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AGRICULTURAL MACHINERY AND IMPLEMENTS INDUSTRY *)

(Preliminary Study)

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SUMMARY AND CONCLUSIONS

The present study "Agricultural Machinery and Implements Industry", produced in a very short space of time, has two objects:

a) To present an integrated survey of the problems of agricultural mechanization and of industrialization policy in the developing countries;

b) To make it possible to design and organize a subsequent world-wide study of the agricultural mechanization industry.

I. THE PROBLEM OF AGRICULTURAL MECHANIZATION

The study analyses all the questions posed by the evolution of agricult ral mechanization.

Amongst these the most important are those concerning agricultural mechanization as the intersection of systems, the dominant model of mechanization, its trends and its problems, the critical re-evaluation of the latter and agricultural mechanization as an entry route into the capital goods industry for the developing countries.

1. Agricultural mechanization at the intersection of major systems

Agricultural mechanization is at the intersection of several major systems : industry, agriculture, eco-systems and the social system. It constitutes an interactive sub-system with these systems, reacting in its turn on the production of capital goods, agricultural production, the environment, employment and the stability of rural communities. It follows therefore that it would not be correct to study agricultural mechanization unilaterally, either from the agricultural or from the industrial aspect. The supply and demand for agricultural mechanisation products do not answer identical operating logics.

The industrial system produces a range of tools and machines, the coherence of which results from that of the industry; the agricultural system calls for a range of tools and machines the coherence of which is not, a priori, identical.

The basic question is therefore one of the compatibility between the products offered and the products required, particularly in the developing countries.

The choice which has been made in this study has been to consider agricultural mechanization as a sub-system which is interactive with the other systems and to give priority to two principal links: that with the agricultural demand, and that with the production of capital goods.

2. The dominant model of mechanization, its trends and its problems

a) Mechanization and motorization

Agricultural mechanization covers a series of production operations, the most important being the clearing, development and cultivation of new land, irrigation, the actual work of cultivation, transport, storage of products and farm activities. These production operations require a range of tools from hand tools, simple hand- or animal-drawn machines, tractors and towed machines to specialised and self-powered machinery.

Different technical levels and distinct models of mechanization correspond to these four categories of goods. Light mechanization uses simple machines. Heavy mechanization starts with the use of tractors, of increasing power, and specialised machines. It is this form which becomes dominant in the market economy and planned economy developed countries, and which is also spreading in the developing countries.

Priority is given to tractorization, which tends to become a monolithic technical model. This model derives from the constraints of industrial production, from the influence exerted by the major firms which dominate the agricultural mechanization market. The supply of high-capacity tractors and machines corresponds to the exigencies of agricultural production where speed of working and the extension of the areas to be worked are involved.

But agricultural production is not a homogeneous productive process. Production operations and agrarian structures are diverse and require the combined use of a totality of mechanical goods of different technological content.

This primary truth is often lost sight of. Exclusive attention is given to the tractor which becomes a social symbol of modernity, power and prestige. This study seeks to balance the analysis, not by denying the value of tractorization in the developing countries but by putting forward the alternative of models of multiform mechanization which are appropriate

to the specific conditions of the various eco-systems and the objectives of the developing countries.

b) The relative saturation of the markets

The heavy mechanization model seems - at least in the market economy developed countries - to be reaching saturation. Undoubtedly some special crops are still mechanizable. But the market now consists mainly of the replacement of existing equipment. The present economic recession only partly explains the slowing-down in the demand. In fact the relative over-equipment of agriculture in certain industrial countries was seen before the recession. The profitability of using equipment of increasing power and performance has become doubtful.

The equipment goods for agricultural use which are exported by the industrial countries to the developing countries represent about 25% of the total exports. A priori there is, therefore, a potential market, but one which has its own limits. Mechanizable forms of agriculture are limited in many developing countries by reason of existing production structures and geographical constraints and also by the agrarian structures, the relative costs of capital and labour and the solvency of the farmers. Part of the market which is possible because of the socio-economic factors in the developing countries and also because of the fact that the industrial supply is orientated towards sophisticated machines, has already been occupied. Although the heavy mechanization model has not exhausted its possibilities on a global scale it is nevertheless tending towards a long-term saturation in the developing countries.

Broadly, therefore, it may be concluded that the expansion of the agricultural mechanization industry assumes the opening of new markets, with mechanization in forms which are specific to the fundamental mass of the peasantry in the developing countries, 95% of whom use either hand tools or animal-power.

c) The complexity and specialization of agricultural machines

The agricultural mechanization industry follows an underlying trend which is common to the whole of industry, that of the increasing power of machines coupled with their specialization and their increasingly complex nature.

This underlying trend is coupled with the reaction observed in producer firms in other sectors when the market situation tends towards saturation. In such a case the strategy of the major firms is shown by the increasing diversity and complexity of products. Mechanization has proceeded by successive waves, by grouped innovations which have allowed the successive opening of new markets. Agriculture itself - the actual working of the soil - was the first to be mechanized, then the harvesting of cereal crops with combine-harvesters, then the harvesting of other crops. The movement towards mechanization has now reached stock-raising, the storage and removal from storage of crops, and the mechanization of special crops is now being envisaged.

In general agricultural machinery has been designed to replace pregressively agricultural labour and to utilize new agricultural products such as improved varieties of seeds, fertilizers, weedkillers and insecticides.

Mechanical equipment has become more complicated by the addition of elements which are not solely mechanical. A sophisticated tractor - either powerful or miniaturized - is no longer a simple mechanical object. It now forms a complex system of mechanical, electrical, electronic and hydraulic sub-systems.

The mechanization which made the engine the central unit of the machine has now changed direction. Complex machines - such as self-powered machines - are characterized by the increasingly total integration of the components which form them.

This study therefore puts the emphasis on a phenomenon which is often underestimated but of which the practical consequences are very important: modern specialized agricultural machines represent a different technological line from that of previous tractors. Mastery of their use

becomes more difficult for the user - if not impossible - since it involves maintaining and repairing the equipment.

The evolution of the techniques initiated by the major manufacturers has other consequences.

The cost of the new equipment, because of the increasing cost of manufacture and of innovation, cannot always be amortized within economies with a less productive agriculture. Similarly the net added value contributed by the use of heavy equipment is no longer sufficient for self-maintenance of the progressive accumulation of capital in agriculture. New and special equipment is manufactured in short production runs and hence at a relatively high price. These circumstances lead the major international manufacturers to open up markets in the developing countries, so making it possible to distribute equipment of known technology and in this way amortizing R & D costs and extending production runs.

The basic question is therefore one of knowing if the mimetic transfer of this mechanization model is, in general, in accordance with the needs and specific characteristics of the developing countries.

3. A critical re-evaluation of the dominant model of agricultural mechanization

a) The re-balancing of agricultural inputs

Essential questions as to the road to be followed are posed not only in the developing countries but also in the most advanced industrial countries themselves. The most recent data on agronomic science seem to indicate a prospect of other combinations within the "packet" of inputs intended for agriculture. These new combinations give priority to agronomic, biological and genetic innovations rather than to chemical and mechanical innovations.

b) Appropriate technologies and the adaptation of the agricultural machinery industry to the needs of the developing countries

As a reaction to the negative consequences of mimetic transfer to the developing countries there has been created, in recent years, a school of thought, often connected with ecological movements, which recommends the implementation of appropriate technologies.

The study suggests that this appropriate character is not defined by the technical specifications of this or that machine but by a combination which is suited to the economic, social and political objectives and constraints. The level of action is not that of a group of countries or of any one particular country but that which corresponds to precise and specific regional, ecological and social conditions.

The analysis of appropriate technologies cannot, by definition, result in any global proposal since such technologies relate to specific situations.

In this way the model of heavy tractorization may be appropriate in the case of large cultivatable areas to be cleared, in irrigated zones with high acreage yields, in under-populated zones which are used extensively or in land surrounding towns where supplying the market is essential.

In other cases the objective of ensuring the maximum level of employment for a large population will lead to light mechanization based on the use of irrigation pumps and simple machines. If the low-power tractor of the 1950's, multipurpose and robust, may meet existing needs under particular circumstances it is by no means certain that the mechanization of agriculture in the developing countries must always be carried out by the widespread use of tractors, nor even by the use of such a model.

The objective of rapidly improving the subsistence of local populations may involve giving priority to storage facilities for the crops, so as to limit losses, etc.

The appropriate combinations of technologies are therefore very diverse. There is no universal recipe or counter-model to the dominant mechanization model, but an undoubtedly necessary reversal of the policy which has been followed up until now, namely that the supply largely predetermines the demand. The required reversal is that it should be the demand which induces the supply.

This leads to asking the following practical questions: How is a change to be effected in the machines supplied by the agricultural mechanization industry in the industrialised countries, where the highly concentrated production of tractors has repercussions on the most widely

dispersed parts of the industry ? How are the precise demands from the developing countries to be explicitly formulated ?

Over and above these questions, in respect of which the study attempts to provide some suggestions, the more general question is posed of the "appropriate" character of the world agricultural mechanization industry in regard to the needs of farmers in the developing countries since it is an industry built on the needs, and as a function of the specific objectives, of western economic and agricultural systems.

c) Towards a reversal of the trends ?

The movement in favour of appropriate technologies operates in the opposite direction to the trend towards heavy mechanization.

Although these technologies, as has already been pointed out, cannot be the subject of a global proposal this counter-current does lead to a glimpse of new lines of growth for agricultural mechanization in the developing countries.

Simple adaptation of tractors designed for use in developed forms of agriculture seems to be insufficient. Even the most economic and the most intelligent solutions still remain relatively complex and costly. It is necessary therefore to be even more radical in the direction of simplification.

In fact it involves producing a tractor on new technical lines, not of returning to the relatively simple tractor of a quarter of a century ago. The first trials have been carried out with the assistance of UNIDO (1), and other are proposed.

In this same spirit the analysis of the various operations which are capable of being mechanized, and of the principal components of the machines and tools used in each case, shows that the most frequent common denominator is a simple engine.

The specification for this arises from the same considerations as apply to the simple tractor. Simple machines, multipurpose, adaptable, and the pluralism of combined technological solutions: these are the first elements in a possible reversal of the underlying trends in agricultural

(1) The TIMTABI tractor.

mechanization. In regard to the trend towards saturation which has been noted it is possible to envisage new solutions which are capable of opening up a new market and giving the agricultural mechanization industry its second wind.

d) Concentration of the industry versus decentralization of activities

The essential contradiction of the agricultural mechanization industry is that it is both a highly concentrated industry but is also necessarily very decentralized.

In fact less than 10 major manufacturers share tractor sales in the market economy countries, together with an increasing share of the world market for agricultural machinery. They control world standards and the rate of technical progress. They form the dynamic nucleus of agricultural mechanization policies which imprint an irreversible evolution on agricultural policies.

However these major manufacturers are far from being able to produce the totality of machines and tools which correspond to the diversity of agricultural systems operating throughout the world. There are, necessarily, therefore a large number of medium or small factories and workshops.

A form of decentralization will be permanently required, dealing with matters of maintenance and repair which can only be carried out on a decentralized basis. This fact, which is common to all agricultural systems, sets the limits to the concentration process but also suggests the value of a policy of agricultural mechanization which takes into account the necessary decentralization of part of its activities.

e) Occupying the vacant "niche" for agricultural mechanization in the developing countries

A vacant space for mechanization exists in the three continents of Africa, Asia and Latin America.

The questions are how, and by whom, the gap will be filled.

The relative shrinking of the market is naturally causing the large agricultural mechanization industries - European, Japanese, American - to penetrate new markets in the developing countries.

The introduction of power-cultivators and miniaturized tractors is a first effort at adaptation. But this introduction, as has been analyzed, is still on the line of complex technology and does not essentially modify the dominant model.

The problem remains one of creating new lines which genuinely correspond to the needs of the developing countries.

The alternative is therefore that of occupying the "niche" left as a result of variations in the dominant model of agricultural mechanization, or of implementing new solutions which are better fitted to meet the needs of agriculture, or more broadly of rural life, in the developing countries.

The vast size of these needs suggests that there is a place for exports from the industrialized countries and, simultaneously, for the local production of agricultural equipment goods.

4. Agricultural mechanization as an entry route into the capital goods industry

In this respect the study on agricultural mechanization is a continuation of that carried out by UNIDO on capital goods[1]. The latter pointed out that only five developing countries with a market economy possessed capabilities in this field; by contrast 96 countries and 18 territories depended entirely on the developed countries for their supplies of capital goods.

In all these countries agriculture is at the centre of their way of life.

Comparing the universal distribution of agriculture and the necessary decentralization of the agricultural mechanization industry suggests that the latter offers, by the simplest of steps, a practicable entry, both widely and universally accessible, into the capital goods industry.

The existing and simple technological routes are the first links in this chain.

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(1) An analysis of the structures of the capital goods industry (preliminary study) I.C.I.S./UNIDO - February 1978.

Forging is a simple technique which opens up a basic route for the production of equipment goods: it is capable of modernization, and can be made more complex by the addition of the route involving welding and electrical welding.

Maintenance and repair operations create another opportunity for entering the capital goods industry. Such activities require forging and welding capabilities, together with mechanical capabilities. Mastery of simple machine tools is another link in the chain.

The chain may be made more complex by adding to it that of the cast-iron route, then that of heat treatment, etc. The order of acquisition of the routes is not arbitrary. This approach has important consequences.

Firstly it does not involve liquidating local know-how, however simple that may be; secondly it does not freeze local artisan labour which, if it is not remodeled, must eventually disappear from the scene.

Finally it opens up possibilities for reciprocal adaptation between the level of simple machines to be redesigned and that of local manufacturing know-how. One can, in fact, take the latter as the point of departure for designing new tools or, starting from the design of the new simple machine, determine accurately what improvements need to be made to master the different routes.

Educative and training programmes can then be devised, country by country, as a function firstly of the machines which it is proposed to construct, and secondly of the level of local manufacturing know-how. The precise object of these programmes will be to forge the missing link so as to ensure the progress of the whole. This obviously involves the detailed identification of local capabilities.

Finally it opens up prospects for the production of capital goods for uses and sectors other than that of agricultural production.

In this way it is possible to proceed from simple maintenance and repair work to the production of spares and sub-assemblies.

However, and as soon as welding is available as well as forging, it is possible to envisage the production of metal structural work and boilerwork products. The first links in an equipment goods industry chain, starting from the agricultural mechanization industry, would in this way be capable of meeting not only the needs of agriculture but also of rural life. Agricultural production is accompanied by the operations of transport, storage and conversion of its products. The framework of rural life and of small localities necessitates an improved habitat and collective equipment, so raising the concept of "basic needs".

It would, therefore, seem to be possible to trigger off, starting from agriculture and rural life, a to-and-fro movement between the process of making the technical routes of agricultural mechanization more complex and the creation of the first links in a capital goods industry and the satisfying of vital needs.

In this way a methodology of action appears to be possible for the hundred developing countries which do not produce capital goods.

II. FORECASTING LIMITS AND THE NEED FOR A PROSPECTIVE STUDY OF AGRICULTURAL MECHANIZATION

1. Forecasts and projections

a) Difficulties in forecasting

Long-term forecasts in this sector come up against major difficulties.

Firstly the statistics - apart from those covering tractors and specialised heavy equipment - are incomplete, both in terms of time and of geographical coverage.

The main reason, however, is that forecasting the demand poses fundamental problems.

In effect any projection - as is always possible - of past trends into the future assumes the development in time and space of the model of agricultural mechanization which has until now dominated the industrialized countries. It has been seen that this model is now being questioned in

a number of industrialized countries because of the impasses to which it leads, including the over-mechanization of agriculture, and of the increasing difficulty experienced by users in mastering the complexity of more and more specialized machines. Should one, under these conditions, transfer this model to the developing countries ?

The future is not inevitable: it is built. In this field it depends largely on the vision of those responsible for the multinational firms which dominate this sector and the acknowledgment of their real needs by the policy-makers in the developing countries.

The preliminary to forecasting the evolution of the sector is therefore a critical examination of the existing situation and the elaboration of new models of mechanization. At this stage the problem is more of a qualitative order.

b) The objectives of the Lima Declaration and the growth of the agricultural mechanization industry in the developing countries

The present contribution of the developing countries to the production of agricultural mechanization is very small.

Although 90% of the hand tools and 40% to 60% of the simple machines used are produced in the developing countries their total value compared with world production of agricultural machines is very small. The share of the developing countries in world production of tractors appears to be of the order of 10%, but is less than this in the case of specialised heavy equipment. If, however, the fact that an important fraction of the components is imported for subsequent assembly is taken into account the true added value in the developing countries is not likely to exceed 5% of the world production of tractors.

Taking into account the respective weighting of the value of the different products the contribution of the developing countries to the world production of agricultural machinery is likely to be about 5%, a figure slightly higher than that found for all capital goods which is of the order of 3% of the world production. Exports from the developing

countries are even smaller, being less than 2% of world exports; 95% of these exports come from only 13 countries with more than 50% coming from the Argentine, 80% from this country plus Brazil, Colombia and Mexico, whilst 92% of the exports from these countries are made to Latin America. Only Mexico exports a large proportion (55%) to the developed countries (USA), but the actual volume is very small. The scope for expansion of intra-regional trading and trade between the three continents is, therefore, potentially very considerable.

These statistics show that the distance between the present situation and the objectives fixed by the Lima Conference for the year 2000 is very considerable.

The basic problem is not one of determining how, for example, to increase the production of the developing countries five-fold but of determining what is to be produced, what types of equipment. Qualitative choices are of greater importance than quantitative choices.

c) Impasses in the projections

In the medium term, for example in 1985, there is a high probability that the situation will result from the lines of the present trends. The inertia of industrial and rural structures does not permit any profound changes. Projections can therefore, in this case, have some reliability. The same does not apply to 1990 or, a fortiori, to the year 2000, since projects may re-model the future.

As a consequence those projections which depend on the unsustainable postulate that the future will be formed from the same factors and the same intensity as in the past, can only have the function of providing the images of trend scenarios, which does not mean that they are probable, possible or desirable.

The study considers three projections: that of a system of an extensive agriculture with a relatively low level of mechanization, that of a system of intensive agriculture, and that based on a system of adjustment in respect of equipment.

The first system corresponds to the conditions of American agriculture, the second to that of Belgian agriculture. In this latter case the expenditure per acre to be envisaged would be ten times that observed in

the USA, so that obviously the generalization of the Belgian model is an absurd hypothesis.

But the generalization of the American model of mechanization to the Third World countries would represent an investment cost estimated at $ 450 billion, an order of magnitude which is greater than the gross domestic product of Asia, Africa and Latin America in 1970.

An objective of mechanization corresponding to 0.50 HP per hectare for the developing countries is to be compared with the present mean of 0.17 HP, covering all forms of energy - human, animal and mechanical - which is very unequally distributed: 0.05 HP in Africa, 0.19 HP in Asia and 0.27 HP in Latin America. This objective of adjustment, which is not unrealistic since it corresponds to an annual rate of growth of 4.4%, would still require an investment of not less than $ 180 billion, or a sum larger than the GNP of Latin America.

These orders of magniture express, for various intensivities, the mimetic transfer of the dominant models of mechanization, and show the impasse reached by the latter and reinforce the idea of seeking new solutions.

2. Elements of a prospective study

Prospective studies correspond to a creative attitude in the face of a future which is both experienced and wished. It is not passive; it does not consider that the past explains the future but only that the past provides the raison d'être of the present.

The prospective attitude therefore implies the use of methodological instruments which are capable of influencing projects and hence the future.

It is in this spirit that this study proposes research into an active method for the critical evaluation of the demand and into the identification of the projects of the actors and of new trends.

To understand the evolution of the sector it necessary to appreciate more fully the agricultural demand so as to deploy industrial activities: it is necessary not to pre-determine the industrial supply, but to anticipate the agricultural demand.

Anticipation of the latter leads to putting forward a method of evaluation of which the principles are summarized below. It starts from an analysis of agricultural systems in order to determine the operations which are necessary. To each system of production and to the operations there then corresponds a list of machines.

These machines have a series of specific effects: some, for example, may reduce employment whereas others create agricultural jobs.

The lists of machines, by operations and by their effects, are compared with the principal and secondary objectives of development: for example to ensure self-sufficiency in foodstuffs, to maximise employment, to increase productivity, to balance foreign trading, to develop the industry, etc.

The types of mechanization suited to the objectives are then chosen. With the aid of a series of indicators the nomenclature and quantities of the machines are then estimated. The method is extended on the industrial side by analysing the technological routes which are necessary and then, as a function of local capabilities and of a programme for improving these, by the establishment of industrial strategies.

Evaluation of the demand for agricultural mechanization is therefore no longer a passive act but an active method, a means, within each country, for studying the demand for mechanization and for checking, from time to time, that it remains appropriate to the needs.

III. ORGANIZATION OF THE STUDIES AND DISCUSSION THEMES

The object of the studies which are proposed is, as a consequence, to forge the instruments for action.

1. The studies

1.1 In-depth study of the problem of agricultural mechanization

After the preliminary study it would therefore be necessary to continue with the following work :

- a - typology of the sub-routes for agricultural mechanization production corresponding to the needs of agriculture and to the potentialities for the production of other capital goods;

- b - a systematic study of the technological complexity of various technical lines of agricultural machines;

- c - the identification, in the developing countries, of local capabilities for mastering those technological routes which are essential for the establishment or development of an agricultural mechanization industry;

- d - a synthesis of existing information on the relationships between mechanization and agricultural and industrial employment.

1.2 Establishment of the prospective study

- e - evaluation of the supply: by interviews with the major manufacturers, to obtain a precise picture of the horizons, technological projects and industrial economic policies relating to agricultural mechanization;

- f - evaluation of the demand in the developing countries :
  i) to test and develop the method in one country,
  ii) to extend its application to interested countries;

- g - the establishment of new relationships between the supply and the re-evaluated demand :
  i) to identify the implications of tests using simple tractors,
  ii) to test the hypothesis of a simple and multipurpose engine allowing basic mechanization,
  iii) to organize a dialogue between the experimenters with new types of mechanization in the developing countries and representatives of the major manufacturers of agricultural mechanization;

- h - technological forecasting :
  i) to list the new products likely to appear in this field during the next 20 years (eg. solar energy pumps, machines using biological gas, etc.),
  ii) to study the prospects for the reciprocal evolution of new agro-biological techniques, improvement of plant strains and agricultural equipment;

- i - to identify projects for the creation and development of agricultural mechanization industries in the developing and industrialized countries and to analyze their complementarity or incompatibilities;

- j - to prepare possible scenarios, considering :
  i) technological trends,
  ii) the projects of the major manufacturers,
  iii) the demands of the developing countries;
- k - to specify the development prospects for the capital goods industries in those countries do not possess one, starting from the technological routes of an agricultural mechanization industry.

