88	30	62	14.9	23.5
Total	1120	1.79	139	185	11.5	29.4

The highest degrees of tractorization will be reached in Libya, Algeria and Tunisia. The very wide land-man ratio in Libya is to be seen in connection with the high per caput income and the resulting pronounced decrease of the agricultural population. Tunisia's tractorization process is conditioned by the wide land-man ratio (high level of urbanization). 80 % of all cereal production and 90 % of all fodder production is assumed to be carried out by

---

[1] For the country-by-country details for this section see Annex 3.

tractor. All three countries will by the year 2000 have gone through the most rapid phase of the mechanization process; replacement will by then reach a high share in annual gross investment (see also section 4.4).

The tractorization levels for Morocco, the Sudan and Egypt are lower. In spite of a lower per caput income and of a narrower land-man ratio Sudan surpasses Morocco; here important crop area expansion is predicted. In addition the rapid economic growth between 1990 and 2000 shows its effects (Scenario B leads to a markedly lower tractorization level). A characteristic of Sudan is the importance of tractor use for cash crops like cotton, groundnuts, and sugar cane (50 % of the total tractor work). Egypt also uses a considerable portion (30 %) of the tractor input for cotton and sugar cane. Here the narrow land-man ratio does not permit a higher overall level of tractorization; rather the cultivation of labour-intensive crops like fruits and vegetables under irrigation increases. This path of intensification also characterizes the development in Morocco.

In Northern Africa as a whole cereals, pulses and fodder crops, often grown in rotation, account for almost 70 % of total tractor use. Cane, groundnuts and cotton are of considerable importance in Egypt and Sudan, while in Tunisia and Libya this holds for fruits and vegetables.

Relatively high per caput incomes and high rates of economic growth are obviously the major driving force of tractorization in Northern Africa. Another important factor in this region is the natural environment (dry, subtropical). Tractors are essential for deep and timely cultivation resulting in higher yields and larger areas under cultivation than would otherwise be possible. The labour-saving effect of tractorization is therefore only one aspect. Increase of yields and total production imply an increase in the productivity of the land and an employment effect counterveiling the labour saving effect. Besides dry farming, irrigation is very important in Northern Africa accounting for over two thirds of total irrigated farming in Africa. In Egypt practically all arable land is under some form of irrigation already and is to become fully irrigated by the year 2000. In Morocco, Algeria and Tunisia the fully irrigated areas increase from 0.65 to 1.6 million hectares in 2000. The main crops are vegetables, citrus, sugar beet and fodder. The largest increase takes place in Sudan from 1.0 to 2.2 million hectares, particularly for cash crops like cotton and sugar

cane. Under irrigation tractor ploughing often constitutes a technical necessity due to the soil conditions but it is also an important organizational instrument: To have all fields prepared at the time when the water becomes available and to allow multiple cropping.

An additional aspect of crop mechanization in both irrigated and in dry farming relates to harvesting. The reduction of losses alone often justifies combine harvesting in a dry environment. For some of the Northern African countries therefore the standard tractor package has been enlarged to account for the use of combine harvestors (see also section 4.4.).

3.2 Western/Central Africa

Western/Central Africa contrasts with Northern Africa in that it is the region with the lowest mechanization level both at present and as predicted for the future.

Four sub-regions are distinguished within the Western and Central Africa: the Sahel countries, Nigeria, the countries of the West Coast and Central Africa. The differences in the natural environment and the farming systems, the differences in actual and projected income levels but also the weight of Nigeria as by far the most populous country suggest the differentiation.

Table 8 gives the determinants and indicators of mechanization for the subregions.

Table 8: Determinants and Indicators of Mechanization in Western and Central Africa in 2000 (Scenario A)

Country/ Country Group	GDP per Caput (US $)	Land-man Ratio (ha/man)	Tractors in Use (1000)	Draught Animals (1000)	Draught Factor (%)	Tractor Factor (%)
Sahel[a)]	240	1.34	19	1836	10.3	1.7
Nigeria	1030	2.21	134	1386	4.3	6.7
West Coast[b)]	900	1.40	83	184	1.1	5.7
Central[c)]	560	1.46	59	80	0.5	3.6
Total	780	1.73	295	3486	4.1	4.8

a) Chad, Mali, Mauritania, Niger, Senegal, Upper Volta

b) Benin, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Sierra Leone, Togo.

c) Cameroon, Central African Republic, Congo, Gabon, Zaire.

Table 8 clearly shows that none of the subregions comes anywhere near the level of mechanization reached in Northern Africa. The Sahel countries display a distinct pattern with their low income level and the significance of animal draught. The differences among the other sub-groups are less pronounced. For reasons of presentation they will be dealt with under one heading.

The Sahel Countries

The Sahel countries are on a low income level and are not projected to be able to substantially increase per caput incomes. The natural environment and the farming systems include factors that favour mechanization just as in Northern Africa. Thus timely soil preparation in the arid environment is important and the use of tractors would allow yield increases and area expansion. The leading crops are cereals and pulses (groundnuts and cotton as cash crops) which lend themselves to mechanization. Irrigation is of some importance; although much reduced in comparison with Northern Africa it is significantly higher than in the remainder of Africa. In spite of these factors the low income levels strictly limit the prospects for mechanization, particularly for tractorization. Table 9 shows determinants and indicators of mechanization for the region country by country which in this sub-region display a good degree of homogeneity.

Table 9: Determinants and Indicators of Mechanization of Crop Agriculture in the Sahel Countries in 2000 (Scenario A)

Country	GDP per Caput (US $)	Land-man Ratio (ha/man)	Tractors in Use (1000)	Draught Animals (1000)	Draught Factor (%)	Tractor Factor (%)
Mali	210	0.80	6	841	17.6	2.2
Mauritania	510	1.09	0	154	14.2	0.1
Niger	260	2.44	2	271	13.3	1.3
Senegal	200	1.58	7	223	7.4	4.0
Upper Volta	210	0.98	2	110	2.5	0.4
Chad	270	2.03	2	237	9.6	1.0
Total	240	1.34	19	1836	12.0	1.7

The tractorization factor for the year 2000 even in scenario A stays below 2 %. Only 19.000 tractors will be in use in all of the Sahel. Two countries, Senegal and Mali, account for two thirds of tractor use. There is a relative homogeneity among the countries in mechanization indicators and determinants. Animal traction and tractors will have about the same share in gross investments for mechanization in the year 2000 (Annex 3). Given the difference in cost, about 30 times more animal traction units will be demanded than tractor units. Animal traction in fact expands considerably in this area and it is here that mechanization will need to focus. Overall the Sahel countries are projected to remain at a low level of development with an average per caput income of US $ 240; the level of mechanization remains correspondingly low.

In the Sahel countries cereals account for 3/4 of the total crop area. Mechanization is mainly used for cereal production. The other important crops for mechanization are groundnuts, cotton and sugar cane. In Mali, Senegal and Chad the cash crops groundnuts, cotton and sugar cane require 40 % of the total draught power availability although these crops account for only 20 % of the crop area. Underlying this is the "classical" mechanization pattern for the semi-arid areas of West Africa: Agricultural development is based on the introduction of attractive cash crops like groundnuts and cotton; this requires expansion of the crop area over the subsistence requirements which is achieved through the introduction of animal draught. Expansion of the crop area may imply a reduction in fallow periods and the use of more marginal areas leading to a reduction of the yield levels. This is particularly pronounced for the case of groundnuts in Chad.

The irrigated area is assumed to increase from 0.4 million ha to 1.0 million ha particularly for rice growing. This area accounts for 50 % of tractor use in 2000. The major irrigation development for rice is to take place in Senegal and Chad.

West Coast, Nigeria and Central Africa

The coastal countries of West Africa and Central Africa could be lumped together as a sub-region displaying a similar mechanization pattern were it not for Nigeria. Nigeria by its weight dominates the region and is different in terms of its land-man ratio, its ecology which spans from the humid south to the semi-arid north, the importance of animal draught and its projected economic growth.

Table 10 sets beside Nigeria the other important individual countries while both for the western and central sub-regions the remaining countries are grouped.

Table 10: Determinants and Indicators of Mechanization of Crop Agriculture in Nigeria, West Coast and Central African Countries in 2000 (Scenario A)

Country or Country Group	GDP per Caput (US $)	Land-man Ratio (ha/man)	Tractors in Use (1000)	Draught Animals (1000)	Draught Factor (%)	Tractor Factor (%)
Nigeria	1030	2.21	134	1386	4.3	6.7
Ivory Coast	1850	1.26	43	55	1.0	10.4
Ghana	760	1.99	24	69	1.6	5.0
Other West[a)]	500	1.25	17	89	0.8	2.2
Zaire	180	0.74	37	0	0.0	4.0
Gabon	21100	0.66	8	0	0.0	38.9
Other Central[b)]	680	1.20	14	80	1.7	3.0
Total	880	1.54	277	1679	8.2	5.7

a) Benin, Gambia, Guinea, Liberia, Sierra Leone, Togo

b) Cameroon, Central African Republic, Congo.

Nigeria accounts for 45 % of the tractors, 40 % of the arable land and 42 % of the agricultural labour force; in most indicators the country therefore carries that sub-region. Nigeria differs from the other countries in its wide land-man ratio which has a high starting level (1.67 ha/man in 1975) and is projected to increase due to area expansion and increase of the cropping intensity to

2.2 ha/man, partly made possible by progressive mechanization. The country is also characterized by the fact that it covers almost the total span of the ecological zones from the very humid in the south to the semi-arid in the north. One tenth of the arable area is in the low-rainfall zone. As part of the mechanization process in Nigeria the draught animal population is projected to increase from 950,000 to 1.4 million. This increase must be assumed to take place largely in the sub-humid zone with animals progressively moving from the semi-arid zone south into the tsetse-infested zone while the humid belt in the south, in part densely populated,would remain more similar to the West Coast and Central Africa countries with their quasi absence of draught animals.

Among the other countries in the region Gabon is exceptional with the highest projected per caput income in Africa for the year 2000 at US $ 21,000 (in 1975 prices) on account of its oil and forest resources. The tractorization level is accordingly very high but the weight of this country in the region is small. The only other country having a tractorization factor of over 10 is Ivory Coast, again on account of its relatively high rate of economic growth.

The region as a whole is projected to reach mechanization levels that are lower than those for the Sahel and much lower than those for Northern Africa in spite of a sizeable growth in per caput incomes. This is to be seen in connection with the ecology and the farming systems of the area. In the drier areas hoe agriculture is traditional, particularly where cultivation is more or less permanent requiring the hoe for weed control. The growth of the woody vegetation is sparse and a transition to animal draught and tractors is both technically possible and advantageous for timely soil preparation and for weed control, but constrained by the population densities. High population densities and small farm sizes characterize northern Ivory Coast, northern Ghana and northern Nigeria. With the notable exception of the coastal strip of West Africa (highly urbanized) and of southeastern Nigeria the humid areas have a lower population density. Digging-stick systems become more important and replace the hoe systems as the traditional form of agriculture in the rainforest. Here shifting cultivation is occasionally practiced without cultivation implement; after burning off, seed is sown in the ashes. The axe and the machet are the main tools. Immediate replacement by animal draught or tractors is not possible because the areas first have to be cleared. This requires higher costs and implies a higher technological

jump. In addition the problems of maintaining soil fertility and preventing erosion under a system of permanent cropping are by and large still unresolved in this ecological zone. This is reflected in the high proportion of land classified as problem areas both in the West Coast and in the Central Africa region. Large-scale clearing by heavy machinery and ploughing up large tracts of land is hardly a feasible development for these areas. Animal traction is constrained by the presence of tsetse flies and trypanosomiasis. For reasons of this desease complex the humid zone is practically void of zebu cattle. Trypanotolerant breeds of cattle occur and are used for traction in the sub-humid zone. They are, however, small breeds that could hardly cope with tasks of clearing and heavy ploughing in the humid zone. Besides even trypanotolerant animals succumb to trypanosomiasis under stress which may be provoked by work. Overall the mechanization possibilities are more limited because of the predominance of root, tuber and tree crops and of valley bottom rice. Rice cultivation in valley bottoms and tree crop husbandry in the upland areas are viewed as ecologically sound farming systems for the humid zone. These crops lend themselves less to mechanization than grain. Exceptions are Ivory Coast and Angola where coffee growing became largely mechanized.