2. Discussion themes

The promotion of agricultural mechanization industries in the developing countries is certainly one of the most important subjects to be examined in the consultations between countries organized by UNIDO.

Having regard on the one hand to the needs arising from the "basic needs" policy recommended by the United Nations and, on the other, to the objectives of the Lima Declaration, the effort to be made and the distance to be covered to attain these are enormous. The principal problem for the developing countries is to define clear objectives, corresponding to their needs and to their possibilities. The means for cooperation with the industrialized countries cannot be effectively determined except by knowing the projects and intentions of the various partners. For the purpose of advancing in this direction the following discussion themes appear to be the most promising :

a) Identification of the present state and the prospects for the world market for agricultural machines.

b) Identification of projects for the creation or development of the agricultural mechanization industry.

c) Technological trends in the present and future supply.

d) Critical re-evaluation of demands in the developing countries.

e) Evaluation of utilization tests on simple machines.

f) Possibilities for developing international trading in agricultural machines between the developing countries.

g) Potentialities of the developing countries for constructing a capital goods industry based on an agricultural mechanization industry.

h) International cooperation in assisting various developing countries to implement training programmes making it possible to master various technological routes.

CHAPTER I

THE AGRICULTURAL MECHANIZATION INDUSTRY: THE PRESENT SITUATION AND PROSPECTS FOR PRODUCTION AND THE MARKETS

1.1. THE PRODUCTION OF THE AGRICULTURAL MACHINERY INDUSTRY

1.1.0. Manufacturing conditions according to the categories of goods

The production of the agricultural machinery and tools industry can be broken down into four categories of goods.

1. **Hand-tools** whose use still essentially and exclusively characterizes more than 60 % of the agricultural producers in the Third World countries. The manufacturing of these goods is often carried on at a village level (artisans, one-man workshops). In this case the tool is adapted to the conditions of the local productive systems. The variety of tools also reflects the variety of restrictions produced by the productive systems which are in operation : ecological restrictions (the tools being adapted to soil fragility), economic restrictions (re-utilization of second-hand tools, relatively low manufacturing costs).

Many projects have attempted to improve hand-tools ; improvement of their resistance, of their cutting edge, of the adaptation of the tools to new crops. The setting up of workshops or factories for " improved material " has often resulted in the disappearance of the village smiths, the polyvalence of traditional tools, and the rise in tool costs. In most developing countries, the main share of manufacturing is still carried out on a local or regional level.

2. **Simple machines** (light mechanization), hand or animal drawn, aim at bettering the performance of the afore-mentioned material, at making farm labour less irksome, and at getting rid of certain bottlenecks (speed of execution). They are most appropriately used in regions of intensive farming where the technical level which has been reached by the farmers makes it possible to envisage production which is not simply for subsistence.

The commercialization of part of the harvest (food products, industrial products, products for export) makes possible the diffusion of a technical model different from that which emerges from the exclusive use of hand-tools. The adoption of such a model is made easier by a greater solvency. Light mechanization can be applied to :

- agricultural production (ploughs, seeders, binders, harvesters) via animal-drawn and mounted equipment (sprayer, duster used for spraying plants...).
- the equipping of cultivated areas (hand and motor-drawn pumps).
- transport (carts, lift and adhesion devices, winches...).
- crop processing (mills, winnowers and hulling machines).

Table 1 : Breakdown of types of farming according to the various types of farm tools : hand-tools, hand- or animal-drawn machines, power mechanization

Source : A. MOENS : Agricultural Mechanization in Asia, Vol. III (Winter 1976)

Geographical zone	Proportion of labour spent in agriculture according to energy source		
	Human	Draught animal	Engine
USA	0.01 %	–	99.99 %
Europe	0.39 %	–	99.61 %
South Africa	4 %	22 %	74 %
Asia	26 %	51 %	23 %
Africa	35 %	7 %	58 %

Table 2 : Data on the various types of agriculture : manual agriculture ; animal draught and power mechanized agriculture

Source : CNEEMA. L'agriculture et l'énergie dans le monde (433) Nov. 1977

Heading \ Pure type of agriculture		Manual type agriculture	Mechanized animal draught agriculture	Power mechanized agriculture (supposed concentrated and totally power mechanized	Overall world total
Agricultural area used (only woodland and forests excluded)	in 10^6 ha	2.900	700	900	4.500
	(in %)	(65)	(15)	(20)	(100)
Number of farmers	in 10^6	240	64	16	320
	(in %)	(75)	(20)	(5)	(100)
Population working in agriculture (in economic terms)	in 10^6	460	260	50	770
	(in %)	(60)	(33.5)	(6.5)	(100)
Surface A.A.U. per working person		6.3	2.7	18	5.8
Amount of equipment in service	tons	17.500.000	80.500.000	172.000.000 (incl. 17.5 mil. tractors of 40 ch)	275.000.000
	(in %)	(6)	(31)	(53)	(100)
Annual consumption of fertilizers (in 10^6 tons)	N	7.77	5.83	25.26	38.86
	P_2O_5	3.42	3.42	15.94	22.78
	K_2O	1.50	2.49	15.95	19.94
	Total	12.69	11.74	57.16	81.58
	(in %)	(15.6)	(14.4)	(70.1)	(100)
Kilograms of chemical fertilizer per hectar AAU and per year		4.4	16.8	63.5	18.1
Primary energy consumptions per year (10^6 ha)					
agric. working population		115	130	60	305
draught livestock		–	165	p.m.	165
material (and fuel)		6.9	27	170	205
chemical fertilizers		23.6	18.8	83.1	125
pesticides		1.5	0.6	4.4	6.5
other means of production		2.3	0.9	6.8	10
	Total	150	345	325	820
	(in %)	(18.3)	(42.1)	(39.6)	(100)

The manufacturing of this category of goods is carried out on a regional level in workshops which may conserve their artisanal characteristics.

These two categories of goods (hand-tools, simple machines) may be jointly produced. The size of the manufacturing units (employment for 10 to 80 persons), the necessary investment (2,000 to 4,000 dollars depending on the goods to be manufactured) may make it possible for the manufacturer and potential users to remain geographically close together. This element thus facilitates the adaptation (adjustment design...) of the material to local restrictions, and its maintenance. The gains in agricultural productivity thus obtained allow a rapid widening of the market (increase in demand).

In the case where a small engine is used (stationary engine, motor pump) the manufacturing workshop becomes more complex. However this facilitates a change at a later date to heavy mechanization based on the use of the tractor.

At the present time, light mechanization (alone or associated with other forms of farm implements or machinery) concerns some 15 to 30 % of farm producers in the developing countries.

3. Tractors and tractor-drawn machines are situated at a different level of technological development. Although it is possible to envisage the production of simple machines after a passage from the artisanal infrastructure existing for hand-tool production, there is however a real " technological gap " as far as tractor manufacturing is concerned. This production, derived in most cases from the models which have been perfected in the developed countries, involves :

– concentrated manufacturing units, and all the more so if there is a low level of industrial development and the quantities sold are small.

– the existence of agrarian structures which allow for the use of tractors (or the will to create these structures deriving from a political choice).

– sufficient solvency, i.e. a previous accumulation of financial means for industrial manufacturing but also by the farmers in order to be able to purchase the goods.

These restrictions explain why the production and use of the tractor are extremely limited in developing countries. It has been estimated that only 3 to 5 % of farmers in the Third World at present use the tractorization model.

The production of tractors in the developing countries is restricted to a limited number of countries. For tractor production to be possible the market has to be of a reasonable size (it is estimated that 10,000 tractors a year are necessary to make profitable the industrial infrastructure needed for their manufacture), the level of technical and industrial development must be sufficiently high (tractor production, for example, is easier in countries which already have car industries, or the beginnings of a mechanical engineering industry), and a priority has to be given to industrialisation. Manufacturing carried out at a national level gives priority satisfaction to the needs of an agriculture based on large farmsteads. The manufacturing of tractors in the developing countries is very often linked with the importing of the "high-class" parts (hydraulic systems, electrical systems, gear-boxes, clutches) which are more and more characteristic of modern tractors.

Tractor drawn equipment, i.e. which has been designed on the basis of and adapted to the requirements of tractorization (adaptation to power take-off and hydraulic lift, material (steel) which resists wear at the speed at which the work is done) is often dealt with in the same technical parkage as the tractor itself. For this reason, it is often imported. Its production in the developing countries could be developed even if :

- the starting-off of this line of production involved initially importing certain raw materials (special steel for the ploughs ; precision parts for the seeders).
- this equipment, like the tractors which will draw it, in most developing countries, is not produced on a mass scale.

4. **Self-propelled machines**, which in general are specialized in harvesting operations (combine-harvesters, maize harvesters, chopper-blowers, ...), represent the new technical form of tractorization. The relative polyvalence of the tractor gives way to the adoption of machines specialized in one specific production operation.

These machines give a better performance when the agrarian structures and agronomical control (use of fertilizers, herbicides, and improved seeds) allow for it, but the market for them in the Third World is restricted to certain food crops (rice, cereals) or industrial crops (cotton).

They are rarely manufactured on the sport. The sophisticated nature of the material means :

- few locally manufactured parts are used
- many parts have to be imported
- high costs of post-sale servicing.

Self-propelled machines then, like heavy tractors, are quite typically the type of industrial good which should be manufactured at a interregional level.

The machines which are derived from the tractorization model (tractors and tractor-drawn machines, combined machines) only represent, at the level of the Third World countries, an extremely small part of the total market for the farm tool and the farm machinery industry.

This model continues to evolve, essentially in relation to the requirements of those agricultures which have the best performances (performances which are measured in terms of productivity per worker). Manufacturing programmes which are envisaged at a national level require a high level of technological development and a great diversification of industrial manufacturing.

Despite the difficulty in always finding an economic justification for it, the model of heavy power mechanization is often adopted as the exclusive technical reference by a great number of Third World countries.

1.1.1. Present production of agricultural machinery and tools

The statistical material which is available highlights not the respective importance of the various categories of goods which are enumerated, but rather the implicit choices which have been made as far as mechanization is concerned.

In general — and despite the numerous recommendations which have been made by specialized international bodies to the countries concerned — our statistical knowledge is far more detailed concerning the heavy tractorization model than the light mechanization model (tools and simple machines).

1. Hand-tool production

According to a recent estimate (1) 90 % of simple tools are made in the Third World countries.

Supposing that the supply of these goods manages to satisfy the agricultural demand, then the rate of growth of these productions should grow at a minimum annual rythm of 2 %. The evaluation figure will be surpassed if in a given zone the stage of simple subsistence produc-

(1) F.A.O. - Effects of farm mechanization on production and employment. Report of the expert panel held in Rome : 4-7 February 1975.

tion is surpassed. To give some idea on the question, we may mention that among the numerous workshop creation projects aided by UNIDO not one of them has come up against a problem of saturation or insolvency of the demand market.

In general, it can be said that the peasantry of the under-developed countries is still under-equipped as far as hand-tools are concerned and that progress in intensifying the most accessible productions can be made through the diversification of the tools made available.

2. Simple machine production aimed at meeting their own requirements is carried out at a rate of more than 70 % by the countries of the Third World.

The coverage of requirements, however, varies according to what category of machine is taken into consideration. It reaches :

– more than 80 % (1), for animal drawn machines inasmuch as most develop countries have given up this model. Certain countries have, however, kept models for export, or have a tight control of local manufacture.

– more than 50 % for apparatus used for crop processing (sprayers, dusters) and for hand-pumps, hulling machines, or hand-hullers.

– less than 40 % for equipment using small mechanical or electric motors : motor-pumps, mills...

The demand for these various categories of farm implements is particularly high in those countries and areas :

– which raise food crops and which have a high labour force intensity : areas of small farmsteads moving progressively on to intensification (two and three harvests a year).

– which raise certain industrial crops and crops for export (coffee beans, cocoa, groundnuits, tea or the basis of traditional farmsteads.

The development of manufacturing is more rapid for the last two categories of goods, inasmuch as they give rise to substantial increases in productivity relative to the capital which has been invested, on the one hand, and on the other hand, because there are few technical requirements in order to be able to use the machine (training : servicing). The production of these goods is carried out by medium-sized manufacturing units (between 50 and 200 wage-earners). The investment per wage-earner does not exceed 2,000 $. The turnover of the stock is rapid given the previous information.

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(1) Evaluation made by the report.

As far as animal-drawn machines are concerned, the main obstacle is still the reproduction, the upkeep and the trai ing of the animals that are to draw the machines (donkeys, horses, cattle, buffalo). Countries which have no traditions of raising livestock or have no livestock, will move rapidly on to power mechanization.

We have little information, unless we extrapolate, about simple machine and simple engine production. In most cases, it would seem to represent less an alternative to be generalised than a possible combination, or rather the phase before tractorization. The techniques which are used, like the technical improvements which can be envisaged (as far as pumping is concerned, sprinkler irrigation or spraying) are within the possibilities of middle-sized production units and, a fortiori, middle sized countries.

3. **The production of tractors and tractor-drawn machines** is still very much dominated by the constructors of the developed countries. Even though certain Third World countries have at present their own national production, in most cases this is carried out under the control of Western companies. This trend is less visible with regard to tractor-drawn machines, or at least for the more simple of them.

(i) Tractor production is fairly well known for two main reasons :

- their construction is concentrated
- tractorization is the main technical reference model. What is more, it is easier to register statistically the existence of a tractor than that of a hand-tool or an animal-drawn implement.

On a global level it can be estimated that 10 % of world tractor production is carried out in the developing countries. The manufacturing of these tractors however covers a variety of industrial situations : completely national design, semi-integrated manufacture, mere assembly or preparation of the imported tools.

World tractor production has been growing at a rate of 4.7 % per year for the last 20 years. However, we should distinguish between the growth rate within the countries of the OECD and that of Eastern Europe or of Japan.

Table 3 : Growth rate of tractor production for various countries in the world (more than 10 h.p.) (in %)

	1960-1965	1965-1970	1970-1975
U.S.A.	8,8	– 7,2	1,8
Japan	33,6	31,0	23,9
France Germany, F.R. Italy United Kingdom	1,2	1,6	0,6
Bulgaria Czechoslovakia German Dem. Rep. Hungary Polland Roumania	4,4	5,0	5,9
USSR	17,9	5,3	4,8

On the basis of previous information, we can extrapolate production for the various countries mentioned.

Table 4 : World Tractor Production (tractors of 10 h.p. and over, other than industrial and road tractors)

COUNTRY OR AREA	FOOT-NOTES	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
AFRICA											
ALGERIA		-	-	-	-	-	-	-	-	389	800
ANGOLA		-	-	93	-	52	76	89	9	36	...
AMERICA, NORTH											
MEXICO		...	...	3592	6188	8748	3596	5078	6219	6837	7985
UNITED STATES	1/	271809	288100	262006	234023	219587	191679	166232	237291	283818	...
AMERICA, SOUTH											
ARGENTINA	2/	13698	11181	9654	9682	9342	10882	13268	14802	19854	28506
BRAZIL		8123	9069	6219	9648	9971	18029	22197	29338	27106	...
ASIA (INCL. USSR)											
BURMA	2/	...	...	-	828	909	686	657	584	1700	...
INDIA		6312	7686	10526	13828	18091	19931	16448	17485	23837	28983
IRAN		...	...	89	319	292	2181	3823	5008	...	...
JAPAN	3/	20939	31816	84352	63557	82094	80608	69780	82810	182787	208518
TURKEY		...	...	...	15168	13395	7709	15693	22933	32797	23623
EUROPE (INCL. USSR)											
EUROPEAN ECON. COMM.											
BELGIUM		...	949	728	806	52	23	6	...	...	...
FRANCE	5/	120177	132337	128283	138840	169300	144600	112800	109300	118900	...
GERMANY, FEDERAL REP.		135051	104805	107453	111710	101703	105389	83767	84237	99856	116111
ITALY	6/	63053	67717	72991	75198	72742	94097	72027	76943	93132	126878
UNITED KINGDOM	7/ 8/	178516	197256	165739	178212	180437	160703	151500	134285	119283	...
EFTA											
AUSTRIA		11748	13221	10019	7870	8092	8608	9200	9233	9289	10167
FINLAND		2931	3701	2997	2639	2680	2943	2478	3183	3230	...
SWEDEN		13933	14741	13252	11942	13234	12171	10128	9951	10988	...
EASTERN EUROPE											
BULGARIA		2300	2052	2141	2981	3757	3493	3688	3894	3958	8241
CZECHOSLOVAKIA		30536	25168	26559	24824	24617	18480	21798	22753	23975	27065
GERMAN DEMOCRATIC REP.		12921	12210	11120	18202	15489	10376	15172	8295	3885	8048
HUNGARY		2961	2276	3583	2797	2043	1830	1832	1178	1066	730
POLAND	9/	21822	23195	30956	31917	28588	40888	83515	87216	83158	85038
ROMANIA	10/	15936	16500	17571	21200	24995	29287	30400	34893	38800	34550
OTHER EUROPE											
GREECE		29	28	22	93	275	280	370	895	1125	...
SPAIN		13126	16737	19591	20901	24490	19513	17850	24382	29656	...
YUGOSLAVIA		958	823	389	302	696	805	529	558	278	340
USSR											
USSR		256527	282488	305071	323380	341725	358525	472013	477822	529562	531091
BELORUSSIAN SSR		70170	75187	78108	79143	79515	80321	81080	81790	82950	83085
UKRAINIAN SSR		118321	124183	133172	138734	141775	137514	149182	175485	176894	136551
OCEANIA											
AUSTRALIA	11/	13888	10467	10095	9882	9378	7518	...	5636	6312	...
NEW ZEALAND	10/11/12/	2266	2783	2704	1949	1458	1840	1822	2101	...	...
TOTAL.....		1292406	1400419	1178818	1836031	1887339	1858266	1868744	1872181	1835340	1785198

3822-611A TRACTORS OF 10 FP AND OVER, OTHER THAN INDUSTRIAL AND ROAD TRACTORS 71250-2A

VEHICLES CONSTRUCTED ESSENTIALLY FOR HAULING OR PUSHING ANOTHER VEHICLE, APPLIANCE OR LOAD, WHETHER OR NOT THEY CONTAIN SUBSIDIARY PROVISION FOR THE TRANSPORT, IN CONNEXION WITH THE MAIN USE OF THE TRACTOR, OF TOOLS, SEEDS, FERTILIZERS OR OTHER GOODS, ETC., IRRESPECTIVE OF THEIR MODE OF PROPULSION (INTERNAL COMBUSTION ENGINE, STEAM ENGINE, ETC.). THIS HEADING INCLUDES AGRICULTURAL AS WELL AS OTHER TRACTORS, FOR EXAMPLE FOR USE IN FORESTRY OR IN CONSTRUCTION. ROAD TRACTORS FOR TRACTOR-TRAILER COMBINATIONS AND INDUSTRIAL TRACTORS ARE, HOWEVER, EXCLUDED. WALKING TRACTORS, EQUIPPED WITH A SINGLE DRIVING AXLE CARRIED ON ONE OR TWO WHEELS, THE STEERING OF WHICH IS EFFECTED BY MEANS OF TWO HANDLES, OFTEN LIKE AGRICULTURAL TRACTORS AND POSSIBLY WITH INTERCHANGEABLE IMPLEMENTS, ARE ALSO INCLUDED. TRACTORS OF LESS THAN 10 HORSEPOWER (GARDEN TRACTORS) ARE EXCLUDED.

1. ESTIMATES.
2. AGRICULTURAL TRACTORS ONLY.
3. TWELVE MONTHS ENDING 30 SEPTEMBER OF YEAR STATED.
4. INCLUDING BULLDOZERS.
5. AGRICULTURAL TRACTORS OF ALL SIZES.
6. PRIOR TO 1970, DATA ARE NOT STRICTLY COMPARABLE WITH THOSE FOR SUBSEQUENT YEARS.
7. DELIVERIES OF WHEELED AND HALF-TRACK TRACTORS.
8. PRIOR TO 1972, DATA ARE NOT STRICTLY COMPARABLE WITH THOSE FOR SUBSEQUENT YEARS.
9. ONE-AXLE AND TWO-AXLE TRACTORS.
10. INCLUDING ROAD TRACTORS.
11. INCLUDING TRACTORS OF LESS THAN 10 FP.
12. TWELVE MONTHS BEGINNING 1 APRIL OF YEAR STATED.

Table 5 : Number of tractors in service world-wide
(Source : FAO)

	1961-65	1970	1971	1972	1973	1974	1975	1976
USSR	1.427.000	1.977.000	2.045.700	2.111.000	2.188.000	2.267.000	2.336.000	2.402.000
Developed	9.710.706	11.431.055	11.622.590	11.819.630	11.979.912	12.249.038	12.623.867	12.844.367
– N. America	5.319.726	5.212.426	5.207.244	5.211.118	5.214.322	5.211.871	5.123.557	5.030.000
– W. Europe	3.862.159	5.344.803	5.546.797	5.718.141	5.855.972	6.073.508	6.271.990	6.459.277
– Oceania	370.246	423.391	428.417	430.546	432.448	430.849	430.700	431.000
– Other dev. ped.	158.575	450.435	440.132	459.825	476.670	532.815	797.650	924.090
Developing	703.171	1.168.514	1.278.390	1.375.837	1.466.543	1.582.561	1.705.036	1.809.507
– Africa	87.804	150.459	157.766	166.129	174.358	181.790	187.211	192.434
– Lat. America	446.363	657.140	689.730	714.695	751.719	782.961	818.192	844.797
– Near East	96.859	187.638	207.402	233.326	260.517	311.591	361.453	405.267
– Far East	65.327	169.428	219.568	257.613	275.729	301.881	333.751	362.515
– Other Developing	2.818	3.849	3.924	4.074	4.220	4.338	4.429	4.494
Centr. Plannd	1.995.941	2.886.598	3.006.196	3.120.695	3.255.051	3.396.122	3.515.418	3.624.934
– Asian CPE	93.310	165.333	182.200	193.550	205.350	216.850	228.950	240.350
– Europe USSR	1.902.681	2.721.265	2.823.990	2.927.145	3.049.701	3.179.272	3.286.468	3.384.584

In the range of tractors offered, two categories of machines should be distinguished :

– tractors (more than 20 h.p.) and their mounted or drawn equipment which can be classified in the category of heavy power mechanization ;

– walking tractors and motor hoes whose production has increased more rapidly in the developed countries (horticulture ; small-scale mixed farming ; animal husbandry ; part-time agriculture) than in the underdeveloped countries where they are often considered insufficiently powerful and resistant (outwith irrigated rice-growing in the Far East), and which can be classified in the category of light mechanization.

These two ranges of machines differ not only on the basis of substantial price ratios (the difference is from 1 to 10 for the categories of light walking tractors and heavy tractors (1)) but particularly because of the cost of the additional equipment which makes their full use possible.