3.3 Eastern/Southern Africa

With respect to both present and expected levels of mechanization the Eastern/Southern region takes an intermediate position between Northern Africa and the Western/Central region. Table 11 shows determinants and indicators of mechanization for the region in a subdivision that yield relatively homogenous subgroups.

Table 11: Determinants and Indicators of Mechanization of Crop Agriculture in Eastern and Southern Africa in 2000

(Scenario A)

Country/ Country Group	GDP per Caput (US $)	Land-man Ratio (ha/man)	Tractors in Use (000 Units)	Draught Animals (000 Units)	Annual Gross Investment (Mio US $)	Draught Factor (%)	Tractor Factor (%)
Ethiopia	190	0.88	48	5461	569	26.6	3.0
Kenya	500	0.69	123	1016	646	11.4	14.6
Other Eastern[a)]	320	0.98	122	2759	1175	9.7	4.4
Southern[b)]	670	1.72	191	999	1009	7.9	13.5
Madagascar	490	0.81	24	1640	430	23.0	4.9
Mauritius	1110	1.20	1	5	15	4.8	14.3
Total	420	1.15	509	11880	3844	14.5	6.9

a) Burundi, Malawi, Rwanda, Somalia, Tanzania, Uganda

b) Angola, Mozambique, Rhodesia, Zambia

Ethiopia and Kenya

Ethiopia is the country that stands out for its high draught animal population and the high share of animal draught in total power input. At the same time it shows the lowest per caput income still in the year 2000. Tractorization is constrained by low income levels on one hand and high population pressures and ruggedness of the terrain at least over much of the central highlands of the country on the other. Scenario A projects an appreciable increase in tractorization from 1990 onwards while this is not pronounced in scenario B. From the point of view of the cropping pattern the high share of cereals would favour mechanization but the low level of per caput income continuing to pertain in the year 2000 and the high population pressure particularly in the central highlands put an effective check on the level of tractorization that can be reached.

Kenya shows an even narrower land-man ratio than Ethiopia. Combined with the fact that a higher portion of the arable land is classed as low rainfall there are all indications of high land pressure. At the same time, however, the history of a dualistic agriculture and the relatively higher per caput income result in higher rates of tractorization. Particularly strong is the difference between the A and B scenarios. In the B scenario the income level reaches US $ 300 only and the number of tractors in use in the year 2000 is only 71,000 instead of 123.000 in scenario A.

Other Eastern

The remainder of eastern Africa is relatively homogenous in terms of low income levels and relatively narrow land-man ratios both factors contributing to the low levels of mechanization that are reached. Two situations require mentioning because they deviate significantly from the average pattern. Rwanda and Burundi are the most densely populated countries in Africa. Lowest incomes, traditional farming techniques, a high degree of fragmentation due to the high population pressure and the importance of bananas in the cropping pattern are all obstacles to any significant mechanization. The other situation is Somalia which as an arid country with a low per caput income resembles the Sahel countries. This also holds for the relatively high importance of animal draught. In addition it deserves mentioning that a good part of mechanization in Tanzania and Uganda is assumed to take place in connection with the expansion of sugar cane cultivation.

Southern

The southern region is characterized by a long standing influence of European agriculture, relatively wide land-man ratios, a relatively high proportion of good rainfall land and relatively high income levels. It is therefore not surprising that tractorization is to proceed at a relatively rapid rate while animal draught continues to be of importance.

Islands

There remain the islands of Madagascar and Mauritius which cannot be treated together since completely different. Madagascar stands out for the importance of irrigated rice which accounts for 90 % of the area under cereals and 50 % of the total arable land. Animal draught has a relatively long tradition and is important and adapted to work in wet fields. Irrigation is to expand from 1 to 1.6 million hectares, 65 % of the draught animal power and 50 % of the tractor power in the year 2000 is used in irrigated rice. The overall level of tractorization reached is low because as a result of the low income level.

Land use in Mauritius is dominated by sugar cane cultivation. Income levels permit a significant tractorization level to be reached but the absolute tractor numbers are small due to the small size of the country.

4 Investment Requirements and the Demand for Agricultural Machinery and Equipment

4.1 Mechanization and Total Agricultural Investment

As agricultural production increases the power requirements increase. The different mechanization patterns refer to the determinants and indicators of how the power requirements are met. The relative importance of mechanization for overall agricultural development can be characterized by the production elasticity of power requirements (power elasticity) and by the share of mechanization in the total investment requirements for agriculture. The power elasticity expresses the relative increase in power requirements for a unit of relative change increase in production. In Table 12 cereal production is used as a proxy for total agricultural production.

Table 12: Increase of Power Requirements in Crop Agriculture in Africa 1975 to 2000 (Scenario A)

Country Groups	Power Requirements in 1975 Mio MDE	Power Requirements in 2000 Mio MDE	Power Requirements Increase 1975/2000 p.a. %	Cereal Production Increase 1975/2000 p.a. %
Northern	2241	4027	2.37	2.70
Western/ Central	5136	9848	2.64	4.08
Eastern/ Southern	4812	9090	2.58	3.81
Africa Total	12189	22965	2.57[a)]	3.52[b)]

a) This is equivalent to an increase by the factor 1.89 over the whole period.
b) This is equivalent to an increase by the factor 2.37 over the whole period.

Total power requirements increase at the average rate of 2.6 % p.a. while cereal output grows at 3.5 %. The rates are fairly uniform over all regions except North Africa, where they are lower due to the higher starting levels. The power elasticity is less than unity, 0.7 for the average figures given. This means that the growth of power requirements is less than the growth of physical production, which points to the importance of practices without power input (e.g. improved seed) and to inputs complementary to power in achieving increases of output. The differences in power elasticity among regions are on this aggregate level non-significant.

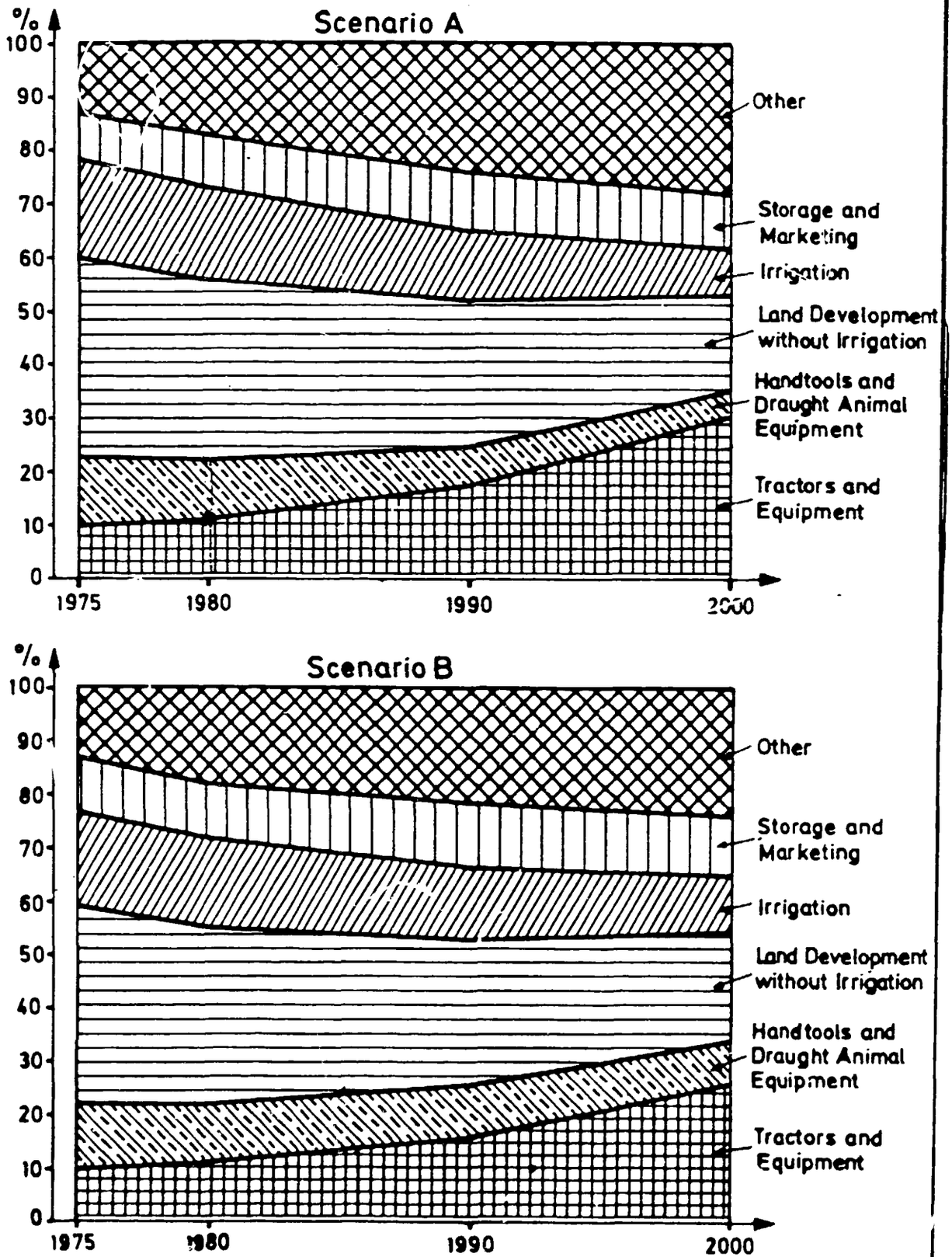
Depending on the way in which the power requirements of growing agricultural production are met the power requirements translate into a different share of mechanization in the total investment requirements. Figure 1 shows that in both scenarios crop mechanization (hand tools, draught animal equipment and tractors) account for the largest proportion of total annual investment requirements. The most dynamic development takes place for tractors. No other investment component grows as rapidly, particularly from 1990 on, as tractors. It should be noted that the component 'other' includes a portion of current costs of tractor operation and therefore adds to the investment requirements[1)]. The investment requirements for hand tools and draught animal equipment decrease in importance in both scenarios.

---

1) Current inputs are translated into investment requirements in AT 2000 by taking 50 % of their value.

Graph 1

Development of Shares of Annual Investment in Agriculture in Africa, 1975, 1980, 1990, 2000.



1) Gross Investment defined as "OECD narrow" stated in FAO: AT 2000 without Livestock Herd Increase and Draught Animals Increase.

The aggregate figures conceal considerable differences among subregions. For demonstration three countries/country groups have been taken that represent (1) high levels of tractorization (Algeria, Libya, Morocco and Tunisia), (2) a situation in which draught animal predominate (Ethiopia) and (3) a situation of low levels of mechanization (Central Africa). Figure 2 is largely self-explanatory. To be noted is for North Africa the importance of irrigation development and in Central Africa the large investment requirements for land development and for the establishment of permanent crops.

For crop mechanization the investment requirements can be translated into demand for machinery and equipment both as additional demand and as demand for replacement. In the approach of AT 2000 the different categories of investment requirements can be equated with effective demand for the different investment items.