Thus it is not simply the tractor (its production and cost) that has to be taken into consideration, but rather the tractor plus the tractor-drawn equipment. The cost revealed in USA shows that for $100 invested for tractors, $75 are spent for implements. To give and example, we may examine the mechanical sets used on French farmsteads in order to have some idea of what farm machinery will have to be produced if the heavy tractorization model is generalized. For every 1.3 more tractors of more than 45 h.p. we find 1.08 share-ploughs, 0.52 seed-drills, 0.82 fertilizer spreaders, 0.53 tractor mounted sprayers, 0.65 cutter bar mowers, 0.52 pick-up bailers, 1.28 trailers.

Table 6 : Farm machinery and tractor production (in no. of units built)

	1960	1965	1970	1971	1972	1973	1974
Tractors of more than 10 h.p.	1.011.161	1.292.406	1.458.266	1.386.744	1.472.181	1.635.340	1.745.198
Combine-harvesters	160.797	245.968	214.960	198.289	211.830	228.077	291.029
Ploughs	1.148.983	1.204.134	837.089	793.406	750.792	800.367	783.468
Rakes, tedders	–	117.020	92.996	78.957	80.976	92.362	90.842
Seeders	576.861	796.869	1.032.491	1.087.724	1.175.052	1.315.935	1.565.139
Harvesters		903.184	900.042	811.561	865.325	791.217	963.813
Fertilizer spreaders		299.258	299.211	215.621	235.620	280.636	250.972
Milking machines		175.818	160.029	177.135	179.517	182.403	180.980

(1) Very generally speaking, the cost of an extra h.p. can be estimated at 100 $ for tractors of more than 35 h.p.

The figures mentioned include both animal-drawn machines and power-drawn machines. It would seem that the production figures are an underestimation and do not take account, in particular, of the production carried out in the developing countries (see, for example, the figures quoted for plough production) but they also indicate that Western markets are saturated and that technical changes are taking place (tractors are being replaced by combined machines ; there is a shift from ploughs to chisels etc...).

As far as tractor-drawn machines are concerned, the percentage of production carried out in the developing countries is about 20 % for simple machines (share-ploughs, simple seeders, harrows, rollers, hoes, fertilizer spreaders...). In this field technological autonomy would seem to be greater and explains the variety of models. For more specialized machinery, (particularly in the field of cropping : lifters, pick-up bailers or new forms of ploughing and tilling, and sowing (pneumatic seeder) or of spraying), or machinery adapted to higher-powered tractors (chisels, rotavators, rotary cultivators, cutter blowers) imports cover more than 90 % (local production is estimated at less than 10 %) of national requirements.

The choice of tractor does, without a doubt, effect the amount of draught equipment to be imported or manufactured on the spot.

With regard to the industrialized countries, it has to be noted that the value drawn from the construction of farm machinery and specialized equipment has increased more rapidly and is far greater than the turnover on what can properly be called tractors (cf. table 8).

(ii) The main tractor and tractor-drawn machine producing countries are, in order of importance :

– The Eastern European countries

With the Soviet Union, the foremost world tractor producer, Poland, Rumania, Czechoslovakia ; the E. European countries supply nearly half of the world production in tractors. Also oriented towards the production of heavy equipment, they put onto market, however, less sophisticated models, which are also less costly to buy and to use.

They have a sustained demand on their home markets and an export potential in the Third World and on the main Western markets. The experience of Socialist countries shows that the dynamics of the home market is an important element as far as creating new products is concerned.

– the countries of the O.E.C.D., whose large surplus in tractor production supplies a substantial flow of exports. An estimated 70 % of exports going towards the developing countries comes from these countries. For certain countries in W. Europe (Great Britain, Italy, Belgium) exports account for more than 60 % of total production.

Production is orientated towards the upper range of tractors (average tractor produced in 1976- 55 h.p.). This production has to face the problem of a relatively saturated home market.

Table 7 : Value of equipment in agricultural machinery (1971-75) (in thousands of dollars)

I—Farm Machines and Equipment

	1975	1974	1973	1972	1971
Planting, Seeding and Fertilizing Machinery	470,931	354,436	244,528	196,517	155,523
Harrows, Rollers, Pulverizers, Stalk Cutters	455,090	394,933	249,018	188,585	146,565
Plows	251,594	182,901	130,635	98,810	75,974
Harvesting Machinery	1,232,409	1,093,107	892,462	643,658	540,532
Haying Machinery	476,111	407,652	256,596	190,239	147,153
Farm Dairy Machines and Equipment	68,037	80,309	67,157	60,543	44,571
Sprayers and Dusters	139,575	109,287	93,791	61,049	64,624
Farm Elevators and Blowers	82,231	91,952	69,256	51,979	38,203
Cultivators and Weeders	221,996	162,786	104,196	76,920	59,629
Machines for Preparing Crops for Market or Use	254,284	254,921	171,660	110,699	94,219
Farm Poultry Equipment	65,841	76,154	72,374	62,859	57,385
Hog Equipment	36,292	45,460	37,382	25,980	17,736
Other Barn and Barnyard Equipment	126,336	167,521	144,560	109,447	82,750
Garden Tractors, Motor Tillers	562,185	561,250	414,330	311,073	234,782
Farm Wagons, Other Farm Transportation Equipment	174,362	186,204	144,848	103,793	77,116
TOTALS	4,617,234	4,198,453	3,059,013	2,292,492	1,836,347

[1] Excluding walking type garden tractors

Source: U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports, Farm Machinery and Equipment (MA-35A)

II—Wheel Tractors and Attachments

	1975	1974	1973	1972	1971
Wheel Tractors, Farm Type	2,099,501	1,509,806	1,322,794	1,141,033	991,977
Wheel Tractors, Non-Farm[2]	155,321	160,688			
Attachments for Wheel Tractors, Farm and Non-Farm	39,990	35,937	31,803	30,803	20,026
Parts for Wheel Tractors, Farm and Non-Farm	254,755	238,970	193,177	169,200	223,357
TOTALS	2,549,567	1,945,401	1,522,774	1,341,036	1,135,360

[2] Industrial Type, excluding tractor chassis, shipped as a part of front engine mount, integral design tractor shovel loader/backhoes

Source: U.S. Dept. of Commerce, Bureau of the Census, Current Industrial Reports, Tractors, Except Garden Tractors (M35S)

The main manufacturing countries are, in order of importance : U.S.A., Japan, Italy, Great Britain and Germany. The W. European countries and the U.S.A. also play an important role in manufacturing tractor-drawn equipment.

Table 8 : Breakdown of seeder production between the various manufacturing countries (in %)

	1960	1965	1970	1974
U.S.A.	20.4	15.4	9.1	8.4
Denmark	1.1	1.2	1.0	1.6
France	2.7	5.2	5.1	4.0
Germany F.R.	12.9	14.4	14.2	5.8
Bulgaria	0.4	0.5	2.5	1.5
Poland	3.5	6.1	3.1	2.9
Roumania	2.5	0.4	1.1	1.4
USSR	19.4	32.8	15.8	11.3
Total world	100	100	100	100

Table 9 : Breakdown of plough production between various plough-building countries (in %)

	1960	1965	1970	1974
U.S.A.	9.7	11.0	7.0	23.3
Japan	21.9	14.2	8.9	n.q.
France	7.8	7.3	9.8	11.2
Germany, F.R.	8.5	5.7	4.2	2.9
Poland	6.3	9.5	9.0	8.7
USSR	13.0	13.8	24.2	27.9
Total world	100	100	100	100

Japan

Although a latecomer in tractor production, Japan has become the second world producer. Japan occupies a privileged position in the production of tractors in the 20 to 35 h.p. range. The particular characteristics of Japanese agriculture (small farmsteads often run on a part-time basis) help to explain why at the present time she has also become a substantial producer of walking tractors and motor-hoes. This country also supplies nearly half of the garden tractors produced in the world. Her success on foreign markets (large-scale production, relatively low manufacturing costs) underlies most of her industrial manufacturing programmes.

4. Self-propelled machines and specialized equipment

Although monopoly in tractor production is tending to grow weaker, it is still very real in combined machine production. It would now seem that one combined machine is made

Table 10 : Combine-harvesters in service (no. of units)
Source : FAO

	1961-65	1970	1971	1972	1973	1974	1975	1976
USSR	513460	622600	639100	655800	658000	673000	680000	685000
DEVELOPED	1566075	1678113	1695385	1716724	1769909	1830072	1935680	2007593
N.America	1098058	921706	885636	862901	861541	842925	821449	813000
W.Europe	376784	622066	637270	650802	663835	684610	684675	680563
Oceania	70832	69366	68919	66416	65716	64311	63650	63000
Oth.Dev.Ped.	20401	64975	104060	136605	178817	238226	366106	451030
DEVELOPING	101854	124100	129024	133656	138490	143433	148806	153417
Africa	11810	13063	13401	13701	14022	14560	14860	15253
Lat.America	77351	92968	96863	100231	102963	105889	109281	112165
Near East	11760	16608	17185	18036	19751	21051	22659	23918
Far East	788	1215	1312	1410	1466	1625	1688	1743
Oth.Dv.Ping.	145	251	263	278	288	308	318	336
CENTR.PLANNED	588886	744649	760207	778360	777801	791903	800864	811.927

for every six tractors in the world. The proportion of the one compared with the others increases as agricultural production techniques improve (both from an agronomical and mechanical point of view : elaboration of resistant crop varieties which are homogeneous for mechanical cropping), as the labour force becomes less abundant, and as the farmsteads are restructured.

The U.S.A., the U.S.S.R. and Germany which have dominated this sphere of production for a long period are at present being surpassed by Japan which accounts for probably about 40 % of world production (cf. table 11).

Table 11 : Breakdown of world production of combined machines (in %)

	1960	1965	1970	1974
U.S.A.	18.8	37.9	9.8	9.8
Japan	n.q.	–	21.0	40.3
Germany, F.R.	23.6	n.q.	10.5	6.4
USSR	36.7	34.9	46.3	30.4
Total world	100	100	100	100

Firms building self-propelled machines are often relatively autonomous in relation to the major tractor firms. Originally small in size – at least in the W. European countries – they have been at the forefront with regard to innovation and the elaboration of new mechanical engineering techniques (see the grape-picking machine). There are real prospects concerning harvesting, which is not as yet, in relative terms, subject to mechanization, but also concerning soil preparation (new forms of ploughing and tilling, combined with a sprayer and a seeder).

5. Present trends registered in tractor and tractor-drawn machine production

The production of capital goods for use in agriculture is an indication of the importance which the tractorization model has now taken on. This explains the domination of the major industrial countries on this sector as a whole. However, attention should be drawn to the following aspects :

a) – manufacturing is complementary in the privileged zones which are characterized by farming of a high technical level. This complementary nature of manufacturing is apparent, in particular, in the COMECON, the countries of the O.E.C.D., and most of all in the nine countries of the E.E.C. For these latter countries, complementarity is particularly evident in the following fields :

– the production of tractors and self-propelled cropping machines. In W. Europe, West Germany and Great Britain are dominant as far as cropping equipment is concerned.

– with regard to soil-preparation machines (seeders. ploughs, etc...). France is in a privileged position.

– with regard to specialized material, each country often dominates a particular production (thus, for example, Sweden dominates the production of dairy farm equipment).

The production and direct exports of the U.S.A. towards these zones have however fallen substantially over the last few years. Trade within Europe has been constantly rising, given that the supplying of the European countries is carried out at more than 90 % at present (compared with 88 % in 1971) within Western Europe.

b) – <u>The industrial programmes of the developing countries have been reinforced by national policies of " production integration</u> "

These policies, determined on the basis of priority objectives concerning development (job creations, use of industrial products manufactured on the spot, creation or consolidation of a network of sub-contractors),

– are often carried out in stages : the first stage consists in conditionning the imported machines (preparation, adjustment, painting of material). The second stage is the assembly of the machine ; the third stage the supplying by the country of certain parts (coachwork), and the fourth stage is the supplying of complex elements which are necessary for all the mechanical and electrical parts in order to produce the machine,

– are often held back by the existence on the one hand of a network of small and middle-sized firms, in charge of the sub-contracted work, and also by after-sale services in charge of the maintenance and adaptation of material to the farming conditions of a given country,

– are restricted by the partitioning of home markets. The national markets arrive at a relative saturation level given the cost of the material involved. There are not as yet any important manufacturing programmes which have been elaborated on a regional level.

In certain cases this integration has managed to reduce perceptibly the use of imported parts. However, in terms of value, these imports rarely fall below 30 % of the total value of the manufactured product, since the price of the imported parts often rises more rapidly that the price of the parts which are manufactured locally. In the long run, the pursuit of industrial integration strategies, which is immediately at stake, can only be meaningful if this opens the way to scientific and technical research policies leading to the production of the appropriate material for the mechanization strategies which have been adopted.

c) – **New manufacturer-exporters have appeared**

The scale of production is, from the very beginning, intended to supply the international market. This strategy is adopted in three groups of countries :

– the Western countries which are subject to the policies of the main American or Canadian mechanical engineering firms (Great Britain, Benelux). Production is essentially intended for export.

– Japan, where the home market, which is almost at saturation level, and the orientations of Japanese industry, are leading to the generalization of mass production of small tractors, walking tractors, but also combined machines. Commercialization agreements, for example, have recently been signed between Mishubishi and Massey-Fergusson for the world-wide diffusion of their respective equipment.

– countries with planned economies (E. European countries) which seem to be aiming at entering the market not so much through a policy of selling agricultural products, but rather through an international policy of provinding industrial products necessary to agriculture. This equipment which is manufactured and sold on a mass scale is beginning to make its mark on most of the world markets.

1.1.2. The main world manufacturers

When tackling the analysis of the structures in farm machinery production, two spheres should be distinguished :

– that of the production of farm equipment where small- and middle-sized firms are in a majority (cf. A).

– that of tractor production which is dominated by a few large firms (cf. B).

A. The production of farm equipment

– With regard to soil preparation equipment, there is a steady trend towards a grouping together of the manufacturers of tractor-drawn or mounted machines behind the main tractor manufacturers (International Harvester, Massey Fergusson, David Brown, John Deer, Allis Chalmers, J.I. Case...). However, manufacturers specialized in one or two lines of production have been able to keep going and supply heavily the export markets. Among these latter firms, we may mention :

– **ploughs, hoes** : Rome Plough, Athens, Femco (U.S.A.), Howards Rotavator, Ransome, Kelly Plows, Servis (G.B.) ; Cockade, Wilbeck, Bass Technick, Cramer, Eicher (Germany), Tatasoga (Japan) ; Huard (France), SOCOMEC, SOGEMA (Italy).

– **seeders** : Planet Jr. (G.B.) ; Nodet Garnier (France)

Many simple machines are manufactured in the developing countries (cf. above). Industrial manufacture, in this case, often starts off with substantial government grants.

– With regard to crop processing equipment, the hold of the main machine manufacturers remains strong. However, it should be noted that a substantial part of this production is outwith the machinery sector properly speaking. Many manufacturing workshops (especially for hand-drawn equipment) exist in the developing countries.

– With regard to more sophisticated equipment, we may mention the following manufacturers whose exports account for a substantial part of their annual turnover.

– **sprayers** : John Bean, F.E. Myers, R.M. Wade (U.S.A.), Aritmitsu, Hatsuda, Kawasaki (Japan) ; Somax Co., Mesto Ruckenspritzen, Solo Vilcinmotoren, Jels Co., Stihl Motorsagen (Germany) ; Gustafson (Sweden) ; Teenoma (France).

– With regard to crop storage and processing equipment, manufacturing is as yet scattered. However, the present insufficiencies could be reduced by the elaboration of a common definition of a technology which can be adapted to the harvesting and storage conditions in the developing countries.

In the industrialized countries, the turnover made on this category of goods is rising rapidly. This progression is all the more rapid when the stock-breeders provide at the level of their farmstead an important part of the fodder for the animals.

– With regard to irrigation equipment, the prospects seem to be particularly good both in the field of conventional equipment (pumps and motor-pumps) and that of new techniques (irrigation by spraying ; " goutte-à-goutte " ; solar engine pumps ; wind-mills). The demand is coming both from the developed countries (irrigation allows production risks to be reduced) and from the developing countries, where the use of this equipment is one of the best means of encouraging crop intensification.

The manufacturing of this equipment is steadily moving out of the agricultural machinery sector. For the most conventional techniques (pumps, motor-pumps, polyethylene

pipes) production is carried out in all countries. The manufacturing units can be extremely small. The large manufacturers are dominant in specialized equipment (valves, high capacity pumps, irrigation material for major equipment programmes...) and thus appear as the main exporters. Among the biggest exporters, we may mention :

Amex ; Bruckner ; Rain Bird ; Ames Irrigation ; Berckley ; Universal ; Pompes Guinard ; Lister.

– As far as miscellaneous equipment is concerned, it has been remarked that there is a very clear shift of manufactures towards animal products. Equipment intended for dairy use and poultry production share this rapidly expanding market between them, particularly in farming areas near towns. Once again, this market is independent of the general shift to power-mechanization, and small manufacturers remain numerous. The mechanization of activities dealing with animals is one of the most important outlets for farm machinery in the industrial countries. Among the main exporters, we may mention :

– *equipment for poultry production :* Chick-Master ; Big Dutchman ; H.D. Hudson, Kawakita, Denki Kogyo ; Tohzai Sangyo Bocki ; John Wood...

– *dairy farm equipment :* John Wood ; Dunn ; Gordon Equipment ; Lister Landgerate ; Utina-Alektrawerk ; Alfa Laval...

B. Concerning tractors

The accentuation of international competition, the slowing down of economic growth combined with the problems of overequipment of farmsteads in the market economy developed countries have contributed to speeding up the following trends:

1. *Manufacturers of tractor-drawn machinery have been progressively absorbed by industrialists specializing in tractor and combined machine manufacture* (cf. above).

Subject to the technical demands of tractorization (the tools are designed in close relation to their being used by more and more rapid and powerful tractors). The manufacturers of tractor drawn equipment are thus faced by restrictions on their own outlets because of the progressive saturation of the tractor market. It is not by chance if at present their industrial and commercial strategies evolve in close relation with the development of the heavy tractorization model (instruction manual issued by the tractor manufacturers ; orientation of research programmes ; joint commercialization of products). Technical innovation would tend to be

elaborated by the manufacturers of tractor-drawn equipment, then valorized and diffused by the tractor manufacturers.

2. *Technical and financial concentration* (cf. table 12)

The grouping together of the manufacture of tractor-drawn machines has however been less rapid than that of tractor manufacturers themselves. In 1976, the four biggest firms accounted for more than 80 % of tractor production in six Western countries.

From 1965 on, Anglo-american firms make their mark on most of the European countries. However, the only countries in which their expansion is vigorously countered are Germany (Deutz), Italy (Fiat), the E. European countries, and to a lesser extent France (Renault).

Table 12 : Concentration of tractor manufacturing on six Western markets

		1950	1955	1960	1965	1970
North America	Largest				(1966)	
	Firm	30	29	25	22	–
	4-Firm	75+	70+	69	72	–
	8-Firm	90+	90+	91	92	–
United Kingdom	Largest					
	Firm	50	35	40	37	35
	4-Firm	80+	80+	8[illegible]+	85+	85+
	8-Firm	90+	90+	90+	90+	95+
France	Largest	(1951)				
	Firm	20	40	25	22	21
	4-Firm	52	68	75	64	61
	8-Firm	67	84	83	86	84
Germany	Largest		(1956)			
	Firm	–	13	16	21	19
	4-Firm	–	45	49	53	60
	8-Firm	50+	69	74	75	83
Italy	Largest		(1956)		(1964)	(1969)
	Firm	19	16	36	40	50+
	4-Firm	52	49	74	77	–
	8-Firm	65	73	84	87	–
Australia	Largest					(1969)
	Firm	27	34	–	–	23
	4-Firm	75+	75+	–	–	75+
	8-Firm	90+	90+	–	–	90+

The entry onto the European markets was made on the basis of a low-power model (18 to 30 h.p.) at a time when the European manufacturers where still concentrating on upper range manufactures with relatively narrow market opportunities.

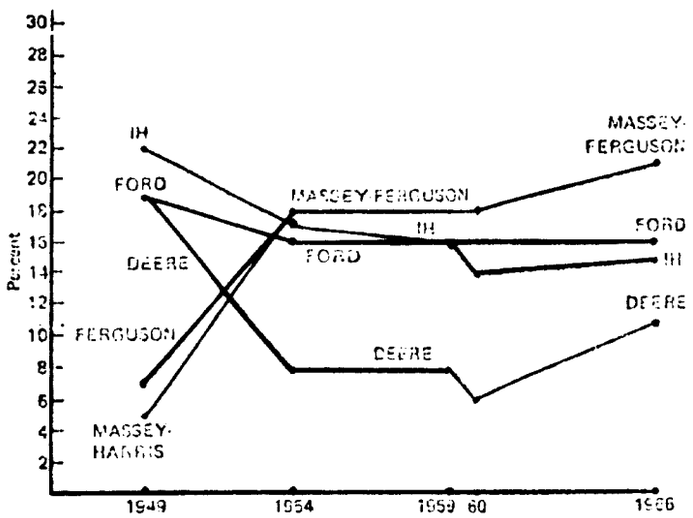
It was by selling to small- and middle-sized farmsteads that American manufacturers obtained their initial implantation in Europe. Later, the European manufacturers were eliminated or absorbed. The only firms to resist and widen their range of products were those tractor manufacturers who were associated with major car firms (cf. table 15).

Table 13: Breakdown of sales of the large firms on Western markets (1966)

	MF	IH	Ford	Deere	Fiat
U.S.-Canada	37.522	59.931	37.261	57.846	–
U.K.	16.539	3.464	14.417	–	–
France	17.663	9.561	7.778	3.241	10.290
Germany	5.906	9.464	3.786	3.559	1.287
Italy	4.318	595	2.937	–	15.915
Australia	4.339	4.339	4.339	–	379

For all of the markets together :

IH	16.8 %
M-F	16.8 %
Ford	13.6 %
Deere	12.4 %
Fiat	5.4 %



Note : Massey-Harris and Harry Ferguson merged in 1953. Data points were chosen on the basis of reliable estimates. Both 1959 and 1960 are shown to indicate the importance to International Harvester and Deere of the North American market and their vulnerability to low farm incomes there.