4.2 The Demand for Hand Tools

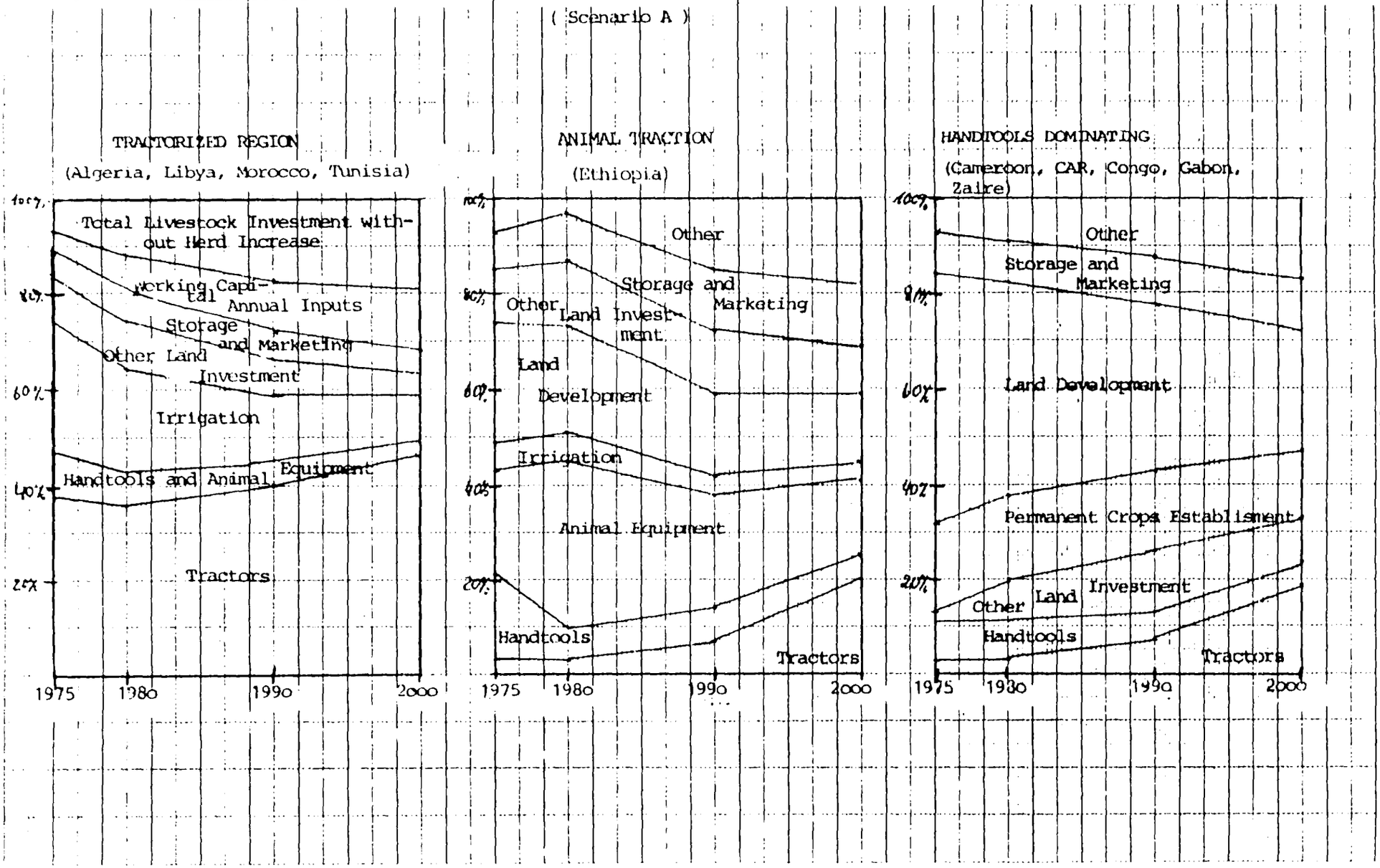
The status of Africa as the continent of the hoe and the head load does not significantly change between 1975 and the year 2000. Particularly south of the Sahara hand cultivation will continue to dominate. Hand labour in crop agriculture also needs equipment, however simple. This translates into a sizeable demand (Table 13) for hoes, digging sticks, axes, matchets, and the like which are contained but not further specified in the package worth US $ 10 per agricultural labourer in 1975 (see also section 2.2.2).

Table 13. Development of Demand for Hand Labour Equipment in Crop Agriculture in Africa 1980 to 2000 in Prices of 1975

Country Groups	Gross Investment p.a. 1980 Mill. US $	1980 Replacement (%)	1990 Mill. US $	1990 Replacement (%)	2000 Mill. US $	2000 Replacement (%)
North	33	90.9	38	92.1	44	93.2
West/Central	104	94.3	117	94.1	127	96.0
East/South	90	94.4	105	94.2	121	92.6
Africa Total	226	93.4	259	93.8	293	93.9

Figure 2: Development of Shares of Annual Gross Investment in Different Regions of Africa, 1975, 1980, 1990, 2000

(Scenario A)



Total annual demand for agricultural tools in 1975 increases by one third to almost US $ 300 million in the year 2000 in both scenarios (compare Annex 3). The demand centers lie in Africa south of the Sahel where a low degree of mechanization coincides with considerable population concentrations. The dominating country in the West/Central region is Nigeria that accounts for 40 % of the demand in the year 2000 followed by Zaire (25 %). In the East/Southern region Ethiopia (23 %), Tanzania (15 %, Kenya (13 %) and Uganda (10 %) stand out in terms of their share in total demand.

Replacement accounts for over 90 % of the gross investment requirements. Differences between regions and changes over time are mainly the result of rounding procedures. This high replacement share points to the crucial importance of the assumption about the useful life of hand tools (AT 2000 puts it at 5 years). It also points to the demand potential if improved tools were to replace existing ones.

The hand tool packages differ according to ecological zones. In the drier areas the hoe-tool package prevails. Its emphasis is on the tools for soil preparation including the various practices for moisture conservation. Narrow-bladed hoes with long sticks are found as well as the 'daba' types with a broad blade and a short stick. For harvesting a knife or a sickle is used. Tools for cutting the natural vegetation are less important. The more humid the zone, the more important become tools for vegetation clearing (ax, matchet) while tillage is reduced to making seed holes (digging stick agriculture). Slash-and-burn agriculture essentially does without any tillage tools. The only instruments are fire and cutting tools. The most elaborate set of hand tools is required for irrigated rice. Levelling and spacing devices, fine tillage instruments for the seed beds and rough equipment for earth moving and terrace building complement the normal hand tool set.

The aggregate figures of demand for hand tools are identical in the A and B scenarios since the underlying agricultural work force is identical and since different employment intensities (MDE per agricultural labourer) are assumed to have no effect on the demand for hand tools (Annex 3).

4.3 The Demand for Animal Traction Equipment

4.3.1 Draught Animals

The draught animal population in Africa has been estimated as part of the livestock model within AT 2000 with consideration being given to the power requirements of agricultural growth and to the feasibility of expanding animal traction. However, these considerations are not further specified. A draught animal is considered to be a bovine. For the aggregate view this is acceptable. For more detailed considerations adjustments would have to be made. Thus in North Africa, in the Sahel countries and in parts of Sudan and Ethiopia donkeys, mules and camels are also used. Senegal stands out as a country in which the horse is used to a significant degree. The different species have different equipment requirements that would have to be taken into account on the local level. Furthermore animal traction in parts of North Africa and in practically all of Ethiopia and in some of the southern countries has a long tradition; equipment used is locally made and technologically very simple. The traditional 'ard' in Ethiopia is less of a plough and more of an animal-drawn digging stick. Demand for traction equipment here is therefore different from areas where animal traction constitutes a comparatively recent introduction like in most of Africa south of the Sahara.

Coming back to the aggregate view, the projected development of draught animals - assumed to be all oxen - will among other things depend on the total number of cattle present and on the degree to which cattle are already used for draught. Table 14 shows the development of animal traction in relation to these magnitudes for the different regions. Ethiopia is listed separately because of the particular importance of animal traction in that country.

The most important animal traction countries in terms of animal numbers are Ethiopia, Sudan, Tanzania, Nigeria and Angola.

In North Africa the high present rate of using cattle for draught and the decline in the animal traction factor results from the high rate of tractorization that is expected for the area as a whole. The aggregate conceals the development in Sudan where animal traction is assumed to grow in importance.

Table 14: Cattle Herd, Draught Animal, Development of the Draught Factor for the African Regions 1975 to 2000 (Scenario A)

Region	Number of Cattle[a] (1000 Head)	Draught Animals %	Increase[b] Ø 1975-2000 % p.a.	Draught Factor 1975	Draught Factor 2000
North	24 912	16.6	- 1.0	21.6	11.5
Sahel	15 212	6.2	2.7	9.0	10.3
Western/ Central	22 830	5.1	1.6	2.8	2.5
Ethiopia	25 879	19.3	0.3	39.1	26.6
Eastern/ Southern	49 492	9.2	1.5	12.0	11.2
Africa total	138 325	11.4	1.5	13.8	9.8

a) Including buffaloes in Egypt

b) Increase of the number of draught animals

c) Without Ethiopia

The Sahel countries show the highest rate of growth for draught animals. It is [illegible]nly region for which an increase in the animal traction factor is projected. [illegible] corresponds with development over the last two to three decades that took place in the semi-arid zone of West Africa.

The development in the Western/Central region is carried by Nigeria and secondly Angola. Most of the other countries have very small cattle populations as a result of tsetse infestation. Since even trypanotolerant animals succumb to tsetse challenge under stress (e.g. through work) development of animal traction will be of minor importance. Furthermore the farming systems in the humid zone (root crops, tree crops) lend themselves less to mechanization.

The development in the Eastern/Southern regio[illegible] is heterogeneous. The largest number of cattle and of draught animals is found here and the growth rate of animal traction is almost identical to that of total power requirements.

Ethiopia already shows about the maximum rate of use of the cattle herd for traction. Increased power requirements projected particularly for the period 1990 to 2000 have to be increasingly met by tractors.

4.3.2 Demand for Equipment

Leaving aside the investment in rearing and training of the animals the investment in equipment for a pair of draught animals is put at US $ 325, the useful life at 10 years. The resulting gross investment requirements are shown in Table 15.

Table 15: Development of Demand for Animal Traction Equipment in Africa 1980 to 2000 in Prices of 1975 (Scenario A)

	Gross Investment p.a.					
	1980		1990		2000	
Country Group	Mill. US $	Raplace-ment (%)	Mill. US $	Replace-ment (%)	Mill. US $	Replacement (%)
North	65	98.5	62	98.4	59	98.3
Sahel	21	71.4	28	78.6	34	79.4
West/Centr.	21	80.9	25	84.0	28	85.7
Ethiopia	84	96.4	87	96.6	90	96.7
East/South[a)]	87	82.8	100	80.8	112	88.4
Africa Total	279	91.0	301	91.4	324	91.4

a) Without Ethiopia.

The value of total demand for animal traction equipment in 1975 prices increases from US $ 279 million p.a. in 1980 to 324 million in 2000. The order of magnitude is similar to that of hand tools, the growth rate is less pronounced.

In North Africa the demand is essentially for replacement with the absolute number of draught animals slowly decreasing. Only Sudan shows increasing net investments. The total demand in that country reaches the value of US $ 20 million in 2000. In the Sahel and the Western/Central region the draught animal herd is expanding, the net investment content accordingly larger. Nigeria is dominating and accounts in the year 2000 for US $ 24 million of the total demand of the region valued at 29 million.

Both the Sahel and the other Western/Central countries show a low demand for animal traction equipment compared with that for East/Southern Africa. In the latter region Ethiopia takes the lion's share with US $ 90 million (44 %). Due to the traditional importance of animal traction the replacement content is very high at 97 %. New

investments account for a substantially higher portion in Uganda (14 %) and in Madagascar (16 %).

Again the developments in the A and B scenarios are identical.

4.4 The Demand for Tractors and Equipment

4.4.1 Development of Demand in Scenarios A and B

The tractor units are valued at US $ 11000 (16000 in Egypt, Libya and Sudan) in 1975 prices and assumed to last on average for 8 years. Development of total demand is different in scenarios A and B. Both sets of figures are therefore given in Table 16.

According to scenario A total demand grows from US $ 335 million in 1980 to 3.65 billion in the year 2000 in 1975 prices. It therefore accounts for more than ten times the investment volume of hand tools and of animal traction equipment respectively. Scenario B still foresees a demand volume of 2.1 billion.

All regions show a decreasing ratio of replacement to new investment underlining the net growth of this type of mechanization. Libya is the country with the highest per caput income at present and the highest projected tractorization level. Here replacement reaches the highest proportion (78 %) in the year 2000. In that year Sudan and Algeria will each account for one forth of the tractor demand in North Africa. An essential difference is that in the former replacements reach only 1/3 of gross investments while they reach 2/3 in Algeria. The other important country in North Africa in terms of its volume of demand for tractors is Egypt. The difference between the A and B scenarios is least for North Africa because sufficient income levels are reached in both scenarios to drive the demand for tractors.

The Sahel shows a very low demand still for the year 2000 and even this level is very sensitive to the assumed economic growth (compare scenario B).

For Western/Central Africa the demand is assumed to increase ten-fold between 1975 and 2000. The major shares in the assumed investment volume (scenario A) of US $ 700 million are held by Nigeria (290 million), Ivory Coast (110 million), Zaire (87 million), and Ghana (55 million). Between 1990 and 2000 alone a trebling of demand is projected in all countries.

Table 16: Development of Annual Demand for Tractors and Associated Equipment for Crop Agriculture in Africa 1980 to 2000, Scenarios A and B

Country Group	1980 Units (1000)	1980 75-value Mio US $	1980 Replacement (%)	1990 Units (1000)	1990 75-value Mio US $	1990 Replacement (%)	2000 Units (1000)	2000 75-value Mio US $	2000 Replacement (%)
Scenario A									
Northern	28.8	366	64.8	60.0	766	56.3	137.8	1775	51.2
Western/ Central	6.2	67	52.2	17.8	207	42.3	60.9	671	36.6
Eastern/ Southern	9.1	101	57.4	28.7	304	44.7	109.6	1161	38.3
Africa Total	44.1	535	61.9	106.6	1276	50.4	308.3	3650	43.7
Scenario B									
Northern	26.5	346	72.0	46.1	584	63.7	93.9	1216	53.0
Western/ Central	5.7	62	58.1	12.3	135	57.0	34.6	380	48.5
Eastern/ Southern	8.0	88	73.8	14.6	161	54.0	45.4	500	45.2
Africa Total	40.2	497	70.8	73.0	880	60.3	173.9	2096	52.0

A similarly rapid development is predicted for Eastern/Southern Africa. The volume of gross investment there is to exceed US $ 1 billion in the year 2000. The major contributors are Kenya (29 %), Mozambique (15 %) and Tanzania (15 %). Again the thrust sets in between 1990 and 2000 and as in the Western/Central region reduced achievement in overall economic growth (scenario B) would depress this development significantly.

With respect to the two different scenarios the following generalizable trends emerge:

- Countries with presently very low income levels like the Sahel countries and many other countries in Western/Central Africa will not become important users

of tractors by the year 2000 even if development from now on is rapid (scenario A).

- In countries whose income increases significantly beyond US $ 400 per caput tractorization will set in at a relatively rapid rate (e.g. Kenya, Ivory Coast).
- For countries with a power gap developing toward the year 2000 (only Ethiopia and Zaire) rapid tractorization has also been assumed to set in.
- Tractorization will continue in countries with already a relatively high per caput income like the countries of North Africa. Low present levels of tractorization lead to particularly rapid rates of growth (e.g. Morocco).

The difference between the two scenarios in tractorization is illustrated for selected countries in Figure 3.

The countries are selected due to different pathes of development according to scenario A and B, e.g. Algeria and Rhodesia are selected for their low differences between both scenarios, East African countries stand out for the huge deviations and the remaining ones form a medium stage.

4.4.2 Tractorization in Selected Countries

Ten countries of the forty comprised in the analysis account for 75 % of the total tractors in use at present and in the year 2000. Given the important investment consequences a more detailed analysis of the implications of tractorization in these countries is presented in Table 17.

Growth rates of tractor numbers of over 10 % for sustained periods have been experienced in other regions of the world (Japan 40.9 % between 1960 and 1970, 18.1 % between 1970 and 1978, India 14 % and 12.9 % respectively, South America 14.6 % between 1950 and 1970 and most of the European countries between 1950 and 1960). The rates in Table 17 are therefore not unparalleled by any means.

The countries listed in Table 17 also account for the bulk of the demand for tractors both in physical units and in monetary terms (Table 18).

Figure 3: Comparison of Tractor Use in Selected African Countries and Regions, 1980, 1990 and 2000 (Scenario A)

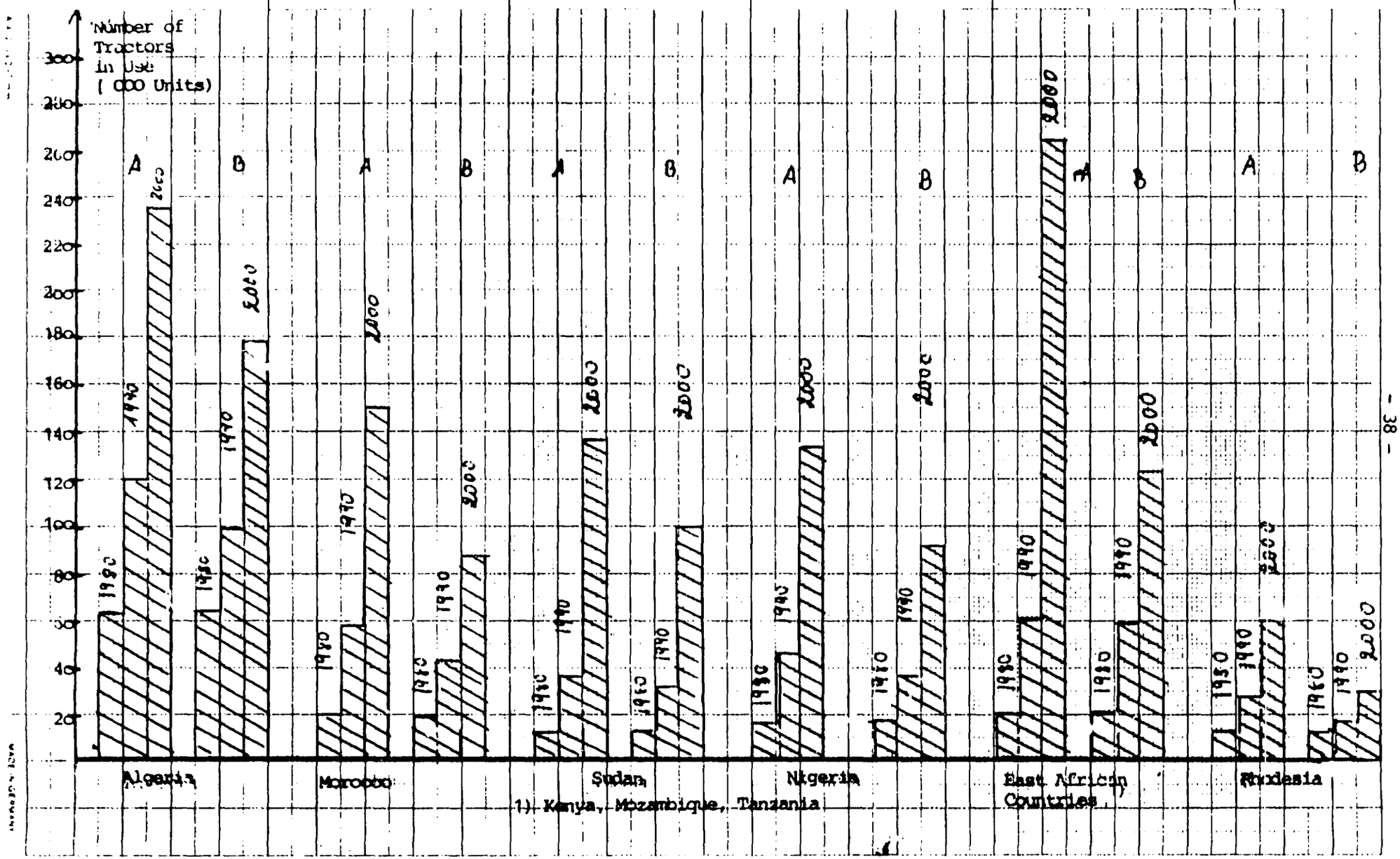


Table 17: Development of Tractorization in Selected African Countries
1980 to 2000 (Scenario A) - in order of tractor numbers in 2000 -

Country	Tractors in Use (1000)			Tractor Factor (Percentages)			Growth of Tractor Numbers (% p.a.)	
	1980	1990	2000	1980	1990	2000	Ø 1980–1990	Ø 1990–2000
Algeria	63	120	235	39.8	52.3	65.3	6.7	7.0
Morocco	21	58	151	7.5	11.6	18.2	10.7	10.0
Sudan	13	37	137	9.1	14.0	23.5	11.0	14.0
Nigeria	17	46	134	2.3	3.9	6.7	10.5	11.3
Kenya	8	25	123	5.7	8.7	14.6	12.1	17.3
Tunisia	33	59	112	32.0	43.5	58.8	6.0	6.6
Egypt	23	39	82	5.7	9.1	17.1	5.4	7.7
Mozambique	6	18	71	4.9	7.3	11.9	11.6	14.7
Tanzania	7	18	71	2.0	3.0	5.5	9.9	14.7
Rhodesia	13	28	60	10.0	14.4	20.1	8.0	7.9
Total	204	448	1176	-	-	-	8.2	10.1
Africa Total [a)]	270	558	1577	4.2	6.2	9.8	8.1	10.4

a) 40 Developing Countries

The highest demand is shown by Algeria with 40000 units per annum in the year 2000. All the countries in Table 17 will have a demand in excess of 10 000 units p.a. which for the purposes of making industrial investment decisions may be considered a substantial basis. With the exception of North Africa, however, the starting levels (1980) are low.

Table 18: Development of Annual Demand for Tractors and Associated Equipment[a] for Crop Agriculture in Africa 1980 to 2000 (Scenario A)

Country	1980 Units (1000)	1980 75-Value[a] (Mio US $)	1990 Units (1000)	1990 75-Value[a] (Mio US $)	2000 Units (1000)	2000 75-Value[a] (Mio US $)
Algeria	10	111	19.9	219	39.3	432
Morocco	3.7	41	11.1	122	28.3	311
Sudan	2.4	39	7.5	120	29.6	474
Nigeria	3.2	35	8.8	97	26.3	289
Kenya	1.6	17	5.5	60	29.5	324
Tunisia	5.2	57	9.6	106	18.5	203
Egypt	3.4	54	6.4	103	14.1	226
Mozambique	1.1	12	3.8	42	15.5	171
Tanzania	1.2	13	3.6	40	15.9	175
Rhodesia	1.7	20	4.8	53	10.5	115
Total	33.0	399	79.9	962	227.5	2720
Africa Total	44.5	535	108.4	1276	308.3	3650

a) New Investment and Replacement

4.4.3 Replacement Assumption and Repair Costs

AT 2000 assumes a useful life of a tractor unit of 8 years. For the different countries this corresponds with a lifetime performance of between 10400 hours (Egypt) and 4800 hours (low income countries) depending on the development stage. The effect of a change in the useful life (and a corresponding change in the performance hours) effects the investment requirements significantly (Table 19).

Table 19: Development of the Annual Gross Investment in Tractors in Africa under Alternative Replacement Assumptions 1980, 1990, 2000 (Mio US $ in 1975 prices) (Scenario A)

Replacement after	1980	1990	2000
5 years	650	2003	5199
8 years	535	1276	3650
10 years	325	890	2767

In comparison with the AT 2000 assumption of replacement after 8 years the reduction of the average lifetime to 5 years leads to a 42 % increase in annual investment requirements by the year 2000 (an increment of US $ 1.5 billion). A prolongation of the useful life to 10 years reduces investment requirements by 24 % or US $ 883 million. The effect of differing replacement assumptions increases over time since for Africa as a whole replacement becomes a more important item as the process of tractorization goes on (Table 20).

Table 20: The Effect of Alternative Replacement Assumptions on Annual Gross Investments in Tractors in Africa by Region 1980, 1990 and 2000 (Mio US $in1975 prices)

	Replacement Assumption					
	Five years			Ten Years		
Region	1980	1990	2000	1980	1990	2000
North	393	1171	2409	201	470	1057
Central/ West	113	339	1118	42	170	728
East/South	144	493	1672	82	250	982

The effect of the replacement assumption is highest on North Africa, the region with the highest tractorization rate and the highest replacement burden. A lenthening of the useful life not only leads to a reduction of total investment

but also to a narrowing of the gap between North Africa and the other regions in the investment requirements and thus demand for tractors and equipment. Conversely the gap widens if the replacement period shortens.

None of the mechanizaton packages includes an allowance for spare parts and total repair costs. For tractors this is in the order of at least 10 % of the purchase value p.a. and adds substantially to the total demand. This aspect is related to the question of a tractor service network on which successful adoption of tractors is dependent. Especially in the initial phase with low tractor densities the service network adds considerably to the overhead costs of a tractorization programme.

5 Issues and Conclusion

5.1 The AT 2000 Framework

This present analysis is placed completely within the context of the FAO study AT: 2000. That study does not constitute a projection exercise but rather a planning exercise that outlines the likely and the possible agricultural development pattern if certain efforts are undertaken. Even for scenario B the efforts required are massive on all fronts (and yet the improvements for the year 2000 are still only modest). The mobilization of substantial resources, both internal and external, is an essential underlying assumption of the FAO study on which not only the mechanization pattern but all aspects of agicultural development depend. Of course it is thinkable that not even the development levels implied by scenario B will be reached and that the rate of mechanization will accordingly be reduced. Such a situation cannot be discussed with reference to a single aspect like mechanization alone.