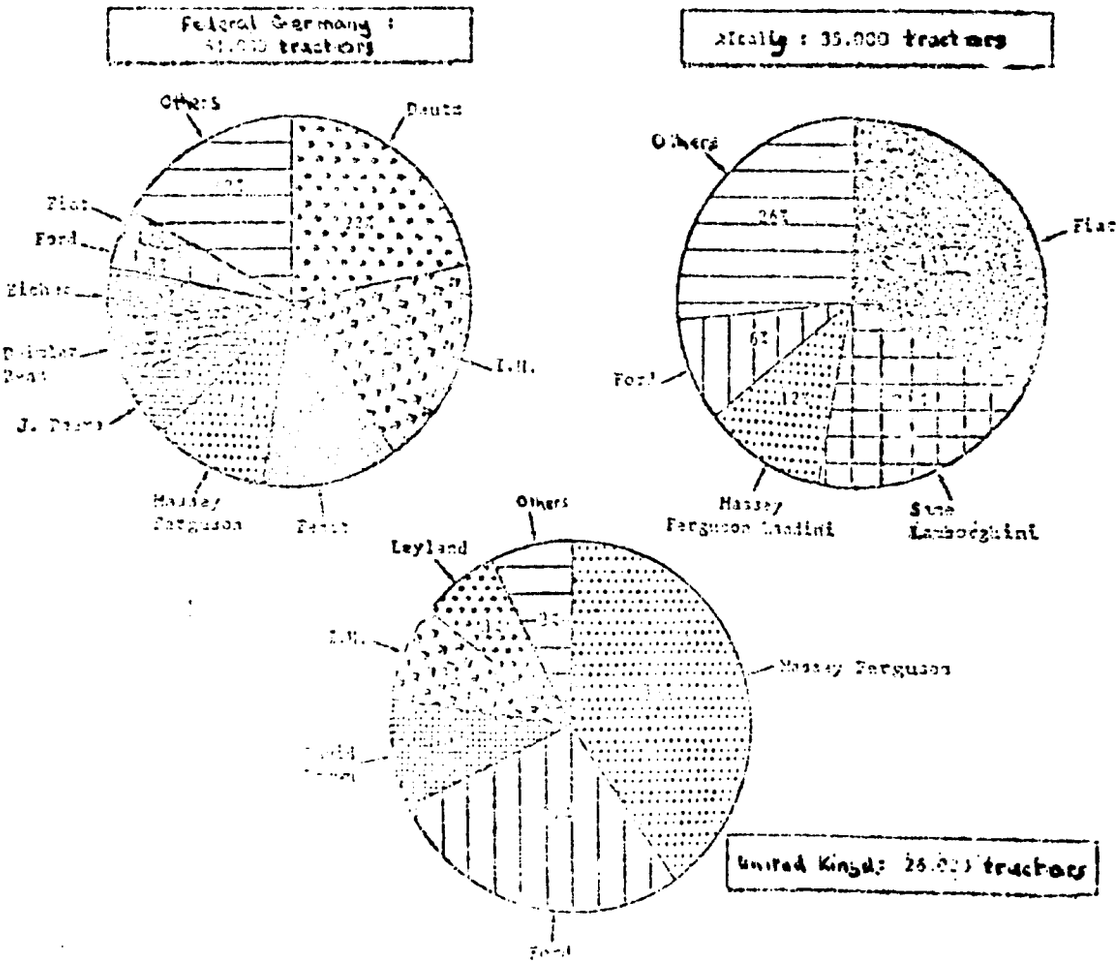
Source : Output for Ford is available from published company figures. See Mira Wilkins and Frank Ernest Hill, *American Business Abroad : Ford On Six Continents* (Detroit : Wayne State University Press, 1964), p. 439, and the Company's *Annual Reports.* Massey-Ferguson (and predecessor companies) has its tractor output presented in E.P. Neufeld, *A Global Corporation* (Toronto : The University of Toronto Press), pp. 61 66, 121, 139, 284-285. Production estimates for all firms in 1966 are presented in Table 1-4. A U.S. production estimate for International Harvester in 1949 is from Michael Conant, "Competition In the Farm Machinery Industry", *Journal of Business*, 26 (January, 1953), p. 36. Other estimates are based on industry and official sources of production, market share, and trade cited in Chapters Seven and Eleven below.

Source : from KURDLE - Agricultural tractors : a world industry study Ballinger - Cambridge - Mass. 1975.

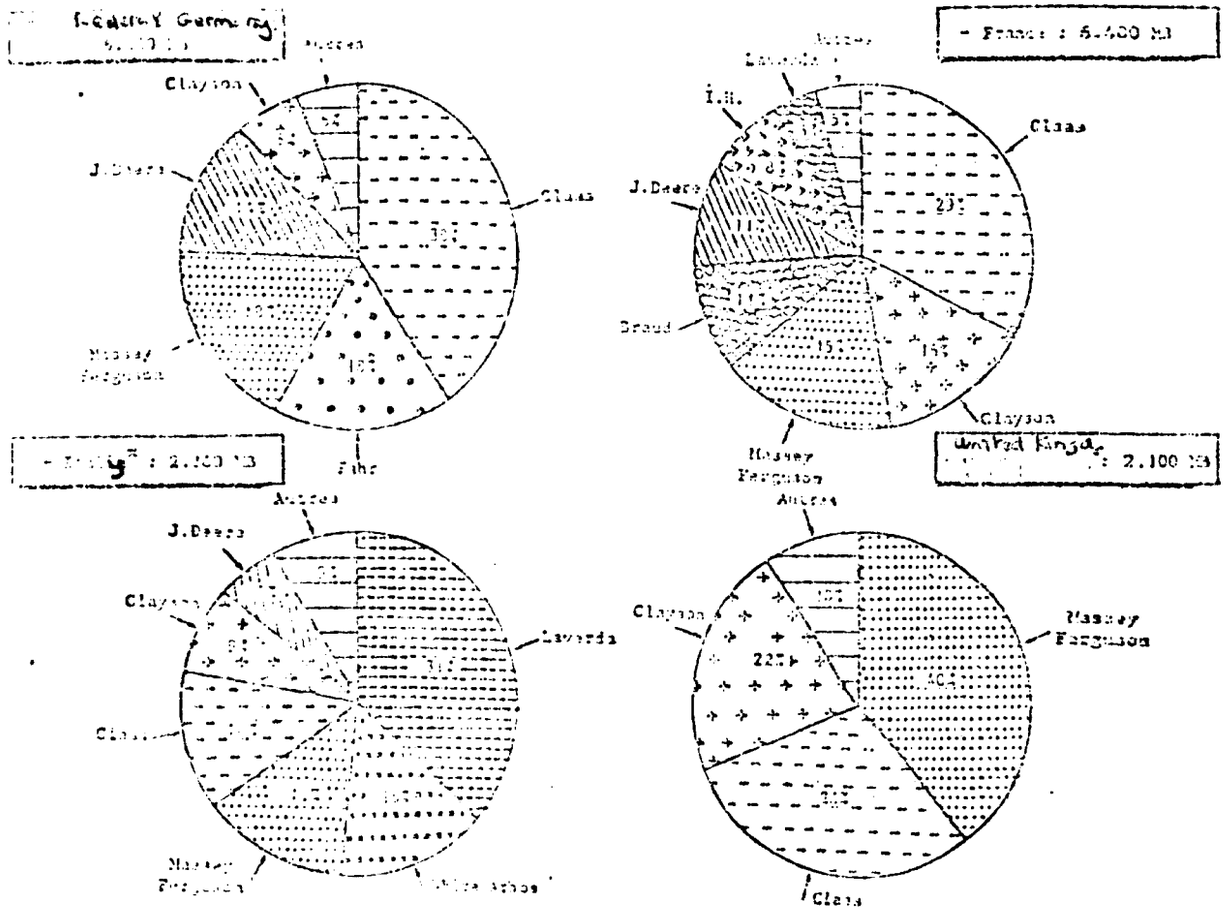
However, the concentration of production is greater for self-propelled machines than for tractors. Thus the more sophisticated the mechanical engineering involved, the more production is structured oligopolistically. This is illustrated by the breakdown of tractor and combine harvester sales for three Western countries.

Table 14 : The breakdown of tractor and combine harvester sales for three Western countries (Source : DAFSA)

1. Tractors



2. Combine Harvesters



3. *Diversifying of lines of production*

Technical and financial concentration contribute to the redeployment of industrial activities. However, for the time being this concentration rarely causes the dominant technical model to be put into question. Quite the contrary, since in most cases the characteristics of heavy power mechanization are accentuated.

In farming, one may note :

– a shift from tractor manufacturing to self-propelled machines going along with a thinning out of the labour force in agriculture in the industrial countries ;

– the orientation of production towards mechanizing of animal production. Closely associated with the modernization of feeding procedures (mechanical feeding chain) the agricultural machinery industry is extending its scope of production to cover the manufacturing, distribution and storage of animal fodder, the sheltering of the animals, the processing and conservation of animal products (dairy industries in particular).

Besides farming, and given that a great number of agricultural machinery and tractor manufacturers are working in association with car firms (Ford, Fiat, British Leyland, Renault...) or with manufacturers of public works equipment (Caterpillar), diversification continues in the following spheres :

– the manufacture of heavy equipment which may be used for programmes intended specifically to meet the demands of handling in agriculture (farm conveyor, buckets and haulage equipment distinct from what are properly termed tractors).

4. *The internationalization of production* (cf. tables 15, 16, 17)

In many cases, the diversifying of production goes along with a change in the geographical location of manufacture. Production units thus become specialized as a result of the characteristics of each market. On a European level, this strategy has the following results :

– a certain complementarity of the ranges of models offered by the factories set up in the various countries of the Common Market ;

– also, because of the progressive saturation of their traditional market, a noticeable shift, over the last ten years, of tractor manufacturing units from Northern Europe towards Southern Europe (Italy, Greece, Spain, Portugal, Turkey) and shortly towards the other countries of the Mediterranean Basin as these become better equipped, and integrated into the European agro-feeding complex ;

– the deployment of activities towards the Third World ;

– the specialization of certain countries (the Belgo-Luxembourg union ; Great Britain) in the manufacture of goods essentially intended for export.

The spread of manufacturing units throughout the world takes place as a result of the opening of the market. Table 16 shows the breakdown for 1966. Ten years later, we should

add to the licenced manufacturers countries like Mexico or Argentina, Pakistan, Algeria or the Philippines.

Table 15: The breakdown of world production between the major companies (1966)
(in millions of $)

Company Ranking According to Market Share	World	U.S.A.	Britain	Federal Republic of Germany	France	Italy	Belgium	Sweden	Spain	India	Austria	Australia	Japan	Brazil	Finland	Others
Massey-Ferguson	153.8	38.8	78.6		29.2	3.2								4.0		
Ford	118.4	38.6	57.1				22.7									
International Harvester	108.0	62.0	21.0	15.0	8.5							1.5				
Deere	78.0	60.0		18.0												
Fiat (Fiat + Someca)	41.5				6.5	35.0										
Renault/Porsche	19.0				19.0											
David Brown	18.5		18.5													
J.I. Case	17.5	17.5														
Deutz	17.0			17.0												
Allis-Chalmers	15.5	15.5														
Brit. Leyland (Nuffield)	15.0		15.0													
Volvo	14.7							14.7								
Oliver (Cockshutt)	15.0	15.0														
Minneapolis-Moline	7.0	7.0														
Valmet	4.0													.9	3.1	
Other (known companies)	9.4								6.0	3.4						
Other (not identified)	157.2	15.6	20.2	51.0	2.1	10.6			7.1	8.6	11.7	9.3	9.7	1.1		10.0
World Total	809.5	270.0	210.4	191.0	65.3	49.0	22.7	14.7	13.1	12.0	11.7	10.8	9.7	6.0	3.1	10.0

Source: Clarence Barber (Royal Commission on Farm Machinery), *Special Report on Prices* (Ottawa: Queen's Printer, 1969), pp. 4-5.

This transfer of production should not hide the fact that many "high-class" parts are still manufactured in the countries which have a long industrial tradition or where the machines have long been used. The following example concerning the breakdown of production units of three major firms in Europe serves to illustrate this phenomenon (cf. table 17).

The shift towards the internationalization of manufacturing is confirmed by the analysis of the sales of the major companies in the world. In 1973, for Massey-Ferguson, for example, sales on the U.S. market accounted for only 28 % of total sales. Those made in Europe for 35 %, and 25 % for the countries of the Third World (cf. table 16). Given the difficult economic situation in W. Europe, the markets of the developing countries are likely to be more and more sought after, at a lower cost.

Table 16 : Breakdown of world sales of the firm Massey-Ferguson - 1973

– N. America	:	34.7 %	including 28 % to the U.S.A.
– Europe	:	35.8 %	
including U.K.	:	9.7 %	
France	:	9.1 %	
W. Germany	:	6.8 %	
Italy	:	3.6 %	
Benelux	:	1.1 %	Source : DAFSA
– Latin America	:	15.2 %	
– Africa	:	5.6 %	
– Australia	:	4.9 %	
– Asia	:	3.8 %	

Table 17 : The industrial implantation in Europe of three major North American companies
Source : DAFSA

	W. Germany	France	Italy	U.K.	Other European countries
MASSEY - FERGUSON Turnover (73) 1 605.2 M U.S.$ Total manpower (73) 51,267	Massey-Ferguson GmbH 100 % CA(73) : 192.6 M$ – **Eschwege** : gear box, shafting, components for tractors and combine harvesters – **Escher GmbH** 30 % Tractors	Massey-Ferguson S.A. 100 % CA(73) : 137.4 M$ – **Beauvais** : tractors – **Marquette-les-Lille** : combine harvesters, pick-up bailers, components for tractors	Massey-Ferguson Landini 100 % CA(73) : 54.5 M$ – **Aprilia** : track-drives – **Como** : components for tractors – **Fabbrico** : wheel tractors – **Simmel S.p.A.** 33 % Equipment for track-drives – **Beltrami S.p.A.** 50 %	Massey-Ferguson Limited 100 % CA(73) : 146.8 M$ – **Baginton** : components for tractors – **Coventry** : – **Kilmarnock** : combine harvesters – **Manchester** : tractors	Massey-Ferguson Nederland 100 % CA(73) : 15.8 M$ – **Motor Iberica** : 36.6 % Agricultural equipment

INTERNATIONAL HARVESTER	W. Germany	France	Italy	U.K.	Other European countries
Unified Turnover (73) 4192.5 M $ incl. turnover (73) agric. machinery 1359.8 M $ Total manpower 107,890	**International Harvester Co. mbH** 100 % – 2 plants Manufacture and sales of agric. equipment for tractors and engines	**International Harvester France** 99.9 % – 3 plants Manufacture and sales of agricultural machines and tractors	**International Harvester Italiana** 100 % Sales in Italy of I.M. products	**International Harvester Co. of Great Britain Ltd** 100 % – 3 plants Manufacture and sales of agric. equipment and various types of track-drives and tractors	**Aktieselskabet International Harvester Co.** Denmark Sweden 99.9 % Building and sales of agric. equipment and tractors Compania Internacional de Maquines agricoles 100 % Sales of I.M. products in Spain

JOHN DEERE and COMPANY	W. Germany	France	Italy	U.K.	Other European countries
Unified turnover (73) 2002.9 M U.S. $ incl. turnover (73) agric. machinery 1498.4 M $ Total manpower 50,058	**John Deere Vertrieb** Turnover (73) 53 M $ 2 plants – Mannheim – Zweibrücken	**John Deere S.A.** 100 % Turnover (73) 70 M $ 3 plants – Arc-les-Gray – Saran – Sanonches 1 " commercial firm " at Orléans	**John Deere Italiana SpA** 100 % Commercial activities	**John Deere Ltd Langar** Commercial activites **John Deere Ltd Scotland** Commercial activities 99.9 %	**John Deere Svenska Eslav** **John Deere Iberica SA** 100 % Turnover (73) 55 M $ 1 plant at Madrid

1.1.3. Characteristics and evolution of the dominant technical model

Among the goods produced by the agricultural machinery sector, a distinction should be made between those which come under the heading " mechanization " and those under " power mechanization ".

– What can be properly called " mechanization ", as distinct from the trend towards " power mechanization ", i.e. essentially, tools, animal drawn machines, small-scale pre- and post-harvesting equipment.

This mechanization corresponds to a given level of agricultural and industrial development which is marked by the preponderance of the rural over the urban. It also corresponds to agricultural and industrial needs derived from production structures which are decentralized, not very concentrated, and which use simple techniques.

Restricted mainly by the available sources of power (human and animal) the machines and equipment which are used for agricultural production :

– have nonetheless made possible the elaboration of most of the technical innovations which are at present used in power mechanized agriculture (cf. table 19) ;

– have contributed to advances in agronomy and in the control over risks in production ;

– can be applied, because of their simplicity and low utilization cost, to the problems which have appeared in Third World agriculture (piecemeal and narrow nature ; low productivity ; solvency ; low maintenance costs) ;

– may again become of interest inasmuch as there have been innovations concerning energy (use of solar energy for pumps, of windmills for electricity production).

– **Power mechanization**, in which the dominant element is tractorization. At the present time, in the sphere of agricultural machinery there is a close relationship between power mechanization and mechanization, inasmuch as the agricultural machine is designed more and more in relation to its use by the tractor, and the gradual disappearance of the characteristics of mechanization as it has already been described.

The generalization of the shift towards power mechanization in the developed countries has taken place in an economic context marked by a rapid reduction of the agricultural labour force, an increase in labour costs which was greater than that of the use of technical goods, the rapide growth of upstream industries (suppliers to agriculture) and downstream industries (transformation of agricultural products), and the rapid transformation of agricultural demand (shift to a fodder rich in protein, generalization of food preparation and conservation techniques).

A. The main stages of agricultural power mechanization

The power mechanization model has been held in favour these last few years both from an agricultural and an industrial point of view.

In the industrialized countries over the last fifty years its diffusion has taken place in four main stages.

Table 18 - Historical perspective on agricultural machinery (1)

Category of equipment	Date of invention or application
A. Soil preparation equipment	
- Single-furrow iron plough without gallows (Dombasle)	1820
- Steel Share (John Deere)	1837
- Brabant plough with wooden beam and mould board (Fondeur)	1825
- Steel brabant plough (Delahaye)	1856
- Reversible brabant plough	1860-1880
- Soft centre steel mould board	1900
- American disc plough	1893
- Zig-zag harrow (Puzenat)	1872
- Disc harrow	1889
B. Sowing and fertilizer spreading equipment	
- Cup-feed driller (Drancourt)	1754
- Grain drill with cell wheel distribution (Duhamel de Monceau)	1750
- Sparing drill for sugar beet seeds (Le Docte)	1843
- Miscellaneous mechanical drills	1855
- Fertilizer applicator (Garret)	1870
- Fertilizer applicator (Gougis)	1875
- Conveyer and brush distributor (Boirenoult)	1890

Category of equipment	Date of invention or application
C. Hay-making equipment	
- Rotary Scytte (U.S.A.)	1822
- Wheel-less draught hay-rake (U.S.A.	1820
- Cutter-bar (U.S.A.)	1820
- One wheel scytte (U.S.A.)	1847
- Two-wheel scytte (U.S.A.)	1853-60
- Fork-type hay tedder	1850
- Stationary hay bailer	1853
- Steam driven stationary bailer	1885
D. Harvesting equipment	
- Pushing harvester with articulated scyttes (Bellenoue prototype)	1788
- Harvesting barrow (Person)	1794
- Multidisc rotary mower for cereals	1806
- Push mower for cereals	1811
- Reels	1822-1825
- Push front cut harvester with reel (Scotland)	1827-1853
- Same type of harvester, improved model (Hussey, U.S.A.)	1833
- Same type of harvester in France	1855
- Automatic side delivery rake	1856
- Side delivery reaper	1851-1853

(1) On the basis of the CNEEMA studies 380 and 383:
"Du bâton à fouir à la moissonneuse-batteuse", n° 396:"Compte-rendu abrégé de la session de perfectionnement" the 11th 12th and 13th of decembre 1973 on farm tractors (I.N.A. Paris.Grignon/CNEEMA:also on the basis of the Bulletin

.../...

Category of Equipment	Date of invention or application
- Binding attachment	1878
- Animal draught corn binder (Mc Cormick and wood)	1890
E. Treshing equipment	
- Camshaft "thresher" (French Revolution)	1790-94
- Circular thresher (Lenure)	1808
- Stem thresher	1865-1880
F. Combine Harvesters	
- Animal draun combine harvester (U.S.A.)	1828
- Animal draun combine harvester (first prototype of H.Moore,U S.A.)	1835
- Steam engine draun combine harvester (U.S.A.)	1889
- Self-propelled combine harvester with petrol engine Holt,U.S.A.)	1911
G. Other equipment	
- Fork potato lifter	end 19th cent.
- Sugar beet lifter	end 19th cent.

Category of equipment	Date of invention or application
H. Draught equipment	
- Steam plough (England)	1834
- Cable ploughing (Pratt, England)	1839-1849
- Heavy steam plough	1853
- Complete steam tilling equipment (England, Fowler or Howard)winches for cable ploughing driven by steam engine	
- Application of this equipment in France	1861
- Electric ploughing (first attempt in the Marne)	1875
- Electric winch	1878
- Explosion engine	1894
- Petroleum engine tractor (G.B.)	1904
- Three-Wheel farm tractor, petrol driven (Gougis,France)	1906
- Petrole or electric winches in U.S.A. and G.B.	1018 - 1919
I. Tyres	
- Car tyres	1890
- Farm tyres (U.S.A.)	1930
- Farm tyres (France)	1931-1932

Suite de la note (1) ...d'information n° 120 "Les pneumatiques agraires".

1. The ..nplantation of the **stationary engine** at a farmstead level (petrol driven, then more and more driven by electricity as rural equipment programmes progressed), this engine being used in all crop processing operations (winnower, mill) and equipment operations (irrigation).

2. The development of the **small and medium power tractor** whose diffusion was mainly due to the introduction of tyres, of the hydraulic lift, and dieselization.

The generalization of this category of tractors means that gradually it is no longer considered as a simple substitute for animal draught but rather it heralds a new technical model for agricultural production. Even if, for an intermediate period of time, it was necessary to take into account existing equipment, specialized equipment which specifically suits mechanized farming has been elaborated and manufactured with the tractor in mind.

3. The shift to **high power tractors** (more than 60 horse power) accentuates this previous trend.

Thanks to the elaboration of the independent power take-off, of hydraulic transmission of the multiple ratio gear-box, the tractorization model is becoming differenciated. All equipment used for working the land is designed for mechanized farming. Mounted and semi-mounted ploughs can only be used if they are hitched on to a tractor. A vibrating harrow, an instrument of the rotavator type, a beetroot lifter and even more so a chisel or a crusher are inconceivable without a powerful engine.

4. The tractor is losing little by little its rôle as a draught machine, and is becoming **a mobile power centre.** This involves improving technically the manufacture of hydraulic, electric and pneumatic parts which considerably encumber production costs. These high production costs mean that only the very large industrial groups can undertake their manufacture. It is labour savings which come before investment costs for these machines.