Consideration of the implications of such reduced overall performance for the demand for agricultural machinery and equipment is therefore beyond the scope of this paper. If one accepts the two scenarios of AT 2000 as relevant ones, as has been done in this paper, one can only examine the plausibility of implications for particular aspects like mechanization. In this respect the authors are of the opinion that AT 2000 provides a plausible framework.

5.2 The Use of 1975 Prices

The whole AT 2000 study is based on the use of constant 1975 prices. This abstracts from inflation and from changes in relative prices for the whole period up to the year 2000. This approach of AT 2000 is well-reasoned and there is no practical alternative given the scope of AT 2000. This does mean that for the examination of particular aspects like mechanization the framework of constant prices has to be accepted in order to avoid a host of consistency problems. Nevertheless the question is legitimate whether a particular aspect like mechanization can be expected to be especially subject to or sensitive to deviations from the constant price assumption. Thus indications are that the prices for agricultural machinery and equipment doubled between 1975 and and 1980 which implies a rate more rapid than average inflation. Furthermore the cost of agricultural machinery and equipment has a high foreign exchange

content. If developing countries face increasing foreign exchange shortages the opportunity costs of such items can be expected to increase more rapidly than of those with a low foreign exchange content. Depending on government policy e. g. in respect to the policy of subsidization this would influence demand via its price elasticity. If the income elasticity of demand for agricultural machinery and equipment is high as assumed in AT 2000 the price elasticity of demand and therefore the effects of price changes can also be assumed to be high. Lastly there is the issue of livestock prices. Although not explicitly accounted for AT 2000 expects rising real prices for livestock and livestock products due to decreasing self-sufficiency ratios. This might make mechanization of livestock production more attractive. It would also raise the opportunity cost of keeping oxen for draught purposes.

A formal integration of these considerations is again beyond the scope of this paper.

5.3 Per-caput Income and Tractorization

The most dynamic aspect of mechanization and the one with the most serious implications for an industrialization strategy is tractorization. Fairly high rates of tractorization are projected for many countries. At the same time it is a well-known fact that apart from the context of European agriculture and colonial heritage in Africa tractorization programmes in the past have met with failure more often than not. The functional relationship between per-caput income and tractorization is theoretically sound and has been empirically substantiated for more developed countries. Nevertheless some 'caveats' appear appropriate with respect to the transfer of this relationship to the developing world. Regions outside Africa that have experienced high rates of tractorization also had the following characteristics:

- High demand for labour in the non-agricultural sectors,
- low increase or decrease of the agricultural labour force,
- high level of technical know-how among farmers,
- subsidization of agriculture usually via prices for agricultural products.

These characteristics are often lacking in African countries. This may to a large extent explain the high rate of failure of tractorization programmes in the past. Tractorization programmes will then have to be much more comprehensive than merely making tractors available. A review of past tractorization programmes

and an analysis of their reasons for success and failure might be appropriate. This would highlight the infrastructural, logistical, educational and other prerequisites and point to the supporting elements of programmes that are essential for tractorization even if the basic income condition is met.

5.4 Farm Size and the Organizational Form of Tractorization

The size of holdings is an important determinant of tractorization. Countries with a history of dualistic agriculture and a significant proportion of large-scale farming operations can rely on individual farm units to make their calculus of the profitability of mechanization. This is not so in the case of smallholders. In the latter the organizational form of tractorization, in particular the form of tractor sharing is important. Different organization forms are possible:

- Statal or parastatal machinery stations which provide tractor services upon request and against a fee.
- Centrally organized tractor stations within a project perimeter within which the principle of prescribed and supervised production is followed (e. g. irrigation projects like Gezira in Sudan and Mwea-Tebere in Kenya).
- Cooperative tractor ventures relying in their pure form on the principle of consensus for the distribution of tractor services.
- Contractual tractor work by private entrepreneurs.
- Semi-commercial sharing of tractors (neighbourly assistance, occasional contract work by tractor owners etc.).

Each one of these forms has its particular set of advantages and disadvantages in dependence on the particular situation prevailing. Again a survey of tractorization programmes in the past might provide valuable insights as to the determinants of success and failure.

5.5 The Tractor Package and the Concept of Intermediate Technology

Two criticisms may be advanced against the tractor package used in AT 2000. Firstly the assumption of a standard package (based on a 45 HP tractor with equipment) neglects the modifications that are necessary in many situations for ecological and economic reasons. Secondly the mechanization packages (hand tools, animal traction, tractors) imply discrete jumps in mechanization and do not provide for what one might refer to as intermediate technology.

Specification of the tractor package for a particular situation would take account of the crops, the land/climate types, the prevailing farming systems, farm size and other factors (e. g. the species and type of draught animals). The necessary information to link these factors to specific mechanization patterns on a continental level is lacking. General knowledge of the countries points to considerable differences between e. g. Egypt and the Sudan, or Malawi and Zambia. Specific analyses on a country basis would lead to the modification of the standard tractor package depending on farm size, land/climate types, irrigation,crops etc. A lighter unit would need to be devised based on a 30 HP tractor and a heavier unit based on a 60 HP tractor. Since the smaller package is less power-efficient it would lead to a cost increase of about 15 %. The larger package only becomes more expensive per unit of land worked if special features are added like four-wheel drive for the tractor or a combine or if farm size is insufficient for full utilization. For the development over time larger units are likely to be in higher demand initially because the larger farms are the first to mechanize. Furthermore the general statistical observation has to be taken into account, according which the average size of tractors declines in the initial stages of mechanization until almost full mechanization is reached; then average size increases again.

Related to the above consideration but requiring separate treatment is the concept of intermediate technology. The central question is whether mechanization in developing countries requires special technology somewhere inbetween the high level of the industrialized countries and the pre-technical level still often prevailing in developing countries rather than a transfer of say a tractor package as it would be used in an industrial country. Possible consequences would be that one views animal traction as the 'organic' transition stage between hoe agriculture and tractor agriculture or that the use of small tractors with say 10 HP is deemed desirable initially before in the course of general development larger units are introduced. Exhaustive discussion of this issue is not possible. The authors are of the opinion that there are neither 'organic' development paths nor inherent advantages in the concept of intermediateness of technology. The technical and economic forces in mechanization are compelling and the decades of trial and error from the industrial countries support the existence of minimum sizes below which the rationale for mechanization is largely lost. Not intermediate technology is required but adapted technology, i. e. the best technology for the purposes at hand. There is no reason to

assume that a farmer in the developing world should be content with a 15 HP tractor (which is more expensive and technically less satisfactory) rather than a 45 HP tractor which does the job properly and has a higher cost-effectiveness. However there may well be the need to adjust conditions to that tractor size through the appropriate form of tractor services e. g. a form of joint ownership or the like as described in the preceeding section.

5.6 Implications for an Industrialization Strategy

There is a long way still from the specification of investment requirements and demand figures for agricultural machinery and equipment to the deviation of a strategy to build up industrial capacities to meet that demand. The tasks include:

- The specification of the standard packages that are behind the aggregate demand figures in terms of industrial output units;
- The specification of the quality requirements:
- The determination of production costs and of the economies of scale;
- The examination of possibilities of international cooperation;
- The examination of government policies with respect to factor pricing, product pricing and foreign trade;
- The examination of the market size including the possibility of transnational activities and the risks involved in planning for transnational activities.

These are only some of the tasks specific to the planning of production capacities for agricultural machinery and equipment; others concern the overall industrialization policy, ownership, source of finance etc. None of these issues can be dealt with in the context of this paper. The aim of this paper is merely to illuminate one facet of an industrialization strategy for Africa: The development of agricultural mechanization and the likely size of the demand for agricultural machinery and equipment up the year 2000.

6 References

A Publications

FAO (1980): Land Resources for Population of the Future. Report on the Second FAO/UNFPA Expert Consultation. Rome.

FAO (1979): Agriculture: Toward 2000. Preliminary Report. C 79/24. Rome.

FAO (1976): Perspective Study on Agricultural Development in the Sahelian Countries 1975-1990. Vol. I: Main Report. Rome.

Heumann, G., Rapelius, E., Sievers, M. und Weber, A. (1980): Die Schleppernachnachfrage in einzelnen Regionen der Welt. Eine Analyse der Bestimmungsgründe und Prognose der Bestandsentwicklung bis zum Jahr 2000. Agrarwirtschaft, Vol. 29, No. 5.

KTBL (1980): KTBL-Taschenbuch für Betriebs- und Arbeitswirtschaft. Ed. by Kuratorium für Technik und Bauwesen in der Landwirtschaft e. V. (KTBL). 10th Edition. Darmstadt.

B Informal Documents

Anoymous (1981): Replacement Parts for Agricultural Machinery. FAO, Panel of Experts on Agricultural Mechanization. Rome.

" (1980): Agriculture: Toward 2000. Estimation of Investment Requirements. Agriculture Department and Global Perspective Studies Unit. Rome.

" (1979): Agriculture: Toward 2000. Methodological Background - an Interim Statement. Global Perspective Studies Unit. Rome.

" (1979): Perspective Study of Agricultural Development for Zambia. Country Perspective Study Team. Rome.

Bruinsma, J. (1980): "Agriculture: Toward 2000". The Power Model: Power Scarcity Indices. FAO. Rome.

Giorgis, D. G. (1981): Production and Use of Agricultural Machinery in Ethiopia. Addis Ababa.

Hrabovszky, J. P. (1980): Selected Aspects of the AT 2000 Study of FAO - Power Inputs, Employment and Income Distribution.

" (1978): Conceptual and Estimation Problems Related to Power Inputs into Agriculture as Part of the AT 2000 Study. Note for the File No. 1. FAO. Rome.

" (1978): Power Inputs into "Agriculture: Toward 2000". Note for the File No. 2. FAO. Rome.

FAO (1976): Perspective Study of Agricultural Development for Tanzania. Country Perspective Study Team. Rome.

Ministere de l'Agriculture (1981): Etude de Industrie du Machinisme Agricole au Mali.

UNIDO (1979): Background Information on Possible Local Assembly and Manufacture of Agricultural Machinery. Vienna.

Zaky, M. H., (1981): Country Paper for the First Regional Consultation on Agricultural Machinery Industry in Africa: Arab Republic of Egypt. Cairo.

Annex 1: African Countries and Country Groups

1. Countries and Code Numbers [1)]

Alphabetical Order		By Code in Ascending Order	
Name	Code	Code	Name
Algeria	1	1	Algeria
Angola	18	2	Morocco
Benin	4	3	Tunisia
Burundi	25	4	Benin
Cameroon	19	5	Gambia
Central African Republic (CAR)	2o	6	Ghana
Chad	21	7	Guinea
Congo	22	8	Ivory Coast
Egypt	62	9	Liberia
Ethiopia	26	1o	Mali
Gabon	23	11	Mauritania
Gambia	5	12	Niger
Ghana	6	13	Nigeria
Guinea	7	14	Senegal
Ivory Cost	8	15	Sierra Leone
Kenya	27	16	Togo
Liberia	9	17	Upper Volta
Libya	63	18	Angola
Madagascar	28	19	Cameroon
Mali	1o	2o	CAR
Malawi	29	21	Chad
Mauritania	11	22	Congo
Mauritius	3o	23	Gabon
Morocco	3	24	Zaire
Mozambique	31	25	Burundi
Niger	12	26	Ethiopia
Nigeria	13	27	Kenya
Rhodesia	32	28	Madagascar
Rwanda	33	29	Malawi
Senegal	14	3o	Mauritius
Sierra Leone	15	31	Mozambique
Somalia	34	32	Rhodesia
Sudan	64	33	Rwanda
Tanzania	35	34	Somalia
Togo	16	35	Tanzania
Tunisia	3	36	Uganda
Uganda	36	37	Zambia
Upper Volta	17	62	Egypt
Zaire	24	63	Libya
Zambia	37	64	Sudan

[1)] According to AT 2ooo

2. Country Groups/Subregions

Country Group/Subregion	Country[1]	Code
Northern	Morocco	2
	Algeria	1
	Tunisia	3
	Libya	63
	Egypt	62
	Sudan	64
Western/Central-Sahel	Mauritania	11
	Senegal	14
	Mali	10
	Upper Volta	17
	Niger	12
	Chad	21
Other	Guinea	7
	Sierra Leone	15
	Liberia	9
	Ivory Coast	8
	Ghana	6
	Togo	16
	Benin	4
	Nigeria	13
	Cameroon	19
	Central African Republic	20
	Gabon	23
	Congo	22
	Zaire	24
Eastern/Southern	Ethiopia	26
	Somalia	34
	Uganda	36
	Kenya	27
	Rwanda	33
	Burundi	25
	Tanzania	35
	Zambia	37
	Angola	18
	Rhodesia	32
	Malawi	29
	Mozambique	31
	Madagascar	28
	Mauritius	30

[1] From West to East and North to South to establish order within country group.