What is more, ploughing and tilling machines make more and more frequent use of powered parts : vibrating harrows, rotary cultivators, hoe-discs, lifter parts.

B. Present trends

Among the main trends, we should call attention to :

– high capacity machines and tractors which are intended to meet the requirements of agricultural producers as far as speed of execution is concerned, as well as growth of areas

to be cultivated, and also to meet the demands of manufacturers who wish to renew their markets.

– the progressive abandoning of the polyvalence of equipment. Thus the tractor designed as the " engine unit " of a mechanical chain tends to be replaced by self-propelled machines (cutter-blowers, harvesters, etc...) or by stationary equipment (mills, dynamos).

– the periodic renewal of sets of machines intended for agricultural production (from haying to ensiling, the equipment has completely changed).

The generalization of this technical model involves :

– the soundness of after-sale servicing given the growing sophistication of the machines ;

– sufficiently large farming areas and sufficiently high productivity to justify the investment necessary ;

– financial aid on purchase (credit) ;

– technical training for the purchaser.

However, most Third World agriculture, which as yet remains close to the light mechanization model, seek the satisfaction of the following needs in power mechanization :

– polyvalence and simplicity of the equipment ;

– easy use ;

– low capital immobilization ;

– relationship between small manufacturing and maintenance units and farm users.

The diffusion of the heavy tractorization model carries with it its own problems which will hold up its development. Both for the firms (from an industrial point of view) and for agriculture itself, it will be necessary to redefine a mechanization strategy in order to facilitate the shift to power mechanization. This strategy must :

– enable all the requirements of agricultural production in this field to be covered ;

– make it possible to associate different technical levels within agricultural productive systems.

– prepare a particular agriculture, according to its technical level, to be able to use, in the best conditions, the machine and engine together.

1.1.4. Reestablishment of a multiform power mechanization model

The reference to a single power mechanization model based on the heavy tractor considerably restricts the prospects of development for the agricultural machinery industry.

An analysis of the real situation leads us to the conclusion that agricultural production is not a homogeneous productive process and that it is characterized by the combined use of a set of mechanical goods of various forms and on various technical levels.

The production of machines intended for agriculture should enable the following operations to be carried out :

– land-clearing or recultivation operations. There it is essentially a matter of extending the agricultural area used. The inital investment is substantial, but it represents a definitive gain for the country, region or enterprise which carries it out.

Generally, for such work, the machines used come as much under the heading of building and public works (bulldozer, land-grader) as what, strictly speaking, can be called the agricultural machinery sector (heavy tractor with four driving wheels in order to carry out initial deep-tilling and subscribing ; debrushing and deforesting).

-- maintenance operations on land. These are intended to valorize, maintain and adapt the agricultural area used for what can properly be termed agricultural production operations. Thus, it may be a matter either of very heavy investments, involving the use of substantial equipment (periodic land-drainage operations, contour line development of dikes and low walls, of a network of stable roads and paths) ; or of lower investments making greater use of the labour force (maintenance and cleaning of ditches, periodic debrushing, fencing off of pastures and ranges, maintenance of a network of paths).

– equipment operations for the land which come under the building as much as the agricultural machinery sector. This is a market which is renewed from time to time according to the orientations of agricultural policy, to the changes in agricultural techniques, and to the priority which is granted to one or another type of production (food production, animal production, agricultural production for industry or export).

The investment has a shorter redemption period than for the first type of operation, and longer than the second. The equipment used covers essentially irrigation equipment and buildings.

-- operations specifically related to agricultural production from soil preparation to the maintenance and spraying of plants, passing through sowing, and ending with cropping operations. The mechanization of these operations can be carried out to a greater or lesser degree, as can their power mechanization. Nevertheless, plant production is always more mechanized than animal production ; the renewal period for equipment is doubtless shorter than for the preceding operations ; these operations come under the restrictive heading of " agricultural machinery ".

– operations concerning the transport and processing of agricultural production, for which part of the afore mentioned material is intended. With regard to this, it is often mentioned that tractors spend some 60 % of their time on operations which strictly speaking come under transport. The importance of storing and processing crops is understated. Post-harvesting losses often account for up to 1/5 of the harvest, and this holds for countries where cropping operations are inefficient. It should also be noted that the use of animal proteins (milk in particular) is restricted given the lack of effective control over transport and processing operations. These latter, in our opinion, have not met with the interest that they deserve on the behalf of the major manufacturers (cf. table 19).

* These percentages refer to post-harvesting losses, unless stated otherwise. Although the figures mostly refer to specific crops, they are sufficiently eloquent to highlight the problem of food losses in general.
Source : FAO.

Table 19: Evaluated losses in some countries

Country		Losses		Reference
		Percentage *	Value	
Nigeria	Sorghum	46 41		Colon. Res. Publ. 1952, No 12.40
United States	Stored grain		500 million	Metcalf R.L. Destructive and useful insects 1962 p. 41-43
	Wrapped foodstuffs		150 million	
	All crops		3,500 million	
India	All crops			C.F.T.R.I. Res. and Ind. Conf. CSIR New Delhi, 1965
	Losses in the fields	25		
	Losses in stores	15		
	Losses in handling and processing	17		
	Miscellaneous	3		
W. Germany	Harvested cereals		77.4 million D.M.	Frey, W. Flaughbatt, Biol Bundesanstalt 1951, No 5 8
Sierra Leone	Rice	41		Colon. Res. Stud. 1959, No 2852
	Maize	14		Tech. Rep. W. Afr. Stores Prod. les Unit, 1962, [illegible] 13
Tropical Africa	All crops (storage and handling)			FAO Informal Work Bull. 24, 1964

Each of the operations which we have just described represents a real or potential field of activity for the agricultural machinery industry, and consequently a market. However, we should insist on the following facts :

– these markets do not all have the same technical **complementarity** with the other markets. Thus, the power mechanization of land-clearing operations may be compatible with the continuation of essentially manual-type agriculture as far as what can properly be called agricultural production is concerned.

– these markets do not all have the same **renewal rate**. Bulldozers, tractors, conveyors will have a life-span of between 4 and 7 years, simple tractor-drawn machinery and hand-tools will last longer. The material used in order to equip the farmstead will have an even longer depreciation period (8 to 20 years).

– these markets do not all have the same **solvency**. Investment in material is only meaningful if it steadily facilitates the accumulation of capital. The solvency of a market dominated by manual-type agriculture will not be the same as that of a market which has already gone through various stages of power mechanization, or which is substantially aided by public authorities (development operations in land-clearing or irrigation).

– these markets do not all have the same **technical homogeneity**. It is difficult to combine, in land-clearing operations, the use of the bulldozer and hand-tools. This combination is more easily attainable in intensive agricultural production where use of the tractor (deep-tilling and ploughing operations, preparation of seed beds) at the same time as hand-tools (hoeing, crop maintenance) is not only possible but desirable.

Lastly, on each of these markets, the adoption and adaptation of dominant techniques to the agricultural conditions obtaining in the country do not take the same form.

Confronted with this problem, the agricultural machinery industry has been pushed into imposing a single mechanization model. It was then decided (with more or less success) to work upstream (development and equipment operations) and downstream (production processing operations) the same technical schema derived from the restrictions on industrial production. In many cases, however, such a policy had the following results :

– it accentuated the accumulation of technical goods in agriculture and thus compromised the solvency of the agricultural market.

– it created technical incoherencies between the various operations, and resulted in an agricultural productivity which was far from being in keeping with the investments which had been necessary.

– it caused the agricultural machinery industry to lose certain markets : threat on the transport industry from car firms ; the development operations were taken over by the building and public works sector ; the extension of the chemicals sector into building (silo), crop protection (herbicides of course, but also cultivation on polyethylene films, etc...), and in general into intensive agriculture.

The expansion of the agricultural machinery sector would then seem to involve the reestablishment of a multiform power mechanization model which would be better adapted :

– to the heterogeneous nature of agricultural demand ;

– to the various possible combinations of capital goods and intermediate consumptions (fertilizers ; herbicides ; seeds) emanating from the chemicals industry and agronomical research work ; combinations which fully justify mechanization.

1.2. THE INTERNATIONAL MARKET IN AGRICULTURAL CAPITAL GOODS

The international market in agricultural capital goods is composed of three main categories of goods :

– agricultural machinery

– tractors

– other capital goods

Roughly speaking, we may consider that there are two main markets :

– that of the industrialized countries which is marked by an increase in the demand for capital goods such as self-propelled machines, specialized farm machines, engines and irrigation material. Tractor sales however have reached their maximum ;

– that of the developing countries where the demand for tractors is quite clearly greater than that for other categories of goods.

In 1969, the value of world trade in mechanical and metallurgic products amounted to 76,000 M. U.S. $. Within this global sum, 32,000 M. $ correspond to non-electric goods. Trade in agricultural machines and material accounts for 5,600 million U.S. $, i.e. 20 % of world-trade in non-electric machines.

Of the 2,600 million dollars which correspond to world trade in agricultural machines : tractor trade represents 50 %, soil preparation equipment 40 %, and other machines 10 %.

What is more, it has been calculated that the value of world trade in pumps and centrifuges amounts to 1,900 million U.S. $, engines to 471 million U.S. $ machines for building and public works to 587 M. $.

Exports of agricultural machines and utensils to the developing countries reach, in 1969, the following values : African countries : 127 million U.S. $, Latin American countries : 297 million U.S. $, Asian and Middle East countries : 184 million U.S. $.

The market in the developing countries accounts for only 23 % of world trade in agricultural machines and tools. Tractor imports in each region account for about 70 to 80 % of trade in agricultural machinery, but only 32 % of world trade in tractors.

Table 20 : Relative importance of the agricultural machinery market in the international capital goods market (Source : ONUDI)

	1967		1975	
	(1)	%	(1)	%
Total machinery non electric	32,078 M.	41.9	101,810	42.3
Total electrical machinery	14,135	18.5	46,398	19.3
Total transport equipment	28,842	39.8	88,776	36.9
Agricultural machinery	5,843	7.6	19,210	7.9
Overall TOTAL	76,378		240,220	

Table 21 : The relative importance of the various categories of equipment intended for agriculture in the international capital goods market

	1967		1975	
		%		%
Agricultural machinery	2,257	49.9	8,803	45.8
Pumps, centrifuges	1,537	34.0	6,688	34.8
Other internal combustion engines	367	8.1	1,439	7.4
Land development machinery	418	9.2	2,272	11.8
TOTAL	4,518		19,210	

(Source : ONUDI)

In 1975, the overall value (in current U.S. $) of world trade in capital goods had tripled, and amounted to 240 million $. The share of agricultural machines and material still represented one fifth of the total of machinery non-electric exchanged on the world market.

On a world level, of the 8,808 M. U.S. $ which correspond to the trade in what can properly be called agricultural machinery, the sales in tractors account for a little less than 50 %, and machinery sales for about 40 %.

Sales in material for agricultural use such as pumps, engines, and heavy equipment are about 25 % more than sales in material specifically for agricultural use.

With a time lag of seven years (1), the astonishing stability in the sales structure should be analyzed.

The world figures tend to hide the existence of two realities : that of the markets in the developed countries where trade in agricultural machinery predominates, and that of the markets in the developing countries where tractors predominate.

(1) Unless, of course, this stability is due to the applying of one and the same technical coefficient to all the statistical series concerning agricultural machinery

Table 22 : Exports of agricultural-machinery and utensils to the under-developed countries (millions of $).

	1969	1975
Africa	127	553
Latin America	297	937
Asia and Middle East	184	340 523

Table 23 : Share of exports from the O.E.C.D. absorbed by each developing zone

in %	Africa	Latin America	Asia	Total Developing Countries
1957	16.0	59.0	25.0	100
1961	18.7	54.9	26 4	100
1967	18.9	38.1	43.0	100
1971	22.2	42.4	35.4	100

The relative share of demand from under-developed countries in the overall demand for capital goods for agricultural use has increased by 2 % in 7 years (23 % in 1969 ; 25 % in 1975). This indicates, simply taking into account the overall figures (cf. tables 22 to 24) :

– that the main part of the goods exchanged are exchanged within the framework of the markets of the industrialized countries ;

– that, at the present progression rate, these markets in the under-developed countries globally represent as yet, for the developed countries, a limited outlet for certain products. Their expansion has been less rapid than expected ;

– that heavy mechanization on a tractor and machine basis corresponds to the satisfaction of immediate needs (food crops necessary for town supplies, crops for export). This is the schema which is developing in the oil-producing countries of Latin America and the Middle East ;

– that light mechanization on a pump and machine basis corresponds to the necessity of equipping intensive-type farming zones ;

– that the setting up of manufacturing programmes in the under-developed countries may explain the falling off in demand on the international market for certain continents (Latin America, Asia).

1.2.0. Trends registered on the international market of capital goods for agriculture

Given the preceding data, the following questions should be answered :

– is the existing technical model in the developed countries copied directly by the developing countries. If so, for what goods and under what conditions does this copying take place ?

— Is world trade in agricultural goods and machines vital for the main manufacturing countries, and in what way have they adapted themselves to new trade conditions on the world market ?

— Are the world markets less partitioned than in the past, thus promising more favorable trade conditions for the Third World ? Does this lead to changes in the commodities which are exchanged ?

A. World trade : a reflexion of the priority given to tractorization

World trade between the industrialized countries and the Third World is still marked by the dominance of heavy tractorization. Tractor purchases account for three-quarters of the overall purchases of the developing countries in agricultural material. Despite the increase in prices over the last few years, there is a sustained demand which rose by 40 % in volume between 1974 and 1976.

If we consider the main trade flows between the exporting countries (U.S.A., U.K., France, W. Germany, Belgium and Japan) on the one hand (1), and the importing countries of the Third World on the other hand, we notice :

1. A considerable increase in volume of the demand from the Middle East countries (sales have doubled) over the last two years (137 %), and to a lesser extent, a perceptible increase in the Far East countries (+ 42 %). The disposable funds drawn from the increase in the price of oil have enabled them to cater for initial equipment programmes. However, this demand has settled in Latin American countries, and has fallen off in African countries.

2. A shift in demand towards upper range tractors. Exports of tractors of less than 35 h.p. have been decreasing over the last two years, whereas exports increase by 134 % for tractors of 35 to 100 h.p. (2). The international market in walking tractors has increased only in the Far East, and is now an activity of little im, rtance if account is taken of estimates in terms of value.

3. There has been a perceptible decrease in demand on almost all continents — except the Middle East — for large scale machinery. This is an indirect indication of a general slowing down of major agricultural equipment programmes.

(1) These countries cover about 80 % of exports.
(2) FAO - Agricultural Engineering Services, quoted by O'Callaghan.

Table 24 : Exports of tractors by seven industrialized countries (in thousands of units)

Source : FAO

	Hand tractors numbers			Wheel tractors numbers			Crawler tractors numbers			Total tractors numbers		
	1974	1976	change	1974	1976	change	1974	1976	change	1974	1976	change
Developing	9,529	10,788	13.2	57,783	94,860	69.2	15,165	11,120	-26.7	82,477	116,768	[illegible]
Latin America	1,663	1,337	-19.6	16,586	19,088	15.1	5,668	4,716	-16.8	23,917	25,141	5.1
Near East	4,410	5,233	18.7	14,213	40,234	183.1	1,556	2,363	51.9	20,179	47,830	137.0
Far East	3,184	4,085	28.3	14,838	26,798	80.6	5,736	2,902	-49.4	23,758	33,785	42.2
Africa	272	133	-51.1	12,146	8,740	-28.1	2,205	1,139	-48.3	14,623	10,012	-31.5
Devel ped	153,456	197,982	29.0	231,942	253,575	9.3	13,279	9,229	-30.5	398,677	460,786	15.6
Not Specified	1,089	9,731	---	7,029	11,565	---	404	1,933	---	8,522	23,229	---
Total	164,074	218,501	33.2	296,754	360,000	21.3	28,848	22,282	-22.8	489,676	600,783	22.7

1/ United States, U.K., France, Federal Republic of Germany, Italy, Belgium and Japan.

Diagram 1 : Exports of tractors from the O.E.C.D. countries to the developing countries
(Source : OCDE)

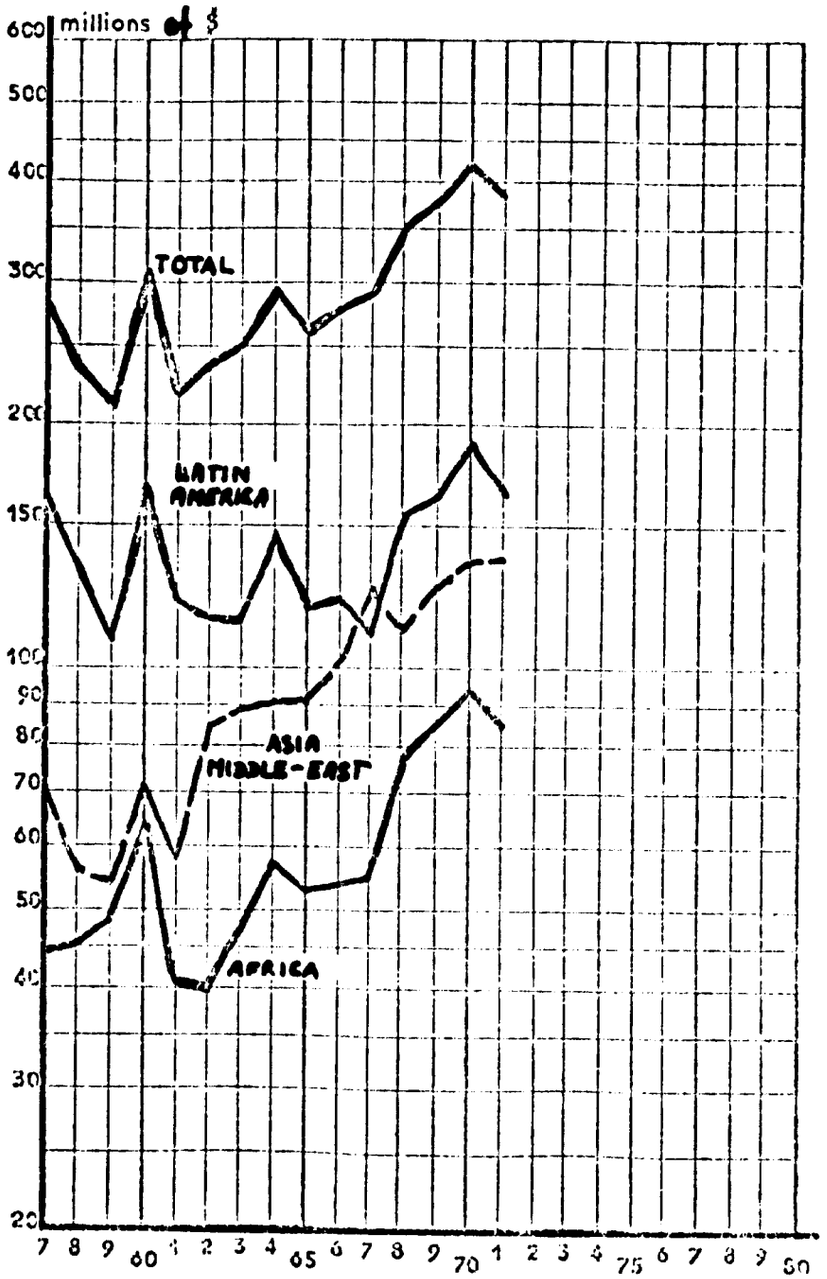


Diagram 2 : The main agricultural machinery exporting countries
(Source : OCDE)

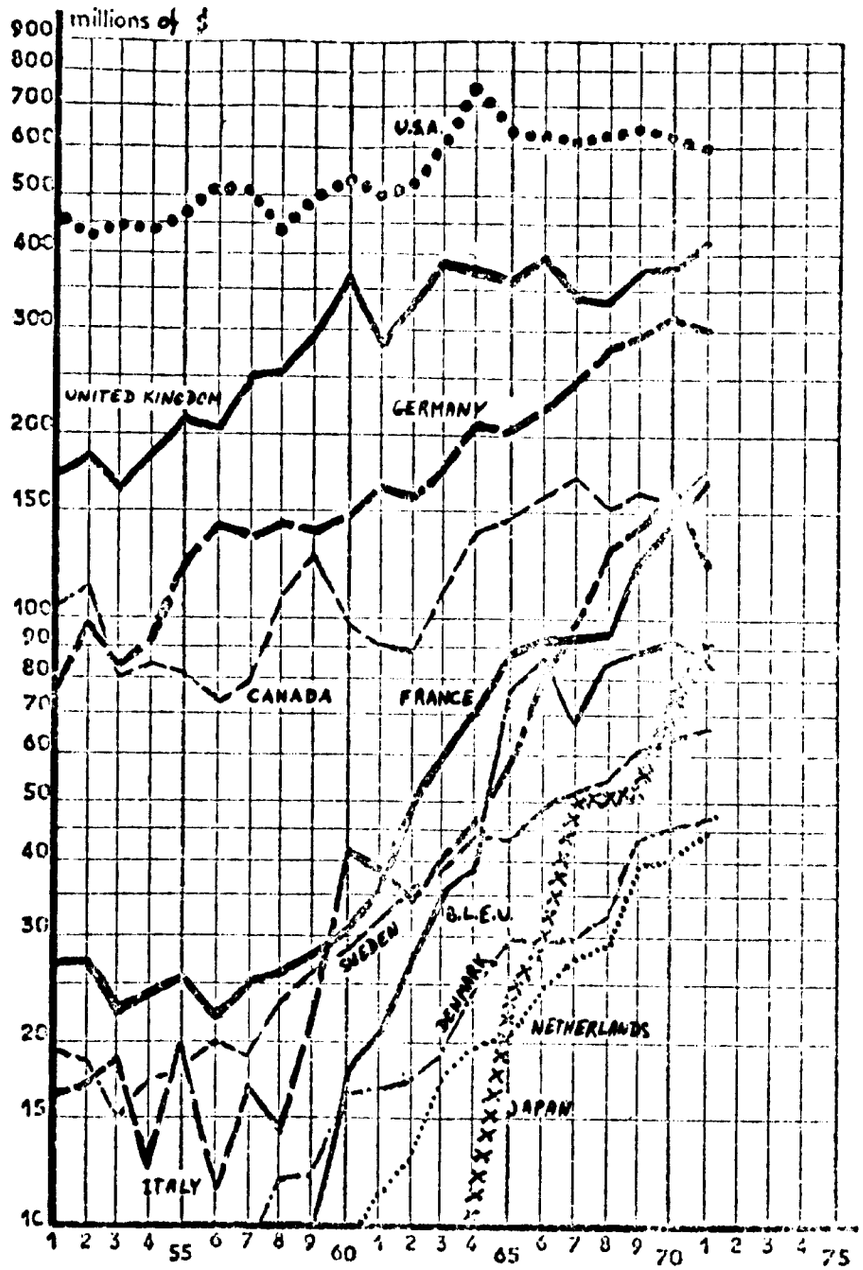
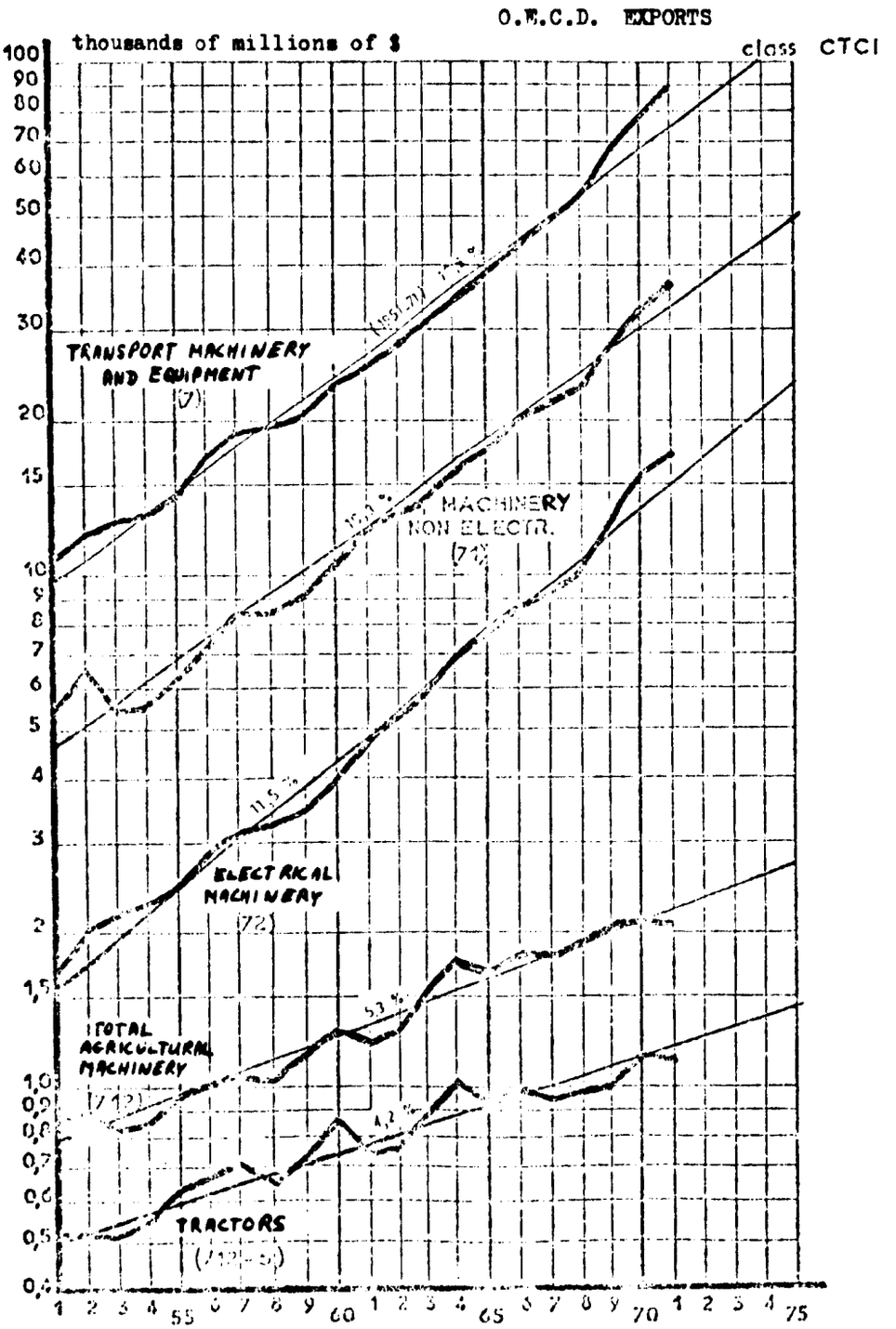


Diagram 3 : Exports of different categories of engineering goods from the countries of the O.E.C.D.
(Source : OCDE)



4. The adoption of a technical model which hinges on imports of high power machines corresponidons, in the importing countries, to the urgency of resolving problems of agricultural and food production.

B. The development of new trade flows

For the time being, these can only be seen as tendencies which do not counter the more pronounced trends which have been registered in world trade statistics. These tendencies are formulated here as hypothesis. The first of these do correspond to tangible realities :

– the appearance of new manufacturing countries on the world market is quite evident. The Eastern European countries, which have long been present in certain countries of the Third World, have now extended their audience to the traditionally exporting countries (imports of Czechoslovovakian or Russian tractors in W. Europe and even in the U.S.A.).

Certain countries Japan in particular, have made their mark on the production of single-axle tractors whose use is being generalized in those countries which have intensive farming in the Far East.

Tractor manufacturing plants belonging to the main world manufacturers are shifting towards the new markets : shift of manufacturers from Northern Europe towards Southern Europe (Italy, Spain, Portugal, Greece, Turkey).

Such tendencies are changing the traditional trade flows.

– The development of national industries producing capital goods for agriculture in the under-developed countries may help to revive inter-regional markets. The variability of

these industries requires the rapid growth of their outlets. Apart from those countries which have a large home market (India, Pakistan, Argentina, Brazil, Mexico...) construction policy involves the development of trade between the under-developed countries (development of South-South trade ; integration zones ; industrial co-production agreements). It would be unfortunate if the manufacturing countries of the Third World were obliged to find their outlets in the developed countries.

– The adoption and generalization of new farming techniques, bringing in their wake different industrial lines of production (falling mainly into technical levels 1 and 2) could bring about an increase in South-South trade between the developing countries.

1.2.1. Outlets and trade in agricultural capital goods in the industrialized countries : is the market for agricultural machinery becoming saturated in the industrialized countries ?

For almost twenty-five years now for the Western European countries and Japan, more than forty years for the U.S.A. and Canada, the modernization of agriculture has brought about a continual movement of substitution of capital for labour. Up until 1965-70 for the former countries, and 1955-60 for the latter, the home markets gave them a growing outlet for agricultural machines and tractors. This phase of steady growth of the market was followed by a second phase, in which renewal operations are more important than extension operations (cf. tables 25–26).

In many cases and for many products, the period from 1960 to 1965 was the golden age for agricultural machinery sales in the industrialized countries. From this time onwards, tractor sales even off and then fall (1). The number of milking machines falls in some countries, although continues to increase in other countries (France and the Soviet Union for example).

The market, despite the fall in the number of buyers, continues to grow, however, inasmuch as :

– old machines tend to be replaced by perfected models, which give a better performance but which are also more costly.

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(1) This does not mean that the firms profits fall since the margin of profit is often greater on upper range machines than on low power machines.

Tableau 24. a.

a) Developing Countries - Exports of Agricultural Machinery in 1974

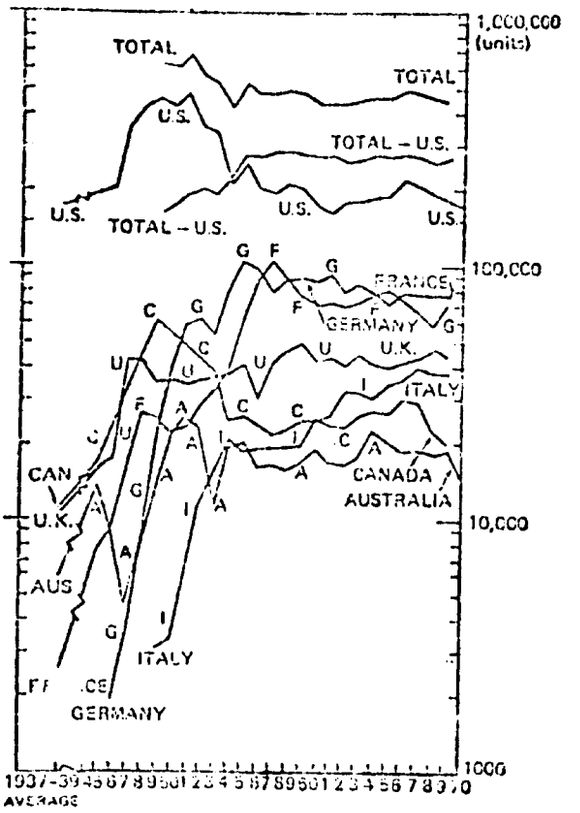
Total Market Economies	5,424,971	
Developing countries		88,203
Major developing countries:		
Latin America:		
Argentina	40,735	
Brazil	22,662	
Colombia	2,013	
Mexico	2,805	
Venezuela	149	
Africa:		
Moroco	390	
Asia:		
India	2,991	
Iran	2,048	
Korea, Rep. of	816	
Pakistan	814	
Philippines	119	
Singapore (from Jan. to Sep.)	598	
Turkey	1,838	

b) Developing Countries - Major Exports of Agricultural Machinery in 1974

	Exports to: developed countries	(in %)	Exports to: developing countries	(in %)
Argentina:	South Africa	0.6	Africa	6.6
	Others	0.2	Latin America	92.6
	Total	0.8	Total	99.2
Brazil:	South Africa	1.3	Africa	3.2
	U.S.A. & Puerto Rico	1.5	Latin America	92.3
	Oceania	0.7	Asia	1.0
	Total	3.5	Total	96.5
India:	few (information n.a.)	6.0	Africa	25.3
			Asia	68.7
	Total	6.0	Total	94.0
Iran:	none	---	Asia	100.0
	Total	---	Total	100.0
Mexico:	U.S.A. & Puerto Rico	54.9	Latin America	36.9
	Oceania	4.1	Asia	4.5
	Total	59.0	Total	41.0
Turkey:	none	---	Asia	100.0
	Total	---	Total	100.0

Source: Statistical Papers; Commodity Trade Statistics according to the Standard International Trade Classification, Department of Economic and Social Affairs, United Nations, New York, 1974.

Table 25 : Maximum tractor demand in the industrialized countries
(Source : Calculations made by Kurdle cf. supra (op. cit.))



Sources:

Total Demand: Estimate of the Ford Motor Company cited in Barber, *Report*, p. 19.

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Canada: U.N., *European Tractor Industry;* Dominion Bureau of Statistics, *Farm Implement and Equipment Sales* (Ottawa: Queen's Printer), various annual issues.

U.K.: U.N., *European Tractor Industry;* A.J. Rayner, *An Econometric Analysis of the Demand for Farm Tractors;* the U.K. Ministry of Transport.

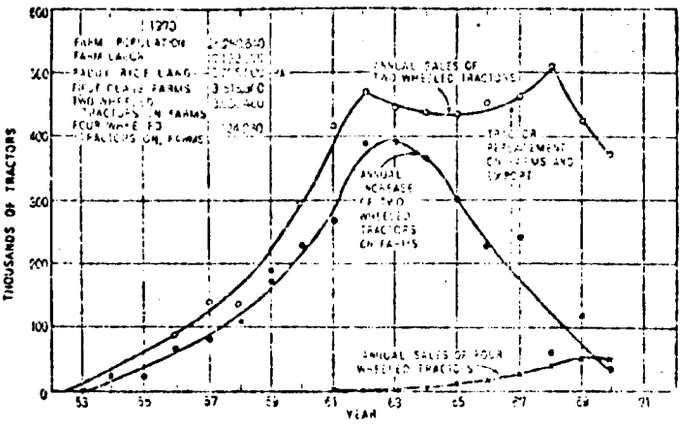
France: Linneman, "U.S. Tractor Industry;" p. 40; Syndicat, *L'Industrie des Tracteurs;* C.N.E.E.M.A., *Bulletin d'Information*, various annual issues.

Germany: *Landtechnik*, October, 1961, p. 653; U.N., *European Tractor Industry*, p. 34; *FIMR*, June 1, 1966, p. 851; *Landmaschinen Markt*, various issues (giving official registration statistics from the Statistisches Bundesamt since 1956).

Italy: *La Meccanizzazione Agricola*, various years, and *AAJ* May, 1968, p. 10.

Australia: Linneman, "U.S. Tractor Industry," pp. 103-110; Commonwealth Bureau of Census and Statistics, *Rural Industries*, various annual issues.

Table 26 : Tractorization of Japanese agriculture
(Source : Farm Machinery Year book of Japan)



– labour costs tend to rise more rapidly than machinery costs ;

– agricultural machinery has entered onto markets on which it was absent, particularly the animal production market ;

– the agricultural policies of most industrialized countries have contributed to both greater investments and greater medium-term debts for agricultural producers (credit policies).

At the present time, the experts state (1) that " the fact that family agriculture is steadily adapting to the labour capacities of correctly employed modern material should bring in its wake a numerical reduction of the instruments in service, which will probably be compensated, at the level of annual requirements in machinery, by a larger average unit size of equipment, by more rapid renewal of equipment – which itself is implied by more intensive use – and by the technology of the mechanisms in practice becoming steadily more sophisticated. Under these conditions, it can be said that agriculture and agricultural machinery have entered into a phase of reciprocal adaptation which could extend over a period of 10 to 20 years, and result, here and there, in imbalances and sudden starts".

It is without a doubt, however, that the agricultural machinery industry, in the years to come, will continue to find its main outlets in the industrialized countries.

It is nonetheless necessary to insist on the contradictions associated with the generalization of heavy mechanization.

(1) Bulletin d'Information du CNEEMA, May 1972, quoted in " Tendances actuelles et prévisibles de la mécanisation et leurs effets sur l'agriculture en Europe ". Commission Économique pour l'Europe.

1. The relationship between forms of equipment and the narrowing of the market

Although the number of tractors sold has been falling steadily for several years now, the total power of tractor equipment continues to increase. Agricultural machinery and capital goods in general are proportionally able to cope with greater and greater quantities. The technical sophistication and the growing specialization of the equipment make it possible to satisfy the new norms as far speed and the elaboration of products are concerned. Similarly, the new situation created by the decrease in the available labour force in agriculture can be coped with. It is possible in this way to renew periodically the range of mechanical goods offered to farmers.

In the sphere of tractors alone, we may quote the following figures : in the U.S.A., the average power of new tractors has moved from 27 h.p. in 1950 to 42 h.p. in 1970 ; in France, the average power per tractor sold in 1960 was 26.5 h.p. and more than 56 h.p. in 1973 (whereas the average power of the tractors in service was only 35.6 h.p. in 1970) ; in the Soviet Union the average power of tractors moved from 36.4 h.p. in 1952 to 64.3 h.p. in 1972.

The investment costs demanded of the farmer grow in relation to the sophistication and capacities of the machine. The renewal of the pool of capital goods based on the same technique should therefore be related to the falling number of potential users, and therefore the number of buyers. In other words, the diffusion of high capacity agricultural material involves the grouping together or restructuration of agricultural production units.

For some years now, the sales of farm tractors on Western markets have fallen perceptibly (cf. table 27).

Table 27 : **Tractors in service in the U.S.A. and W. Europe**
(Source : FAO, *Production Yearbook*)

	No of millions		Annual yearly percentage increase	
	United States of America	**Western Europe**	**United States of America**	**Western Europe**
1950	3.39	0.88	–	–
1955	4.34	1.91	5.1	23.4
1960	4.69	3.13	1.6	12.8
1965	4.76	4.34	0.4	7.7
	4.80	5.16	0.1	4.7
	4.79	5.40	– 0.2	4.7
1976	4.38	6.40	– 0.15	2.7

There is thus an evident contradiction between the sales policies of the major manufacturers (1), which tend to change their models constantly in order to renew the market and the consequences of this on the demand market which must be steadily narrowing if it is to use the material offered at its full capacity.

2. Part of these contradictions are resolved by the overequipping of farmsteads. Thus the generalization of the shift to power mechanization in agriculture helps to reinforce the heavy industry character of modern agriculture.

However, the rythm of accumulation is tending at present to slow down for most agricultural capital goods (cf. table 28).

Table 28 : Farming equipment in industrialized countries (1950-1973)
(Source : Communauté Economique Européenne)

	1950	1960	1970	1973
Number of tractors (/100 ha of arable land)				
E.E.C. (nine countries)	2.6	3.5	4.3	4.7
E. Germany	0.7	1.5	3.2	3.6
U.S.S.R.	0.3	0.5	0.9	1.5
U.S.A.	2.0	2.5	2.7	2.4
Number of A.p. (/100 ha of arable land)				
E.E.C. (nine countries)	–	68.7	144.7	166
E. Germany	–	50.2	145.5	160
U.S.S.R.	10.2	22.8	55.9	72
Number of combine harvesters (/100 ha of cereals)				
E.E.C. (six countries)		0.6	1.6	–
E.E.C. (nine countries)	–	0.9	1.7	–
France	0.1	0.6	1.4	–
W. Germany	–	1.1	3.2	–
G.B.	–	1.8	1.8	–
Number of milking machines (/100 dairy cattle)				
E.E.C. (six countries)	–	–	5.1	–
E.E.C. (nine countries)	–	–	–	–
France	0.6	1.8	3.9	–
Germany	0.1	5.3	9.3	–
G.B.	–	4.0	3.2	–

(1) We will see that part of these contradictions will be resolved by the financing facilities offered by the State to agricultural producers. The policy of credit for agriculture is an important factor in determining industrial policies.

Indeed, it seems that the growth rate of the gross fixed capital formation (cf. table 29) (in particular of machinery) has been too rapid compared with that of the use of the intermediate consumptions (fertilizers, seeds, herbicides) which allow them to be used to the full. In the future, it seems that the full use of agricultural machinery will depend most of all on the technical improvement of these consumptions, and from then on, on ensuring that the gross fixed capital formation expenditure is proportional to that on intermediate consumptions.

This is the only way the registered relative over-equipment in agriculture will not, through a brutal increase in production costs, have repercussions on the prices of agricultural products.

Table 29 : Gross capital coefficients in 1970 : the French case
(Source : BAC (1959 francs))

1. *Agriculture :*
   - Fixed capital coefficient : 2.1
   - Capital coefficient including livestock and land capital : 9.2
2. *Agricultural and food industries :* 1.6
3. *Electricity :* 8.3
4. *Iron and Steel Industry :* 3.7
5. *Electrical and Mechanical engineering industries :* 1.4
6. *Commerce :* 1.2
7. *Branches taken as a whole :* 1.8

3. Equipment, debts, the slowing down of agricultural demand in the industrialized countries

The relative overequipping which has been remarked in the developed countries has three main causes : the fact that the models offered by the manufacturers change very rapidly, this phenomenon corresponding to changes in agricultural production techniques ; the growing specialization of machines, whose price increases in relation to their degree of sophistication, and which, in a period of constant technical breakthroughs, are in use over shorter and shorter periods of time ; the credit facilities offered by credit establishments and by the manufacturers themselves.

This overequipping at a farmstead level is indicated by :

- the growing number of different machines whose presence is not always justified by the effective use which is made of them. According to certain studies which have been

made, the rate of use of tractor capacities in W. Germany was about 51 % in 1951, and by 1965, was no more than 41-42 % ;

– the inability to cope with overall expenditure and to choose the most suitable equipment at the best time ;

– an increase in production costs and a falling off in productivity. These elements tend to put a break on agricultural demand for machines and tractors inasmuch as the increase in production costs cannot always be transferred onto the prices of agricultural products.

This slowing down of agricultural demand is all the more important since each new generation of agricultural machinery – giving a better technical performance – is more costly. It is all the more costly given that the number of potential buyers is decreasing and the number of sellers (manufacturing firms), liable to design and commercialize this machinery, is also decreasing.

We can see in most industrialized agricultures a certain slowing down of the demand for equipment. In these conditions, the opening up of a new market on which an exact transfer seems possible – at least initially and for a certain type of agriculture – is an important element for the major manufacturing firms.

1.2.2. The market in the developing countries : expansion of and obstacles to demand

A. The demand from Third World countries for agricultural capital goods accounts for between 1/4 and 1/3, according to which category is taken into account, of the production of the industrialized countries. This demand however would seem to be fundamental to the reconversion or expansion strategies of the major manufacturing countries.

The demand from the developing countries is growing rapidly with regard to categories of goods for which the demand in the developed countries is now stagnant.

The developing countries' demand for capital goods does not involve any technical changes. The manufacturing technology is already known. Research costs are largely covered.

The developing countries' demand on the world markets concerns mainly the upper range of machines, which thus allows a widening of this market and a relative lowering of manufacturing costs.

The demand of the under-developed countries, mainly based on tractorization, may in the longer term have a multiplying effect on the sales of tractor-drawn equipment, and may make easier the shift to sales of self-propelled machines.

This additional demand which at present is addressed to the manufacturing countries is however limited :

– by the solvency of these countries. It is not fortuitous that the only countries to considerably increase their demand are the oil producing countries.

– to the solution of the most urgent agricultural and food problems.

– by the growth of indirect costs caused by the adoption of heavy mechanization.

– by the development of local manufacture.

For the immediate future, the demand for capital goods expressed by the under-developed countries seems able to resolve certain outlet problems for the developed countries. But do not the very characteristics of this demand contain certain obstacles ?

These obstacles are mainly due to the costs associated with the transfer of techniques by imitation.

The introduction of the dominant technical model in the developing countries is in fact accompanied by additional costs due to :

(i) *insufficient production and use of intermediate consumptions.* The insufficient use of fertilizers and seeds brings about a drop in output, and means that the capacities of the machines used by the farmers are under-exploited.

(ii) *the maintenance costs.* These costs are greater in the under-developed countries, and this is all the more so since the production conditions are not those for which the machines were designed (cf. table 30).

(iii) the depreciation conditions which are linked to the way the equipment is used on difficult ground, but also to the deficiencies of the after-sale services. Overall, there is a reduction of the useful life of the equipment and an increase in the costs of using it (cf. table 31).