Annex 2: The Power Model

a) Total Power Requirements

The total power requirements are entirely met from the three sources: Human labour (P_L) animal traction (P_A), and tractor work (P_T). For the total power input (= total power requirements = TP) the following equation holds

$$(1) \quad TP = P_L + P_A + P_T$$

b) Minimum Hand Labour

Substitutional relationships are assumed to hold only for a portion of the total power input (TP_{R1}): Under the conditions of developing countries and for the period of analysis a fixed minimum input of human labour ($P_{L\ min}$) is assumed to be necessary. TR_{R1} is thus a first residual magnitude for the power input.

$$(2) \quad TP_{R1} = TP - P_{L\ min}$$

$P_{L\ min}$ (and thus TP_{R1}) is not a fixed magnitude. It depends on the cropping pattern, the soil/climate types and the general development level and is estimated for each country in an informal way.

c) Animal Power and its Relationship to Hand Labour

The unit of account for animal power is a draught animal, in particular bovine. Its use for one day is uniformly put at the equivalent of 2.6 man days[1)]. Draught animals are, however, used only on 4o days during the year (rising to 45 days in the year 2ooo)[2)]. One draught animal therefore corresponds with 1o4 MDE or o.416 man-years in 1975; 18o MDE or o.468 man years in 2ooo.

The development of the draught animal population constitutes an estimation that is carried out as part of the livestock model which takes into account total herd size and composition. The estimation is therefore exogenous to the considerations of power requirements and power input. Subtracting the power input by animals (P_A = No. of draught animals from the livestock model multiplied by 2.6 MDE and by 4o days) yields a second residual (TP_{R2}).

$$(3) \quad TP_{R2} = TP_{R1} - P_A$$

TP_{R2} constitutes the labour input that can be provided by tractors and or human labour.

d) The Use of Tractor Power

The relative use of tractor and human labour to meet the secondary residual power requirements is essentially determinend by the development of labour costs and of capital costs. Both determinants can be approximated by the development of per caput income. Conceptionally the sub-

---

1) This corresponds with the following "back-of-the-envelope" calculation: One adult male can work o.4 ha of crops. A family of five persons with 2.5 adult male equivalents works one hectare. A pair of draught animal allows expansion of the crop area to 3 hectares, i.e. one draught animal adds the equivalent of 2.5 men.

2) Exceptions: For Egypt, Libya and Sudan 5o days of work for both periods are assumed; these countries belong to the Near East Region within the original AT 2ooo classification.

stitution of labour by tractors constitutes a movement on a concave isoquant. The relationship between per caput income and ratio of tractor work to human labour is expressed in the following function

$$(4)\quad TLR = \alpha \left(\frac{GDP}{POP}\right)^{\beta}$$

TLR - tractor-labour ratio
GDP - gross domestic product
POP - total population
α , β - functional parameters

The relationship between tractor numbers and the proportion of power requirements met by tractors is dependent on the substitutional relationship between tractors and hand labour. This relationship is technologically determined. At low levels of mechanization tractors substitute for large amounts of labour; the ratio becomes smaller for higher levels of mechanization since it becomes progressively more difficult to substitute for hand labour.

This relationship has not been formalized in the model. Instead judgement-based adjustments have been carried out in the substitutions ratio over time between machine and hand labour.

e) The Hand Labour Residual

The third residual (TP_{R3}) is calculated as follows

$$(5)\quad TP_{R3} = TP_{R2} - P_T$$

All values are expressed in MDE. In order to arrive at the total input of human labour the minimum input of hand labour has to be added back

$$(6)\quad P_L = TP_{R3} + P_{L\ min}$$

The number of agricultural workers can be determined with the assumption that one worker performs 250 agricultural working days. This relationship bears a measure of ambiguity since the input of 250 days is considered as the maximum permissible, not a fixed rate for all circumstances.

f) Model Adjustments (the Gamma Factor)

Having gone through the considerations step by step a consolidation of total power requirements and total power supply is sought, at first for the base year. In particular, the tractor-labour ratio is examined for plausibility in respect to the following rationship

$$(7)\quad TLR = \frac{TN \cdot c_T \cdot u_T}{LN \cdot u_L}$$

TN - tractor number
c_T - conversion rate for tractor into MDE per hour
u_T - utilization rate for tractor in hours per year
u_L - utilization rate for human labour in days per year
LN - number of agricultural workers

$$(8)\quad \alpha = TLR \left(\frac{GDP}{POP}\right)^{-\hat{\beta}}$$

$\hat{\beta}$ - estimated parameter from (4)

In each case the volume of MDE to be performed is checked against probable labour availability (number of workers multiplied by annual use levels) and against the plausibility of the assumptions concerning tractor work (number, conversion rate factor, use rate). The task has been described by Hrabovszky in the following words:

> "Given the complexity of the problems, the many simplifying assumptions made and the large country to country variations, it was necessary to have a number of trial runs and to fine-tune the system before it gave satisfactory results".

This process and the specific assumptions and judgements made in the process cannot be reconstructed. The following elements are of interest:

- Detailed considerations were made for more or less typical countries and results were then extrapolated
- The estimation of the agricultural work force is in line with the UN population projection and the assumed GDP growth rates
- A labour surplus (i.e. a result that the man-years at 25o MDE required are fewer than the available work force) is a permissible result of the analysis
- A minimum use rate for tractors is observed in the form of 3o hectares per tractor and year.

Annex 3

Table 1

Use of the Arable Land Area, Scenario A, 1975 - 2000

Country	Arable Land (000 ha)		Expansion	Thereof (%) Good Rainfall Area		Low Rainfall Area		Problem Area		Irrigated Area [a]		Cropping Intensity [b]		Land-use-ratio [c]	
	1975	2000	1975=100	1975	2000	1975	2000	1975	2000	1975	2000	1975	2000	1975	2000
Northern															
Morocco	7990	8545	107	44.5	41.8	16.6	16.7	29.0	29.0	11.1	12.6	0.75	0.94	2.45	1.59
Algeria	7000	7766	110	56.5	51.5	19.1	19.3	20.1	22.3	4.3	6.8	0.58	0.81	2.10	2.49
Tunisia	4510	4676	104	24.7	23.8	59.3	56.3	13.1	15.0	2.8	4.3	0.81	0.91	6.08	6.96
Libya	2518	2700	107	9.0	8.3	72.3	60.2	11.4	14.8	6.8	16.7	0.37	0.66	6.39	43.4
Egypt	2860	2900	101	-	-	-	-	-	-	100.0	100.0	1.68	1.97	0.89	0.75
Sudan	14290	20471	143	64.6	64.6	11.7	10.5	11.9	11.0	11.7	13.7	0.37	0.57	1.62	1.68
Western/Central															
Mauritania	782	1550	198	17.3	9.0	71.5	81.2	5.1	3.0	5.9	6.8	0.23	0.41	0.68	0.91
Senegal	5564	6850	123	63.4	66.6	24.7	19.0	8.7	8.0	2.9	6.0	0.46	0.52	1.55	1.58
Mali	11728	12931	110	48.1	44.4	41.5	39.9	7.4	11.3	1.3	2.5	0.13	0.27	0.67	0.80
Upper Volta	6780	7834	117	71.5	69.5	14.9	13.6	13.5	16.6	-	-	0.45	0.49	1.08	0.98
Niger	11188	11000	100	4.9	4.9	95.1	95.1	-	-	-	-	0.37	0.45	3.09	2.43
Chad	6981	10613	154	78.2	79.2	17.5	15.1	2.5	3.8	-	-	0.24	0.30	1.21	2.03
Gambia	421	460	109	76.0	71.7	-	-	2.0	2.1	7.6	13.0	0.51	0.86	0.97	1.27
Guinea	4280	6355	151	57.4	54.4	-	-	37.0	40.3	1.0	1.9	0.35	0.42	0.86	1.16
Sierra Leone	1814	1996	110	8.6	7.8	-	-	71.7	70.1	-	-	0.45	0.65	1.02	1.23
Liberia	1331	2257	170	-	-	-	-	86.4	79.0	-	-	0.33	0.36	1.00	1.27
Ivory Coast	9128	10338	113	18.4	20.3	-	-	77.5	74.6	-	-	0.37	0.51	1.20	1.26
Ghana	4511	6977	155	26.6	20.1	-	-	70.4	74.2	-	-	0.82	0.77	1.79	2.00
Togo	1919	2000	104	43.8	42.2	-	-	51.2	50.1	-	3.5	0.32	0.68	0.88	1.28
Benin	2958	4092	139	55.9	72.2	0.7	1.0	32.8	25.6	-	1.3	0.30	0.38	1.29	1.42
Nigeria	32386	40856	127	52.3	56.0	9.6	9.5	35.9	30.6	-	-	0.76	0.97	1.65	2.21
Cameroon	7347	9129	124	41.2	40.5	-	-	57.4	57.6	-	-	0.43	0.48	1.05	1.16
CAR	5918	7260	123	18.4	25.0	-	-	79.9	73.1	-	-	0.15	0.21	0.93	1.14
Gabon	350	350	100	-	-	-	-	98.7	98.7	-	-	0.31	0.39	0.54	0.66
Congo	662	1037	157	7.5	8.3	-	-	85.3	80.0	-	-	0.32	0.43	1.18	2.53
Zaire	13146	19771	150	48.3	55.2	-	-	49.0	41.1	-	-	0.36	0.41	0.57	0.74
Eastern/Southern															
Ethiopia	13728	17632	128	73.9	60.9	13.0	16.4	12.0	21.1	-	-	0.54	0.68	0.75	0.88
Somalia	1049	1724	164	-	-	93.5	94.6	-	-	3.5	3.5	0.60	0.53	0.62	0.61
Uganda	5251	7053	134	89.3	80.6	-	-	8.8	16.6	-	-	0.82	0.98	1.07	1.09
Kenya	4115	5776	140	52.7	42.8	38.7	45.6	7.3	9.3	1.0	2.0	0.79	0.72	0.76	0.69
Rwanda	985	993	110	25.4	23.2	-	-	69.5	70.4	-	-	0.95	1.39	0.43	0.40
Burundi	933	1105	118	50.7	49.6	-	-	36.4	45.9	-	-	0.96	1.17	0.54	0.53
Tanzania	6818	11069	162	67.7	71.6	8.9	7.2	17.9	15.5	-	2.0	0.74	0.90	0.93	1.04
Zambia	5088	6400	128	96.0	94.8	-	-	3.0	3.1	-	-	0.30	0.39	1.19	1.41
Malawi	2278	3238	142	88.2	85.7	-	-	8.6	8.7	-	2.3	0.86	0.95	0.94	0.91
Angola	4588	6230	138	71.1	71.1	-	-	26.7	25.7	-	-	0.37	0.45	1.57	2.13
Rhodesia	2488	3352	135	74.2	72.3	7.4	7.3	16.5	16.4	-	4.0	0.56	0.65	1.07	1.12
Mozambique	5888	8019	140	69.6	72.1	6.7	5.0	20.4	19.0	-	1.7	0.54	0.62	1.06	1.92
Madagascar	2866	4096	143	27.9	30.4	3.5	3.7	30.0	27.5	31.4	31.0	0.75	0.84	0.64	0.81
Mauritius	108	105	105	-	-	-	-	80.0	68.6	15.0	28.0	0.95	1.12	1.0	1.20
Total	219887	283403	129	50.3	51.1	16.9	15.1	27.5	27.2	3.5	4.3	0.53	0.65	1.15	1.31

a) Both fully and partially irrigated area.

b) Cropping intensity or R-value is the ratio of area harvested to total arable land.

c) The ratio of hectares of harvested area to agricultural workers.