Table 30 : Useful life of agricultural equipment in developed and under-developed countries
(Source : American Society of Agricultural Engineers)

Machinery	Data based on U.S. Conditions		Data suggested for developing countries	
	Year to obsolete or worn out	Useful life (hr)	Year to obsolete or worn out	Useful life (hr)
Wheel Tractor	12	12 000	7–8	7 000
Crawler	12	12 000	9–10	8 000
Hold Board Plow	15	2 500	10	1 600
Disk Plow	15	2 500	10	1 600
Disk Harrow	15	2 500	10	1 600
Cultivator	12	2 500	8	1 600
Grain Drill	15	1 200	10	800
Row Crop Planter	15	1 200	10	800
Combine Harvester	10	2 000	7–8	1 500
Mower	10	2 000	7–8	1 500
Field Chopper	10	2 000	7–8	1 500
Hay Baler	10	2 000	7–8	1 500

Table 31 : An evaluation of maintenance costs : comparison between developed and under-developed countries
(Source : American Society of agricultural Engineers)

Machinery	Repair & Maintenance Cost in % of new cost (Average per 100 hr of use)	
	Data collected by A.S.A.E. (U.S. Condition)	Data suggested for developing countries
Wheel Tractor	2.0–3.0	4.0–5.0
Crawler Tractor	2.0–3.0	4.0–5.0
Hold Board Plow	7.0	8.0–9.0
Disk Plow	4.5	5.5–6.5
Disk Harrow	6.5	7.5–8.5
Cultivator	4.5	5.5–6.5
Grain Drill	8.0	9.0–10.0
Row Crop Planter	7.0	8.0–9.0
Combine Harvester	4.5	5.5–6.5
Mower	12.0	13.0–14.0
Field Chopper	2.9	3.9–4.9
Hay Baler	3.1	4.1–5.1

More generally, the diffusion of the dominant technical model comes up against three obstacles :

— a technical deadlock, which prevents the application of the dominant technical model, due to the available farming area (state of land-ownership structures) ;

— an economic deadlock associated with the fall in productivity of the equipment which is used ;

— a financial dead-lock due to the immobilization costs for technical goods.

It is without a doubt, that the market for agricultural machinery in the developing countries is nonetheless an expanding market. Demand is steadily increasing. The farming areas yet to be mechanized are substantial in size. The irksome nature of labour in the conditions obtaining in these countries justifies the introduction of machinery. The urgent nature of the needs to be met with regard to agricultural production, particularly in order to cope with the rapid increase in urban demand, is the best justification of the technical model adopted up until the present time. The potential dynamic demand from the under-developed countries is making itself felt in an overall context which is hardly favorable to the manufacturing firms of the developed countries (with the evening off of demand in the developed countries). This is a circumstance which should be taken into account in the process of international negotiation.

1.2.3. Some elements for a reflexion on agricultural machinery estimates

The forecast of demand on agricultural machinery is particularly complex. The history of forecasts established during the previous decades prompts, on the whole, circonspection.

The problem of envisaging industrialization prospectives from now on to the year 2000 which is to be faced and which has a particular importance to UNIDO is that of industrialization perspectives from now to the year 2000 , and therefore has not only quantivative but also a qualitative aspect. It bears on the uncertainty regarding the types of equipment to be manufactured.

Under these circumstances, it is understood that extrapolations established in the form of linear projections are of little interest.

However, as an indication, and on the basis of the information contained in tables 4 and 5 the results of these calculations have been quoted on diagrams 4 and 5. It is therefore necessary to resort to more elaborated methodologies (see diagrams 4 and 5).

Amongst the work which has been carried out on machinery requirement estimates, we should draw attention that carried out by the FAO :

– for the Indicative World Plan (cf. table 32), the value of mechanical equipment to be produced was estimated for 1985 on the basis of a progression rate of 5 % a year from 1962 onwards.

The evaluation were made on the basis of the estimated figures for the world tractor park, distinguishing renewal of equipment from what can properly be called creation of new equipment. (table 33–34) On this basis (reference year 1962) estimates concerning the investment necessary between the various categories of goods were put forward. For 1985, according to these proposals, it would seem that the major share of investments (outwith Africa) will go towards power-mechanized equipment (95 % for Latin America ; 79 % for the Middle East ; 72 % for Asia) (cf. table 35).

Diagram 4 : Extrapolation of tractor production on the basis of the growth rates registered since 1960

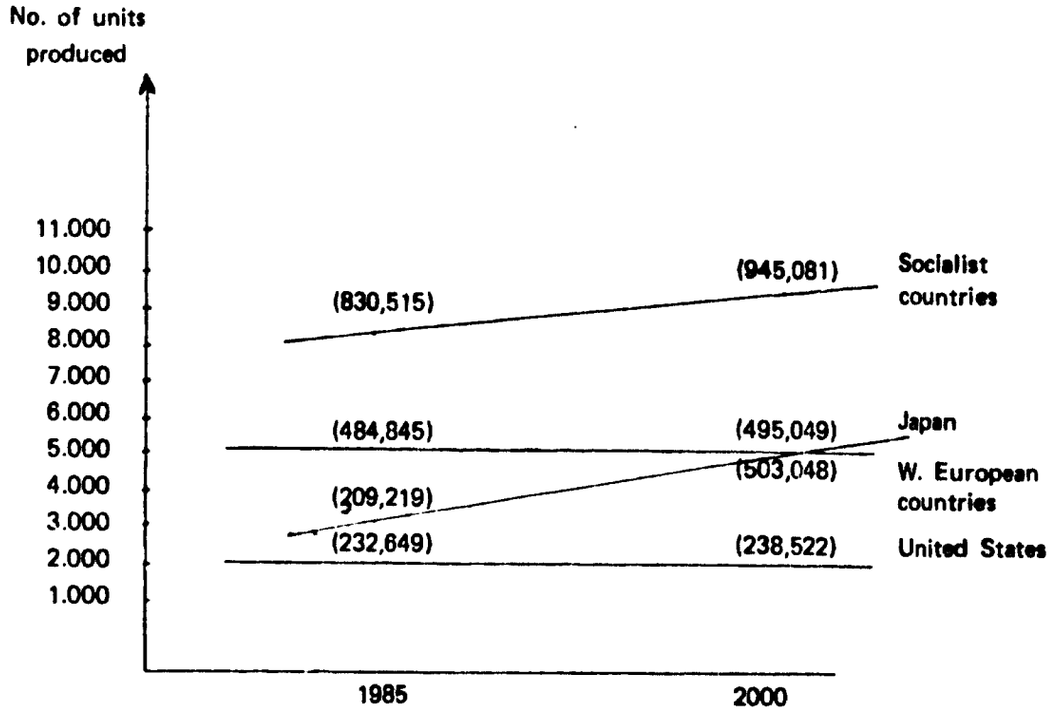
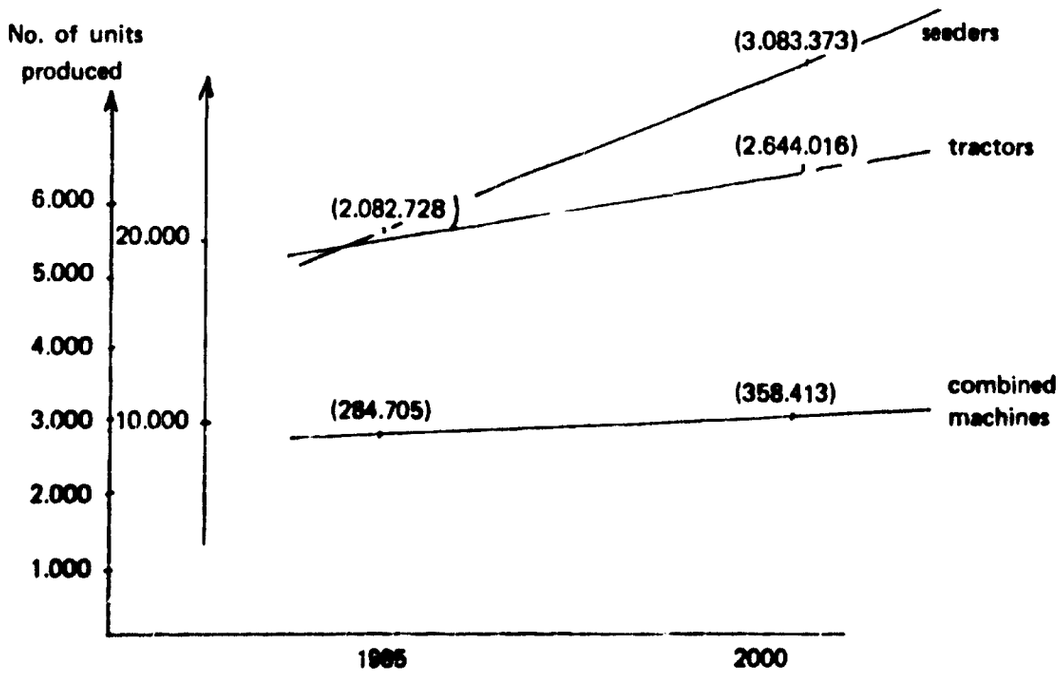


Diagram 5 : Extrapolation of machine production on the basis of growth rates recorded since 1960



– for studies on a country by country basis (at the present time there exist studies for 20 countries), and for a more global study which is at present being carried out dealing with the world food requirements for the year 2000. The estimation methods have considerably changed. This methodology, apart from the fact that it avoids the statistical imprecisions associated with our present knowledge of agricultural machinery production, gives a first priority to demand, and thus tends, by the use of a priority objective (the satisfaction of food requirements), towards an elucidation of agricultural machinery requirements. Given the demands of food production, and the conditions under which this production can be carried out, it is then a question of determining for a set of intermediate years (1980 ; 1985 ; 1990 ; 2000) what will be the requirements in power-mechanized equipment (requirements which are reduced to a typical category of equipment : the 65 h.p. tractor). **These works are in progress (table 32-36).**

1. An evaluation based on the generalization of the mechanization models existing in the developed countries

This tendency to give priority to the heavy power mechanization model nonetheless leads us to ask the question whether the developing countries have the concrete possibility of implementing the model.

To have some idea of what the generalization of this model involves, as far as the capital accumulation to be realized is concerned, we may use two types of evaluation :

(i) an evaluation based on the generalization of a mechanization model of the extensive type (U.S.A.) or the intensive type (Western Europe).

(ii) an evaluation based on what degree of equipment must be obtained in order to attain the objective of " **catching** up " in the field of power mechanization.

Two types of data are used in order to make this evaluation :

– data concerning the farming areas which are not power mechanized (cf. tables 1-2) in the world, i.e. 3,600 million hectars.

– data concerning the equipment of industrialized agricultures in terms of machines. For 1970, we have at our disposal the estimates made by the O.E.C.D. (cf. table 36) for most of the industrialized countries. These are average figures and are a poor indication of the diversity of agricultural productive systems (and therefore of the amount of investment necessary

Table 32 : Value of agricultural inputs in 1962 and levels proposed for 1985
(Source : Provisional study for Plan Indicatif Mondial)

	Fertilizers		Seeds		Irrigation		Crop protection		Mechanization (1)		Total inputs		Percentage of inputs in relation to production	
	1962*	1985	1962*	1985	1962*	1985	1962*	1985	1962*	1985	1962*	1985	1962*	1985
Africa south of Sahara	14.2	180.4	295.0	412.1	–	–	13.6	309.0	27.0	101.2	349.8	1002.7	6.4	9.1
Asia	335.0	5130.9	388.6	1258.7	750.7	1186.0	20.4	1215.8	200.9	1153.9	2175.6	9995.3	9.8	18.9
Latin America (2)	218.3	1861.3	276.4	355.7	479.6	896.9	110.0	397.2	438.5	1031.6	1522.8	4542.9	17.1	25.7
Near East (3)	78.7	470.7	108.1	145.7	264.4	350.8	25.0	116.4	36.7	117.3	512.9	1200.9	18.6	19.2
North Africa	16.0	145.0	51.4	72.1	–	–	11.0	38.5	94.0	206.0	174.4	461.6	20.3	25.2
Total for these regions	664.2	7838.3	1599.5	2244.3	1494.7	2433.7	180.0	2076.9	797.1	2610.2	4735.5	17203.4	11.8	19.2

Growth rate of value of inputs from 1962 to 1985

Annual percentage

	Fertilizers	Seeds	Irrigation	Crop protection	Mechanization	Total inputs
Africa south of Sahara	11.7	1.5	–	14.5	5.9	4.7
Asia	12.6	1.6	2.0	19.4	7.9	6.9
Latin America (2)	9.8	1.1	2.8	5.7	3.8	4.9
Near East (3)	8.1	1.3	1.2	6.9	5.2	3.8
North Africa	11.0	1.7	–	6.5	4.0	5.0
Total for these regions	11.3	1.5	2.1	11.2	5.3	5.8

(1) A certain quantity is also used for animal husbandry.
(2) South America only.
(3) 10 countries only, not including Kuwait and the Arab Republic of Yemen.

Table 33 : Number of tractors proposed (according to the provisional study of the I.W.P.)

	Number of tractors				
	Estimates	Proposals		Growth rates	
	1965	1975	1985	1965-75	1975-85
Latin America	376 000	570 000	810 000	4.3 %	3.6 %
Near East	35 000	71 000	117 000	7.3 %	5.1 %
North West Africa	36 000	49 000	65 000	3.1 %	2.9 %
Asia					
two wheel	19 000	109 000	700 000	19.1 %	20.0 %
four wheel	85 000	200 000	970 000	12.5 %	13.2 %
Africa south of Sahara	22 000	35 000	56 000	4.8 %	4.8 %

Table 34:
Proposed rate of annual tractor supply

	1965	1975			1985		
	Estimated total	As replace-ments	Proposed increase	Total	As replace-ments	Proposed increase	Total
Latin America	43 000	43 000	23 000	66 000	66 000	27 000	93 000
Near East	5 000	6 000	5 000	11 000	11 000	6 000	17 000
Asia							
two wheel	3 500	6 000	26 000	32 000	43 000	167 000	210 000
four wheel	16 000	17 000	36 000	53 000	55 000	130 000	185 000
Africa south of Sahara	4 000	6 000	2 000	8 000	9 000	3 000	12 000
North West Africa	3 000	3 000	4 000	7 000	7 000	1 000	8 000
Total two wheel	3 500	6 000	26 000	32 000	43 000	167 000	210 000
four wheel	71 000	75 000	70 000	145 000	148 000	167 000	315 000

We have only indicated two wheel tractor figures for Asia, since they are of little importance elsewhere.

Table 35 : Estimate of investments in 1962 and proposals for 1975 and 1985
(Source : Provisional study for the I.W.P.)

A - Animal draught equipment and hand tools (not including the cost of draught animals)

B - Power mechanized equipment (tractors, equipment for tractors, combine harvester, etc.)

	1962		1975		1985	
	Value Millions of dollars	Percentage in relation to total investment	Value Millions of dollars	Percentage in relation to total investment	Value Millions of dollars	Percentage in relation to total investment
Africa (south of Sahara)						
A - Animal draught equipment	60	70	75	60	90	55
B - Power mechanized equipment	25	30	50	40	75	45
Total investments	85		125		165	
Latin America (1)						
A - Animal draught equipment	115	20	80	10	50	5
B - Power mechanized equipment	435	80	720	90	1050	95
Total investments	550		800		1100	
Near East						
A - Animal draught equipment	25	36	30	26	35	21
B - Power mechanized equipment	45	64	85	74	135	79
Total investments	70		115		170	
Asia						
A - Animal draught equipment	425	86	483	59	545	28
B - Power mechanized equipment	70	14	340	41	1415	72
Total investments	495		825		1960	

The estimates concerning animal draught equipment in Latin America have been revised upwards since we now consider that the original estimates indicated in the provisional regional study on South America were too low.

Table 36 : Agricultural capital according to categories of possessions in farmsteads using accounts of commercial farmsteads - Value per hectar

Source: O.E.C.D.

Country	Average surface area of farmsteads (hectars) [b]	Value per hectar in U.S. dollars								% of total possessions	
		Real Estate			Capital goods				Total capital		
		Land	Buildings	Total	Livestock	Machines and équip.	Other possessions [c]	Total		Real Estate	Capital goods
Canada	207	296		296	34	50	26	110	406	73	27
U.S.A.	212	349	87	436		125		125	561	78	22
Norway	13	270	344	614	238	209	76	523	1,137	54	46
Finland	19	235	261	496	94	166	72	332	828	60	40
Sweden [d]	17	900		900	159	125	408	692	1,592	57	43
Denmark	20	623	1,016	1,639	280	167	15	462	2,101	78	22
U.K.	68	1,126		1,126	163	120	69	352	1,578	76	24
Eire	16	590		590	159	36	27	222	812	73	27
Netherlands [e]	16	2,356		2,356	583	226	80	889	3,245	72	28
Belgium	11	6,190		6,190		1,270		1,270	7,460	83	17
Luxemburg	20	1,647	405	2,052	297	270	81	648	2,700	76	24
France [e]	24	756		756		607		607	1,363	55 [f]	45
Germany [f]	10	1,055		1,055	372	383	304	1,059	2,114	50 [f]	50
Austria [f]	16	527	568	1,095	108	281	111	500	1,595	69 [f]	31
Switzerland [f]	16	1,045	1049	2,094	542	384	283	1,209	3,303	63	37
Italy	7	1,186		1,186	168	107	141	416	1,602	73	27
Greece [e]	3,3	1,867	128	1,995	220	101	-	321	2,316	86	14
Japan	1,1	5,440	974	6,414	201	348	495	1,044	7,458	86	14

a) Data for last avaible year (generally 1967 or 1968 except for France and tne Netherlands for which we have used 1965 data.

b) Arable land and grassland only

c) This includes mainly crops and supplies stored on the farmstead, till money and various possessions

d) For Sweden, the values of real estate are based on tax evaluations

e) The data concerning these countries are obtained on the basis of global national data

f) The data concerning these countries do not reflect current market values. The values for these countries are based on the agricultural productive value on the land: thus, the values of the real estate expressed in percentages of total possessions would be higher of the market value was taken into account.

according to which system is used). However, we can make the following overall distinctions :

- an extensive farming system with a low rate of equipment per hectar (1),
- an intensive farming system with a high rate of equipment per hectar (2).

On the basis of a generalization of these two marked types of model, we can make two evaluations :

- generalization of the mechanization model : in the case of extensive farming : investment to be realized : 450 thousand million dollars.

- generalization of the mechanization model : in the case of intensive farming (value of the equipment is 10 times greater than that of extensive farming = 4,500 thousand million dollars.

2. An evaluation based on the objective of " catching up " in the field of equipment

It is considered that there is not, in this case, an identical reproduction of the mechanization model existing in the developed countries. However, this model is implicitly taken as a reference, since it is stated that there is a close correlation between the growth of agricultural production and the increased use of power mechanization. Thus, it has been calculated that in Europe there is 0.93 h.p. and in the U.S.A. 1.02 h.p. per hectar of arable land and areas occupied by permanent crops. In developing areas, the power from all sources (human, animal and mechanical) is estimated at 0.05 h.p. only per hectar in Africa, 0.19 h.p. in Asia and 0.27 h.p. in Latin America (3). It is considered that " at least 0.50 h.p. are necessary in order to attain full utilization and thus obtaining high outputs, whereas extra labour force and draught animals can only help in a very small way to bridge the gap between available power and future requirements ".

This objective of " catching up " nonetheless involves multiplying by 10 for Africa, by 2.5 for Asia, and by 2 for Latin America the energy capacities used in agriculture. In order to attain this objective, the tractorization model plays an important part.

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(1) U.S. model : 5 % of the working population work in agriculture ; the average farmstead 45-220 ha ; orientations : cereals, livestock (data 1970).

(2) Belgian model : 5 % of the working population work in agriculture ; the average farmstead 13 ha ; orientations : horticulture, industrial crops (data 1970).

(3) Hall (C.W.) Principles of agricultural mechanization in developing countries, 1973.

On the basis of an average production cost of 150 U.S. $ per tractor / h.p. it will thus be necessary to immobilize about 180 thousand million dollars in order to equip agriculture with the necessary power.

These evaluations lead us to express four sets of observations :

(i) Despite their imprecise nature, the difference between the two initial evaluations varies from 1 to 10 according to which productive system is taken as a reference ; from 1 to 3 for the lowest evaluations. The evaluations of capital to be immobilized give a concrete idea of the financial side of the option for a type of mechanization : heavy power mechanization. Thus they give food for thought in the developing countries as to what priorities should be given to the various sectors of production.

(ii) The sums involved (but also the imprecise nature of the evaluations) make it necessary to consider :

- that a single power mechanization model cannot be transposed in an exact fashion to the developing countries as a whole, but rather that, from now on, it will be necessary to think in terms of mechanization strategies which will match the requirements (determinations of priority objectives) but also the industrial and financial capacities of these countries.

- that mechanization strategies necessitate more precision concerning :

- the after-effects brought about by the mechanization of agriculture (effects on food production but also effects on industrial production) ;

- the combinations of different types of mechanical and power-mechanized equipment ;

- the stages of generalization of power mechanization ;

- the environment (after-sale service ; staff training ; chain of industrial sub-contractors) in which the diffusion of the power mechanization model is to be carried out.

(iii) The generalization of the power mechanization model also leads on to the question of the relation between the adoption of this model and its ability to allow for an increasing accumulation of the technical goods used in agricultural activity.

The mechanization strategies which are adopted must enable either directly (increase in agricultural productivity) or indirectly (state intervention) a labour-using activity to be transformed into a capital-using activity, or they must reinforce the " heavy industry " character of modern agricultures.

(iv) The option taken in favour of power mechanization undoubtedly has repercussions of the employment structure. In what is mainly a development option decided on by the country under consideration, we should take account of :

– the relations between mechanization strategies and agricultural employment, knowing that according to the strategy adopted there may be diminution, maintenance or increase of agricultural employment ;

– the relations between mechanization strategies and effects on rural employment (creation, adaptation, maintenance) ;

– the relations between mechanization strategies and economic growth, or the relations between the destruction of agricultural employments and the creation of industrial and service employments (absorption capacity).

CHAPTER II

THE AGRICULTURAL DEMAND FOR PRODUCTS OF THE AGRICULTURAL MECHANIZATION INDUSTRY

(a methodological essay in the evaluation and forecasting of the needs of agriculture in the developing countries)

21. The present relationships between the agricultural mechanization industry and the mechanization of agriculture

210. Logically any machine or implement which increases work efficiency may increase productivity of the relevant factors, production, and with all other factors remaining equal, earnings : mechanization is the best path to follow in agricultural development.

Still, it has to be shown that mechanization is possible and that the proper conditions can be created so that work is performed more efficiently. There are, however, numerous anecdotes which show that these conditions are not automatically fulfilled.

Depending on the soil type and climate in each natural region, a given tractor will be too heavy or too light ; additional equipment required for the full range of services is not always available ; lack of logically available parts and specialists result in equipment being out of service for long periods after the very smallest breakdown. If equipment is out of service at a decisive moment in the seasonal schedule, the results of whole seasons may be endangered. The tractor rusts at the end of the plot, while it is sometimes impossible to return to pre-mechanization technology.

As a result there is not always an increase in production under average conditions. Nor is there a sufficient increase in earnings to amortize the equipment purchased : even if industry has increased its outlets, agriculture has not resolved its own problems. Even if theory indicates that mechanization in indispensable, in practice its efficiency is neither automatic or spontaneous.