Annex 3

Table 2

Description of Cropping Pattern

Country	1975 First	1975 Second	1975 Third	1975 Share of 1st Three[a]	1975 Share of Cereals[a]	2000 First	2000 Second	2000 Third	2000 Share of 1st Three[a]	2000 Share of Cereals[a]
Northern										
Morocco	Barley	Wheat	Pulses	73.6	75.1	Barley	Wheat	Pulses	63.7	62.1
Algeria	Wheat	Barley	Fruit	77.7	75.8	Wheat	Barley	Fodder	81.6	59.0
Tunisia	Wheat	Olives	Barley	78.4	44.3	Olives	Wheat	Barley	68.6	40.9
Libya	Barley	Wheat	Fodder	80.7	62.1	Fodder	Barley	Wheat	80.8	44.3
Egypt	Fodder	Maize	Wheat	57.0	42.4	Fodder	Maize	Rice	48.6	40.5
Sudan	Millet	Sesam	Groundn.	82.3	61.0	Millet	Groundn.	Sesam	76.2	52.7
Western/Central										
Mauritania	Millet	Pulses	-	89.6	68.2	Millet	Pulses	Groundn.	89.7	88.9
Senegal	Ground.	Millet	Pulses	91.8	45.6	Groundn.	Millet	Rice	83.8	51.1
Mali	Millet	Groundn.	Rice	86.2	79.7	Millet	Groundn.	Rice	81.2	67.6
Upper Volta	Millet	Pulses	Groundn.	90.1	72.5	Millet	Pulses	Groundn.	86.2	64.3
Niger	Millet	Pulses	Groundn.	97.7	70.5	Millet	Pulses	Groundn.	95.2	64.2
Chad	Millet	Cotton	Pulses	86.8	62.9	Millet	Groundn.	Cotton	77.8	47.2
Gambia	Groundn.	Millet	Rice	90.2	41.1	Groundn.	Millet	Rice	87.8	41.6
Guinea	Cocoa	Root	Millet	68.8	23.2	Cocoa	Millet	Root	58.6	31.6
Sierra Leone	Rice	Palmtrees	Cocoa	65.5	49.0	Rice	Palmtrees	Cocoa	59.8	55.2
Liberia	Rice	Rubber	Root	79.6	45.1	Rice	Rubber	Root	79.7	54.1
Ivory Coast	Coffee	Root	Cocoa	58.3	26.8	Cocoa	Coffee	Rice	54.4	28.7
Ghana	Rice	Maize	Millet	75.5	75.5	Maize	Rice	Millet	76.4	76.4
Togo	Millet	Maize	Pulses	60.6	50.3	Millet	Pulses	Maize	68.5	46.9
Benin	Maize	Root	Millet	64.8	50.2	Maize	Root	Millet	57.3	42.8
Nigeria	Millet	Pulses	Root	71.9	51.1	Millet	Pulses	Root	68.4	52.6
Cameroon	Root	Maize	Millet	49.1	30.3	Root	Maize	Millet	46.6	30.3
CAR	Root	Cotton	Groundn.	65.8	20.6	Root	Groundn.	Maize	79.4	24.9
Gabon	Root	Banana	Cocoa	90.8	5.8	Root	Vegetable	-	52.6	9.6
Congo	Root	Groundn.	-	61.8	14.2	Root	Groundn.	-	52.8	17.9
Zaire	Root	Maize	Rice	58.2	22.8	Root	Maize	Groundn.	59.3	26.6
Eastern/Southern										
Ethiopia	Millet	Maize	Wheat	53.7	62.8	Millet	Wheat	Barley	57.1	65.7
Somalia	Millet	Maize	Sesam	90.8	78.5	Millet	Maize	Sesam	83.8	73.9
Uganda	Millet	Pulses	Cotton	48.4	32.4	Millet	Pulses	Root	38.4	36.9
Kenya	Maize	Pulses	Millet	75.8	60.5	Maize	Millet	Pulses	66.9	59.8
Rwanda	Pulses	Banana	Root	67.9	24.1	Pulses	Banana	Root	68.5	21.7
Burundi	Pulses	Root	Millet	78.1	38.2	Pulses	Root	Maize	68.1	29.8
Tanzania	Maize	Root	Millet	98.7	37.3	Maize	Root	Millet	43.1	48.2
Zambia	Maize	Millet	-	86.1	86.3	Maize	Millet	Groundn.	82.6	88.2
Malawi	Maize	Pulses	Groundn.	79.3	61.8	Maize	Groundn.	Pulses	71.3	53.3
Angola	Maize	Coffee	Root	66.2	43.8	Maize	Coffee	Root	62.8	38.8
Rhodesia	Millet	Maize	Groundn.	79.6	78.8	Maize	Millet	Groundn.	78.6	69.2
Mozambique	Maize	Root	Millet	52.2	37.8	Maize	Groundn.	Root	46.6	30.6
Madagascar	Rice	Root	Coffee	75.4	99.4	Rice	Root	Coffee	78.8	94.6
Mauritius	Cane	-	-	84.2	-	Cane	Tea	-	77.1	2.8
Africa Total	Millet	Maize	Pulses	47.9	51.6	Millet	Maize	Pulses	46.7	48.8

a) Related to total harvested area.

Groundn. = Groundnuts

Table 3

Development of Income and Investment in Agriculture

Country	Development of Per Capita Income							Gross Investment in Agriculture							
								2000-A				2000-B			
	1975 (US-$)	1990-A (US$)	2000-A (US$)	Growth Rate p 1975-2000 A (%)	1990-B (US-$)	2000-B (US-$)	Growth Rate p 1975-2000 B (%)	Total [a] (Mill.US$)	Total [b] Machinery (%)	Tractors [c] and Equipment (%)	Land [d] Development (%)	Total [a] (Mill.US$)	Total [b] Machinery (%)	Tractors [c] and Equipment (%)	Land [d] Development (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Northern															
Morocco	460	610	840	2.49	530	640	1.33	952	35.6	32.7	13.4	494	39.1	33.4	22.1
Algeria	870	1330	1920	3.23	1210	1590	2.46	849	52.1	50.9	10.8	610	53.8	52.1	11.8
Tunisia	770	1390	2300	4.45	1210	1730	3.28	365	56.7	55.6	11.0	301	55.1	53.8	12.3
Libya	5420	7180	10500	2.68	5400	6240	0.56	272	47.8	47.4	29.0	193	49.7	49.2	30.1
Egypt	250	460	740	4.47	430	640	3.85	751	33.8	30.1	13.2	606	30.4	25.4	16.2
Sudan	270	410	620	3.35	380	510	2.50	1343	37.8	35.3	31.0	1006	35.0	31.8	37.4
Western/Central															
Mauritania	260	340	510	2.76	260	270	0.17	49	10.2	2.0	36.7	22	18.2	-	31.8
Senegal	410	600	820	2.84	540	680	2.07	174	13.8	9.2	44.8	87	19.7	9.2	44.8
Mali	100	130	210	2.89	110	120	0.64	216	18.5	6.9	34.7	128	22.7	3.1	43.8
Upper Volta	110	140	210	2.80	110	120	0.39	98	14.2	4.2	37.8	64	18.8	1.6	42.2
Niger	140	170	250	2.59	130	130	-0.07	99	12.1	4.0	22.2	55	18.2	-	36.4
Chad	130	170	270	3.07	140	150	0.82	164	7.3	3.0	45.1	59	13.6	1.7	49.2
Gambia	170	250	360	3.13	240	320	2.50	18	16.7	5.6	44.4	10	20.0	10.0	40.0
Guinea	230	320	480	2.96	260	290	0.94	123	6.5	1.6	65.9	75	10.7	1.3	68.0
Sierra Leone	210	210	320	1.76	160	180	-0.74	59	15.3	11.9	50.8	36	11.1	5.6	75.0
Liberia	470	590	830	2.32	540	620	1.16	78	16.7	15.4	66.7	56	14.3	10.7	71.4
Ivory Coast	580	1170	1850	4.76	1060	1530	3.98	395	28.1	25.6	47.1	304	27.0	23.7	57.6
Ghana	530	560	760	1.44	460	520	-0.10	339	18.3	16.2	59.0	204	15.2	11.8	63.7
Togo	240	340	510	3.10	310	380	1.86	62	29.0	24.2	30.6	37	24.3	18.9	35.1
Benin	170	230	350	3.04	210	240	1.49	72	8.3	4.2	48.6	50	8.0	2.0	56.0
Nigeria	410	690	1030	3.75	630	850	2.97	1339	26.1	21.6	23.2	965	25.6	19.3	27.2
Cameroon	290	420	640	3.16	360	440	1.60	195	8.2	3.6	51.8	163	7.4	1.8	56.4
CAR	210	270	430	2.83	210	240	0.50	65	12.2	7.7	64.0	48	10.2	4.0	67.0
Gabon	4170	11500	21100	6.70	11000	19200	6.31	24	750	75.0	4.0	20	750	75.0	10.0
Congo	550	820	1290	3.52	740	970	2.35	54	46.3	46.3	33.3	29	41.4	41.4	34.5
Zaire	90	110	180	2.76	90	100	0.52	412	26.7	21.1	47.6	291	18.9	11.3	55.0
Eastern/Southern															
Ethiopia	90	120	190	2.90	100	120	0.96	569	40.9	20.2	27.8	355	44.5	11.3	28.7
Somalia	110	150	240	3.05	130	150	1.27	122	36.1	27.9	9.8	62	35.5	19.4	12.9
Uganda	230	270	410	2.44	210	220	-0.14	247	26.3	15.0	27.1	159	23.9	6.9	33.3
Kenya	230	340	500	3.14	300	370	1.83	646	55.3	50.2	9.0	395	51.4	42.8	11.1
Rwanda	110	140	210	2.80	110	120	0.29	46	26.1	4.3	19.6	39	25.6	2.6	20.5
Burundi	10	130	210	2.88	110	120	0.67	41	17.1	4.9	26.8	30	16.5	3.3	30.0
Tanzania	160	200	320	2.80	160	170	0.18	635	34.0	27.6	20.0	268	33.6	18.3	27.2
Zambia	450	430	570	1.00	350	390	-0.53	186	31.7	26.9	24.2	99	30.3	21.2	28.3
Malawi	130	210	310	3.59	200	280	3.20	155	33.5	27.7	25.8	121	34.7	28.1	25.6
Angola	560	590	870	1.78	450	520	-0.29	215	36.3	34.4	38.1	121	28.1	24.8	43.8
Rhodesia	580	520	690	0.71	390	430	-1.20	260	49.6	44.2	14.2	153	43.1	35.3	17.0
Mozambique	290	380	560	2.64	298	320	0.40	358	49.7	47.8	27.1	170	37.1	34.1	39.3
Madagascar	250	310	490	2.84	300	370	1.83	430	21.9	13.3	37.0	264	21.6	7.2	47.3
Mauritius	610	1110	1760	4.31	1060	1600	3.91	15	20.0	13.3	33.3	11	22.2	22.2	44.4
Africa total	-	-	-	-	-	-	-	12232	34.9	29.8	27.0	8190	33.1	25.6	31.2

a) Total according to "OECD narrow definition" as given by FAO: AT 2000 except that herd increase and investment in draught animals has been excluded.

b) Excluding investment in draught animals.

c) Share of tractors in total according to OECD narrow definition.

d) Share of total land investment as stated within FAO : AT 2000.

Table 4

Power Requirement and Share of Mechanized Power in Africa
1975, 1990, 2000 (Scenario A + B)

Country	1975			1990-A			1990-B			2000-A			2000-B		
	Total Power Requirement (Mill. HOE)	Animal Traction Factor (%)	Tractor Factor (%)	Total Power Requirement (Mill. HOE)	Animal Traction Factor (%)	Tractor Factor (%)	Total Power Requirement (Mill.HOE)	Animal Traction Factor (%)	Tractor Factor (%)	Total Power Requirement (Mill. HOE)	Animal Traction Factor (%)	Tractor Factor (%)	Total Power Requirement (Mill. HOE)	Animal Traction Factor (%)	Tractor Factor (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Northern															
Morocco	513	31.0	7.0	713	21.0	11.6	651	23.0	9.5	935	15.2	18.2	790	18.0	12.7
Algeria	297	17.4	36.2	321	10.9	52.3	283	12.4	48.4	450	7.8	65.3	378	9.3	59.0
Tunisia	161	13.7	30.4	200	11.0	43.5	192	11.5	38.0	238	9.2	58.8	233	9.4	48.9
Libya	47	12.8	59.6	84	6.0	77.4	72	6.9	70.8	116	4.3	87.1	96	5.2	76.6
Egypt	825	15.8	5.5	1054	10.9	9.1	1012	11.4	7.9	1243	8.4	17.1	1164	9.0	13.3
Sudan	489	26.6	7.8	767	19.0	14.0	718	20.3	12.1	1045	14.9	23.5	957	16.3	18.6
Western/Central															
Mauritania	31	38.7	-	76	21.1	-	46	34.8	-	127	14.2	0.1	64	28.1	-
Senegal	199	7.5	1.5	267	8.2	2.6	233	9.1	2.2	353	7.4	4.0	270	9.6	3.0
Mali	256	10.0	0.8	399	16.8	1.3	338	19.8	0.9	557	17.6	2.2	452	21.7	0.9
Upper Volta	313	2.2	0.3	408	2.5	0.2	380	2.6	0.2	519	2.5	0.4	455	2.9	0.2
Niger	154	14.3	-	200	14.0	0.5	192	14.6	0.5	240	13.3	1.3	218	14.7	0.5
Chad	125	12.8	-	203	11.3	0.5	159	14.5	0.6	291	9.6	1.0	195	14.4	0.5
Gambia	24	-	-	36	2.8	2.8	26	3.8	-	53	3.8	3.8	35	5.7	2.9
Guinea	170	1.2	-	258	0.8	0.4	219	1.4	-	346	1.2	0.3	285	1.4	0.4
Sierra Leone	99	-	2.0	142	0.7	1.4	125	0.8	0.8	195	0.5	3.1	171	0.6	1.2
Liberia	45	-	2.2	68	-	2.9	61	-	3.3	94	-	5.3	83	-	3.6
Ivory Cost	350	0.6	2.3	488	0.8	5.7	466	0.9	4.9	614	1.0	10.4	585	1.0	8.2
Ghana	258	1.6	3.1	357	1.7	3.4	304	2.0	2.6	495	1.6	5.1	409	2.0	2.9
Togo	86	-	2.3	149	0.7	3.4	125	0.8	3.2	210	0.5	5.7	166	0.6	3.6
Benin	72	2.8	-	119	2.5	0.8	112	2.7	0.9	151	2.0	1.3	136	2.2	0.7
Nigeria	1915	5.2	1.9	2889	4.7	3.9	2650	5.1	3.4	3799	4.3	6.7	3372	4.8	5.2
Cameroon	305	1.6	0.3	404	1.7	0.5	391	1.8	0.5	486	1.6	1.0	464	1.7	0.6
CAR	99	1.0	1.0	136	0.7	0.7	126	0.8	0.8	166	1.2	1.8	153	1.3	0.7
Gabon	13	-	7.0	16	-	18.8	15	-	20.0	18	-	38.9	17	-	35.3
Congo	23	-	4.0	38	-	7.9	31	-	6.5	52	-	15.4	40	-	10.0
Zaire	672	-	1.5	966	-	2.2	906	-	1.4	1232	-	4.0	1163	-	1.8
Eastern/Southern															
Ethiopia	1329	39.1	0.9	1883	31.3	1.5	1620	36.4	1.1	2402	26.6	3.0	2022	31.6	1.4
Somalia	90	40.0	3.3	123	36.6	4.1	103	43.7	2.9	162	31.5	8.6	131	38.9	4.6
Uganda	456	11.0	1.1	648	11.4	1.5	580	12.8	1.0	860	10.7	2.7	783	11.7	1.1
Kenya	535	15.5	5.2	789	13.2	8.7	705	14.8	7.2	1046	11.4	14.6	912	13.0	9.6
Rwanda	171	5.8	-	248	4.8	0.4	237	5.1	-	311	4.2	0.3	295	4.4	0.3
Burundi	134	0.7	-	177	0.6	0.6	167	0.6	-	215	0.5	0.5	200	0.5	0.5
Tanzania	666	16.4	2.0	1033	13.2	3.0	856	15.9	2.1	1358	11.5	5.5	1164	13.4	2.2
Zambia	156	12.2	6.4	229	12.2	6.6	187	15.0	4.8	319	10.7	9.4	256	13.3	5.5
Malawi	220	3.2	2.3	321	2.5	4.7	292	2.7	4.5	425	2.4	7.8	385	2.6	6.8
Angola	138	3.6	5.8	197	3.6	7.6	156	4.5	5.1	267	3.1	12.2	219	3.7	6.4
Rhodesia	204	20.6	15.7	284	18.3	14.4	250	20.8	9.6	373	15.8	20.1	334	17.7	11.4
Mozambique	250	4.4	5.2	381	3.7	7.3	308	4.7	4.9	519	3.1	11.9	416	3.8	5.8
Madagascar	448	23.2	1.8	648	23.9	2.6	575	27.0	1.9	836	23.0	4.9	734	26.2	2.3
Mauritius	15	6.7	6.7	19	5.3	5.3	19	5.3	5.3	21	4.8	14.3	20	5.0	10.0
Africa Total	11773	13.3	3.8	16971	11.1	5.8	15888	12.6	4.3	23134	9.7	9.1	20122	10.9	6.5

Annex 3

Table 5

Development of Mechanization in Crop Agriculture

in the African Countries 1975 to 2000 (Scenarios A and B)

Country/ Region	Tractors in Use (1000)			Draught Animals in Use (1000)		Mechanization Factor (Percentage)		
	1975	2000-A	2000-B	1975	2000	1975	2000-A	2000-B
Northern								
Morocco	16	151	88	1530	1211	38.0	33.4	30.6
Algeria	51	235	178	342	296	53.6	73.1	68.3
Tunesia	29	112	91	208	185	44.1	68.1	58.4
Libya	25	56	42	50	37	72.3	91.4	84.4
Egypt	22	82	60	1000	807	21.2	25.6	22.3
Sudan	9	137	99	1000	1200	34.4	38.5	34.8
Western/Central Sahel								
Mauretania	0	0	0	120	154	38.7	15.0	28.1
Senegal	1	7	4	147	223	9.0	11.3	12.6
Mali	1	6	2	245	841	10.5	19.7	22.6
Upper Volta	0	2	1	65	110	2.6	2.9	3.1
Niger	0	2	1	210	271	14.9	14.6	15.1
Chad	0	2	1	150	237	12.8	10.7	14.9
Other								
Gambia	0	1	1	4	14	4.0	7.5	8.6
Guinea	0	1	0	16	32	1.0	1.4	1.8
Sierra Leone	0	3	1	3	6	2.0	3.6	1.8
Liberia	0	5	3	0	0	2.0	4.5	3.6
Ivory Coast	2	43	32	17	55	2.9	11.1	9.2
Ghana	3	24	12	36	69	4.7	6.7	4.9
Togo	0	6	3	3	8	5.9	6.2	4.2
Benin	0	1	1	23	29	2.8	3.0	2.9
Nigeria	12	134	92	949	1386	7.0	11.0	10.0
Cameroon	0	3	2	50	67	2.0	2.7	2.4
CAR	0	2	1	10	13	2.0	3.0	2.0
Gabon	0	8	7	0	0	8.0	38.9	35.0
Congo	0	9	5	0	0	4.0	15.4	10.0
Zaire	4	37	16	0	0	1.5	4.0	1.8
Eastern/ Southern								
Ethiopia	4	71	19	5000	5461	40.9	29.6	33.0
Somalia	1	14	6	350	439	43.3	40.1	43.5
Uganda	2	16	6	482	788	12.1	13.4	11.6
Kenya	6	123	71	800	1016	20.7	26.0	22.7
Rwanda	0	1	0	100	113	5.8	4.5	4.7
Burundi	0	1	0	5	6	1.0	1.0	1.0
Tanzania	5	71	25	1048	1330	18.3	17.0	15.6
Zambia	4	24	11	186	319	13.3	20.1	18.8
Malawi	1	19	15	65	83	5.0	10.0	9.4
Angola	5	36	15	51	65	10.0	15.3	10.0
Rhodesia	19	60	30	401	505	36.3	35.9	29.0
Mozambique	6	71	27	107	135	9.6	15.1	9.6
Madagascar	2	24	10	1000	1640	25.0	27.9	28.5
Mauritius	0	1	1	5	5	6.7	19.9	15.0
Total	232	1578	980	15777	19130	17.9	19.7	17.5

Annex 3

Table 6

Development of Annual Demand for Agricultural Machinery and Equipment 1975 to 2000 (Scenario A and B)

Country/ Region	Tractors and Equipment Units (1000)			Animal Traction Units (1000)		Hand Tool Packages (1000)		Agricultural Machinery Total (Mill. US $)		
	1975	2000-A	2000-B	1975	2000	1975	2000	1975	2000-A	2000-B
Northern										
Morocco	2.6	28.2	15.0	73.9	58.5	50	90	56	339	193
Algeria	7.6	39.3	28.9	15.4	15.4	40	50	94	442	328
Tunisia	4.1	18.5	14.7	9.2	9.2	10	10	50	207	166
Libya	3.5	8.7	5.2	3.1	3.1	0	0	56	130	95
Egypt	9.6	14.1	10.2	49.1	36.9	110	160	72	254	184
Sudan	1.6	29.6	19.9	52.3	61.5	80	130	50	507	352
Western/Central Sahel										
Mauritania	-	0.1	-	6.2	9.2	10	10	3	5	4
Senegal	0.1	1.5	0.7	9.2	12.3	30	50	7	24	17
Mali	0.1	1.4	0.6	18.5	49.2	60	90	13	40	29
Upper Volta	-	0.4	0.1	3.1	6.2	60	80	8	14	12
Niger	-	0.4	0.1	12.3	15.4	30	40	7	12	10
Chad	-	0.4	0.1	9.2	12.3	30	30	5	12	8
Other										
Gambia	-	0.2	0.1	-	-	-	10	1	3	2
Guinea	-	0.2	0.1	-	3.1	30	50	4	8	6
Sierra Leone	-	0.6	0.2	-	-	20	20	2	9	4
Liberia	0.1	1.1	0.6	-	-	10	10	2	13	8
Ivory Coast	0.5	9.2	6.6	-	3.1	60	90	12	111	82
Ghana	0.4	5.0	2.3	3.1	3.1	40	60	9	62	31
Togo	0.1	1.3	0.6	-	-	10	20	2	18	9
Benin	-	0.1	0.3	-	-	10	20	2	6	4
Nigeria	2.1	26.3	16.9	52.3	73.8	300	370	70	350	257
Cameroon	-	0.6	0.3	3.1	3.1	60	80	8	16	12
CAR	-	0.5	0.2	-	-	20	30	3	8	5
Gabon	0.1	1.6	1.3	-	-	-	-	1	18	15
Congo	0.1	2.3	1.1	-	-	-	-	1	25	12
Zaire	0.4	7.9	3.0	-	-	170	220	23	110	55
Eastern/ Southern										
Ethiopia	0.5	10.5	3.5	255.4	276.9	210	280	110	232	158
Somalia	0.2	3.3	1.1	18.4	21.5	20	30	9	44	22
Uganda	0.2	3.4	1.0	27.7	43.1	80	130	20	65	37
Kenya	1.0	29.5	15.4	43.1	52.3	90	160	34	357	203
Rwanda	-	0.2	0.1	6.2	6.2	40	70	6	12	10
Burundi	-	0.2	0.1	-	-	30	50	4	7	6
Tanzania	0.8	15.9	4.4	55.4	70.8	110	180	38	216	90
Zambia	0.5	4.5	1.9	9.2	15.4	30	40	11	59	30
Malawi	0.3	3.9	3.1	3.1	3.1	40	70	9	52	42
Angola	0.5	7.1	2.7	3.1	3.1	20	30	9	82	34
Rhodesia	1.6	10.5	4.9	21.5	27.7	30	40	28	128	68
Mozambique	0.7	15.5	5.3	-	-	50	50	16	178	66
Madagascar	0.4	5.2	1.7	58.5	89.2	70	90	29	94	57
Mauritius	-	0.2	0.2	-	-	-	-	1	3	2
Total	36.6	310.3	173.9	824.6	996.9	2110	2930	880	4267	2714

Note: 1 Tractor Unit of 45 h.p. is fixed at US $ 11000; in Egypt, Libya and Sudan US $ 16000, due to the combine harvester portion. An animal traction unit is filed at US $ 325; a hand tool package at US $ 10. The values are expressed in 1975-prices