On the basis of these internal criticisms of the agricultural sector, more and more authors question the advisability of mechanizing agriculture in the numerous less developed countries :

i. Should agriculture be mechanized when 283 million out of 700 million people are unemployed or underemployed (80% in rural areas)?

ii. Should risks be taken which may increase the degradation of traditional systems of production? Especially when these systems have contributed, at least partially, to feeding the population even before mechanized productive systems got off the ground? Between 1970 and 1976 cereal imports for less developed nations, as a group, increased from 20 million to 60 million tons.

The chain of events that result from mechanization can be described in this manner : "less breeding, less manure, fewer men, lowered employment, less protein, agrarian reform increases the proportion of the rural population without land and without work"(1).

iii. Is mechanization the only solution or the first step in agricultural development, taking into account its cost and the low investment potential in these countries? The right to use western technology in all sectors amounts to 3 to 5 milliards per year (2). The foreign debt of less developed countries is growing larger and larger. In Brazil, for example, just the amortization of this debt equals half of the value of the country's exports.

Representatives of government, industry and mechanized agriculture, in developed as well as less developed countries are questioning the role and procedures of mechanization. This concern is revealed in three question that are at the core of any experience in mechanizing agriculture :

i. What is the function of mechanization in agrarian reform?

ii. What has been its role in the Great Revolution?

iii. What progress is being made on the ideas expressed by the appropriate technology movement?

211. Agrarian reforms and mechanization

The basic and rather expansive objective of agrarian reform is the correction of unequal land distribution between large and small land holders. Depending on existing social and political conditions, and the degree of resistance offered by large land holders, there are various levels of equalization and rates of realization. Widely varying legal conditions govern the private appropriation of land, collectivization of land use or any combination of these possibilities.

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1) AIT AMARA "Aspects socio-économiques de la problematique de la réforme agraire" I.T.P.E.A., Algiers, 1974

2) Jacques CHONCHOL "Evolution des Rapports entre Pays du Tiers-Monde et Pays Industriel" Economie et Humanisme - January 1977. Also see the work done by CNUCED.

In this context, and most often in cases of socialistic or cooperative agrarian reforms visualising large production collectives, agrarian policy is accompanied by a policy of mechanization. Such is the case in agrarian reform in Algeria and, in a different sense, the agrarian reforms in Tunisia and Morocco. Mechanization is then considered more as the sum of technical means accompanying the agrarian policy than as a dynamic set of processes that can be influenced by the technical aspects of social and economic factors. These processes have as much chance of being positive as negative, depending on the context in which they develop.

In the most evolved experiments in agrarian reforms that favour the development of mechanization, there is general agreement on the advantages that can be defined :

i. Mechanization makes it easier to work the soil and harvest crops. A larger area can be cultivated, more even ploughing can be obtained, weed control is intensified, manure and green manure are better utilised, certain work (ploughing, sowing, harvest) can be accomplished in short periods of time when weather conditions demand, work concentration points and bottlenecks are eliminated more easily. The reduction in work time makes it possible to increase the number of crops per season or to change systems of production to require a larger labour force. According to local conditions, the tractor makes it possible either to cultivate more land, or to intensify activity on the same overall area. It sometimes makes it possible to use technology that is not accessible when using traditional production systems and techniques. Wider spread use of tractors does not necessarily imply a reduction in the agricultural work force.

ii. Agricultural mechanization also covers related operations which arise in connection with farming : bringing new land under cultivation (land clearing, stump removal, levelling, drainage etc..). As uncertain as figures are in this domain, more than 200 million hectares can be brought under cultivation in the less developed countries.

The same is true for all incoming and outgoing transportation of agricultural produce. Paramechanization of these operations results in large gains in productivity, often accompanied by an increase in quantity through loss reduction.

Finally this is also true for the preparation of agricultural products on farms or in villages (mills, saws, hoists, etc..). These factors affect the quality of the product as much as the overall productivity.

iii. Lastly, mechanization of irrigation deserves special mention because it justifies a significant extension of paramechanization in this field (1).

With no intention of implying that the use of motor pumps excludes the use of tractors or vice versa, it should be stressed that irrigation equipment offers the same advantages as a tractor, but at a lower price : increasing irrigated areas around each well, irrigation of high and previously inaccessible areas, increasing production and the number of farm activities. The latter makes it possible to increase the labour force and improve the breakdown of work time throughout the year.

In this manner mechanization, using a tractor or paramechanization of irrigation, can simultaneously improve the operations involved in pre-existing production techniques and systems, and make it possible to carry out new operations. In the first case the increase in productivity and proportional liberation of the labour force will only result in increased unemployment if there is no local possibility for extending the activities. However in the second case, it is precisely through mechanization (putting new land under cultivation by irrigation) that an extension of the area under cultivation or intensification and diversification of agricultural production can be envisioned.

The principal theoretical arguments for mechanization thereby contain the limitations involved in its use : the advantages can only be derived if the engines work and if the economic, social and political conditions are combined in such a way so as to effectively obtain the potential positive effects.

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1) According to the Central Electricity Authority of New Delhi India, the number of motor pumps has multiplied 25 times in 15 years.

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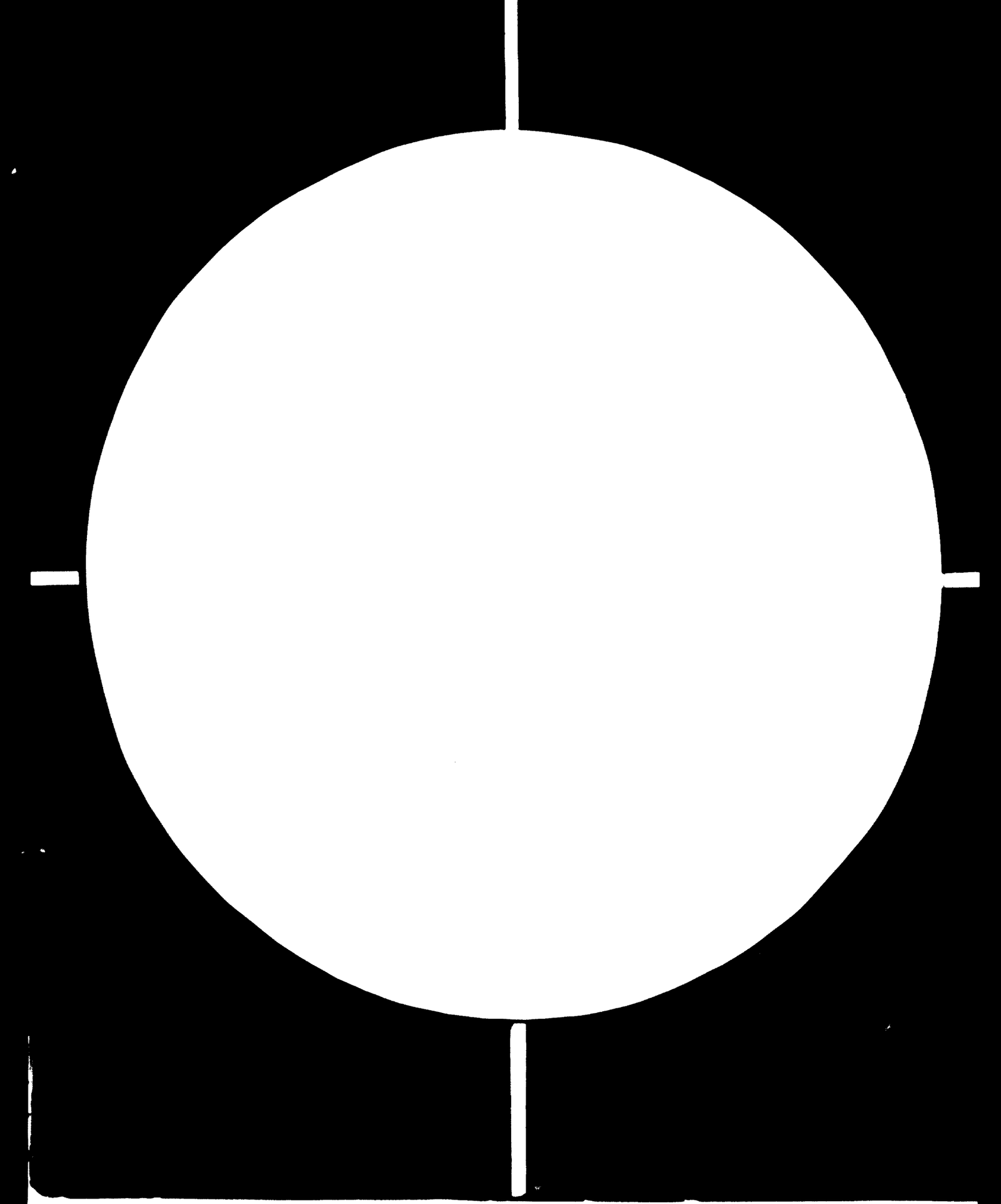

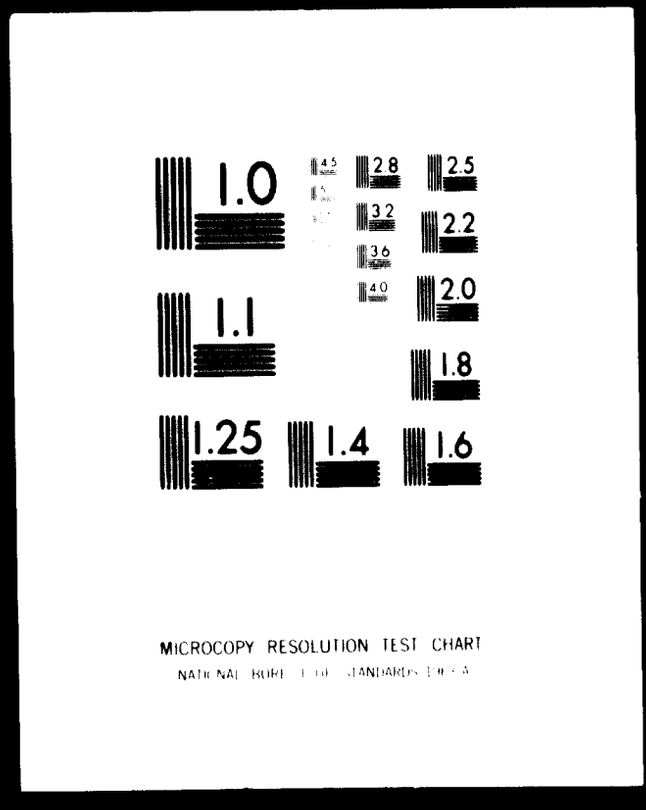

The logical result is that mechanization produces more positive results in collective or cooperative farm production. The institutional environment is better able to valorize production and resources and employment is simultaneously increased.

In this manner forecasts of future demands strongly depend on forecasts of developments in the political structures of less developed countries : those with socialist agrarian reforms are potentially the best clients for manufacturers of agricultural machinery(1). However this only indicates a tendency which is also influenced by the solvability and particular characteristics of each country. Along with political developments, the social system considerably influences the present state of mechanization. This has been shown by the experience of the Green Revolution.

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(1) See tables 10 to 13 in chapter I

212. Green Revolution and mechanization

There is a paradox in the analysis of mechanization in the developments in the Green Revolution : an important aspect in its technical orientation is the use of biotechnical innovations rather than relying on mecanotechnical factors. Cultivation of high yield varieties makes it possible to obtain 50 to 300% yield increases while fast growing varieties make it possible to increase the number of crops per year. This should lead to increased employment. The latter is estimated at 60% by some observers.

On the other hand, the highly divisible nature of the necessary intermediate items (seeds, fertilizer and pesticides) makes the application of the techniques relatively insensitive to scale economics. A number of studies report that productivity of relevant factors is greater on small family farms than on larger more well-to-do farms that use seasonal salaried labour if needed. This could lead us to think that small farmsteads would benefit from this new technology as much as the more well-to-do farmers : this would thus make it possible to avoid the social and political costs of land redistribution, as well as the high cost of mechanization. In addition the latter can only produce the same results if it is rapidly set up on a massive scale.

Today most observers agree that there has been a slowing down in the Green Revolution : all easily irrigable areas and potential farmland has been put to use, the increase in yields has reached a ceiling.

Increased petroleum prices have led to the need for the intermediate items required for high yield varieties. More serious problems, which could transform this orientation, have increased these difficulties. At the basic level these difficulties are not in contradiction with the advantages of this technological orientation.

Setting up the Green Revolution implies, besides overconfidence in technical competence, the need for increased capital : it is thought that the changeover from traditional systems in India to setting up a complete programme of high yield varieties would increase capital requirements from $ 9 to $ 200. In addition the increased yields become much more

dependent on water, and land requirements increase in proportion to the land area needed to amortize a well. In this manner the land and farming capital makes it necessary to take into account the scale economics, and it is well established that the more well-to-do farmers can make better use of new technology. It should be mentioned that there are urban property owners who have the farms cultivated for speculative purposes with these new techniques. The development of the Green Revolution has lead to changes in the social structure that imply the relative impoverishment of small farm owners. They do not have sufficient financial means to make use of current advances in technology.

This makes it possible to understand the harsh judgement as progress in South-east Asia on the Green Revolution has reached the ceiling with no gain in dry land agriculture, no overall gain in agricultural earnings and no better distribution of earnings. The population has continued to grow and per capita cereal production is lower since the beginning of the Green Revolution.

As in other domains, profound changes in agriculture can not only be based on an homogeneous set of technical innovations, no matter how justified the orientation. In the very least can it be said that these techniques will have enabled some number of small farms to be maintained that could not otherwise be maintained? On the other hand and paradoxical to the technological spirit of the Green Revolution, the development of tractor purchases by well-to-do land owners must be emphasized. This may result from the pressure of the demonstration effect or to avoid the necessity of hiring a salaried employee. In the Punjab, the machine for worker substitution rate is predicted (2) to be on the order of 17.4% for 1983-84, thereby eliminating 146 million workdays. More than half of this substitution involves tractors and irrigation installations, and more than a third involves harvesters and threshers. Other studies made in the same region predict that mechanisation results in a 50% reduction in the population used per unit of land area.

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1) See the second 10-year report of the Asian Development bank, "Rural Asia : challenge and opportunity" see a report in Le Monde Diplomatique, January 1978, also see Gary Kenwood, Asie, l'impasse Agricole" in l'Economiste du Tiers Monde, March-April 1977

2) According to a study cited by Z.M. AHMAD in "Les Conséquences Sociales et économique de la Révolution Verte en Asie" Revue Internationale du Travail, January 1972.

Thus, the Green Revolution will paradoxically boost mechanisation, contrary to the initial technological orientation but in harmony with the social context in which it developed. Here once again the size of the increasing demand on the agricultural machinery industry largely results from the social and political conditions which came into being. It would be risky to guess the continuation of the tendencies recorded without making certain that new categories of farmers have access to the economic and financial means needed for mechanization : it is necessary to emphatically state that demand in mechani ation is based on the previous level of accumulation realized by a farmer within the existing economic, social and political conditions.

The partial success of the Green Revolution has among other factors boosted the discussion of appropriate technologies. At least this has emphasized the necessity of another sort of mechanization for the whole set of less developed countries.

213. Appropriate technology and mechanization

Everyone is forced to agree that this current of opinion which has developed over recent years results from various acknowledgements of failures recorded in different forms of agricultural modernization, and that the ideas established in opposition to these experiences do not yet present a synthesis of sufficiently wide range. When we speak of soft, intermediate alternative, progressive technology, or technology based on replacement or on appropriate measures, the very diversity of the titles shows that the ideas are not better established than the language in which they are expressed.

The concept of "intermediate technology is so general that it contributes very little ; isn't every technology intermediate at a given moment in that it falls between the previous and the following technology? Is not this concept additionally dangerous if it leads one to believe that there is a linear continuity between traditional and modern technology? And how can the leaders of less developed countries be convinced that an intermediate technology is not necessarily a regressive technology in relation to the technical level existing in more highly developed countries?

More or less often ornamented with the prefix "bio" or "eco", soft or low impact technologies emphasize the ecological aspects of the technology problem. The appeal is made that world opinion awake to the seriousness of effects in consideration of the fact that the non-awareness of the dynamics of ecological cycles could weigh heavily on economic growth.

Non-reproduction of eco-systems is forbidden. Special consideration is given to renewable resources and energy, with waste being used; the utilisation of housing and production is encouraged to correspond to these objectives. In addition, considering every social system as an integrated part of its eco-system, all forms of human energy, participation, initiatives, etc. are encouraged in self-development strategies(1) that take into account the specific social, economic and cultural handicaps of each "eco-region".

In fact the examples of technology adapted to ecological conditions could be multiplied. They are inexpensive and simple to set into operation, attesting to the efficiency of a technological current that is in direct conflict with the dominating current. Hand or animal-drawn equipment, for example costs 20 to 40 times less than paramechanized farming. Mountainous islands with permanent winds ascending and descending daily, are not all equipped with windmills for irrigation or energy production, although they could be. The same is true for arid, sunny regions which are not systematically equipped with solar motor pumps. Finally the inventory is yet to be made of the whole ranges of technical innovations developed in non-western societies and not yet blocked culturally by the demonstration effect.

No matter how realistic, useful and often economic this orientation is for establishing new criteria in technological decisions, the various countries take into account both the restrictions inherent in using this orientation in the international economy and the objectives of their own national policy. Soft technology does not necessarily create jobs, and if a policy of large projects is necessary, it will not be a small impact policy.

With the adequation of their most closely applied sphere (ecological and social in the largest sense), the criteria for technological choices should also be appropriate to each country's economic conditions and political decisions : thus we could ask if the spread of tractors in India, during the continuation of the Green Revolution is appropriate to the overall conditions in the country or to a political-economic option of maximizing new employment when such a spread of tractors is appropriate to the economic and social conditions or well-to-do farmers?

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1) See the work of I. SACHS and the CIRED.

In this manner it could be said that the term "appropriate" could have too broad a meaning which hardly brings us to better forecasts of future technology ; in fact it refers us back, country by country, region by region to precise and specific ecological and social conditions, to the whole set of restrictions and objectives which are inherently unpredictable. Subsequent summation by groups of countries hides the profound tendencies which actually motivate and explain the future.

214. The lessons to be learned from past experiences in mechanization

It is clear that mechani ation interacts with a large number of variables. Mechani ation experiences linked to agrarian reform emphasize the instutional aspects and the necessity to coordinate mechanization activity with the activities of land capital, technical supervision, and product marketing. The experience of the Green Revolution shows to what point a given technological orientation can be distorted by socio-political conditions. The objective of mechani ation, through increasing productivity, was to increase and equalize levels of existence. In fact it more often reinforced the economic positions of the more well-to-do farmers and contributed to the reproduction of the original social system. Logically the purchase of machinery requires prior accumulation of financial means which are justified by a later increase in earnings. In fact, however, under the most frequently encountered conditions of use, the increase in earnings will not be sufficient to reimburse the tractor and will be even less able to guarantee subsequent steps in the accumulation of capital.

As for any reservations regarding the appropriateness of techniques used in mechanized agriculture, none lead to any form of global proposition. This is because, by definition, these reservations refer one back to precise and specific situations. What remains is that the totality of appropriate technology is defined more by a technological research orientation than by results. It is fundamentally opposed (most often) to the dominant "western" techniques on the world market. The latter with their particular principles of work economy and high capital consumption are not very appropriate. Appropriate technology in developing countries frequently is, or should be, alternative to dominant western techniques.

The question must be posed as to the appropriate character of mechanized agriculture on the world scale in relation to the need of farmers in most developed countries. How can an industry built on the specific needs of western agricultural and economic systems, based on various technological orientations and on objectives formulated in terms of different economic policies offer solutions to the present demands of less developed agriculture? In this regard the role of the tractor of the development of European agricultural mechanization has no doubt been exagerated, isolated from associated factors : technical popularization, inter action of business management calculations, and especially the development of non-agricultural employment which encouraged the exodus from farms and increased the need for mechanization. It is, therefore, not necessarily adequate to return to machines used in the mechanization of European agriculture : if a low powered, versatile and sturdy tractor could correspond to present needs in certain precise circumstances, it is not certain that agricultural mechanization in less developed countries should always start with tractor distribution, nor of this particular type of tractor.

It is a fact that perspective outlets for the agricultural machine industry exist at the present time, these perspectives are limited to that minority of financially solvent farmers who can purchase machines. The true perspective of this industry's future is completely confused : everything takes place as though the potential users and buyers of existing agricultural machinery have already been studied, and the machines modified, better adapted, produced according to a new design. In this manner the offer greatly predetermines the demand. On the contrary, offer must be adapted to demand. This means determining as nearly as possible the machines and equipment which offer the greatest possibility for traditional farmers to make a large and effective increase in resources and earnings. Also making it possible for the strategist of agricultural mechanization to establish a chronological and educational order as each step is being prepared, organizing and securing financing for the following steps. This is in the true interest of the mechanization industry. The production of machines and materials that facilitate the mechanization of the majority of traditional farmers opens the perspective of much larger outlets than those offered by farmers capable of using products that are presently available in developed economies.

Adapting machine offer to agricultural demand also signifies that the best path growth in mechanization is not necessarily that which, at each stage, tends to resemble the dominant technological model in developed countries. Rather, the best path growth would be that which, step-by-step, offered the largest gains in efficiency and emphasizes production operations as defined on the basis of the particular characteristics of each region. This would make it possible to increase the accumulation rate. In one area light paramechanization and irrigation would be more important than the proliferation of tractors, in another area heavy land-clearing machinery would be necessary to put new areas under cultivation.

22. Toward a method of evaluating agricultural machinery needs

Emphasis must be placed on the fact that those products and strategies in mechanized agriculture that are adapted, appropriate, are necessarily products and strategies that respond to the real needs of agriculture. If, up to now, the mechanization of developing agriculture consisted of using products derived from and conceived for developed agriculture, then it is impossible to extrapolate this tendency and to define appropriate objectives. However, if requirements are not analyzed it is impossible to evaluate the discrepancy between what is hoped for and what is actually taking place.

Yet, if it is not completely insufficient to define objectives by using ongoing experiences, an evaluation of real needs even rudimentary, is indispensable. It soon becomes obvious that these needs are related, on one hand, to the possibilities and production objections assigned to the type of farming and, on the other hand, to the possibilities and production of objectives assigned to industry in each country.

Requirements in agricultural machinery do not make up a whole in itself, autonomous : the link between need and demand for machinery is therefore neither simple nor automatic. Correspondingly, evaluation of the demand requires an active evaluation taking into account the whole set of data as well as the whole set of possible choices in mechanization. Such a method thus becomes a means, in each country, to analyze machinery demand, to adapt it in some measure, and to make certain from period to period that it remains appropriate to needs.

221. Taking into account agricultural machinery demands

The preceding makes it clear that a definition of mechanization requirements for developing agriculture is found both at the interface of the particular ecological, sociological and economic conditions for each homogeneous region and in the orientations of economic policy as decided by the state.

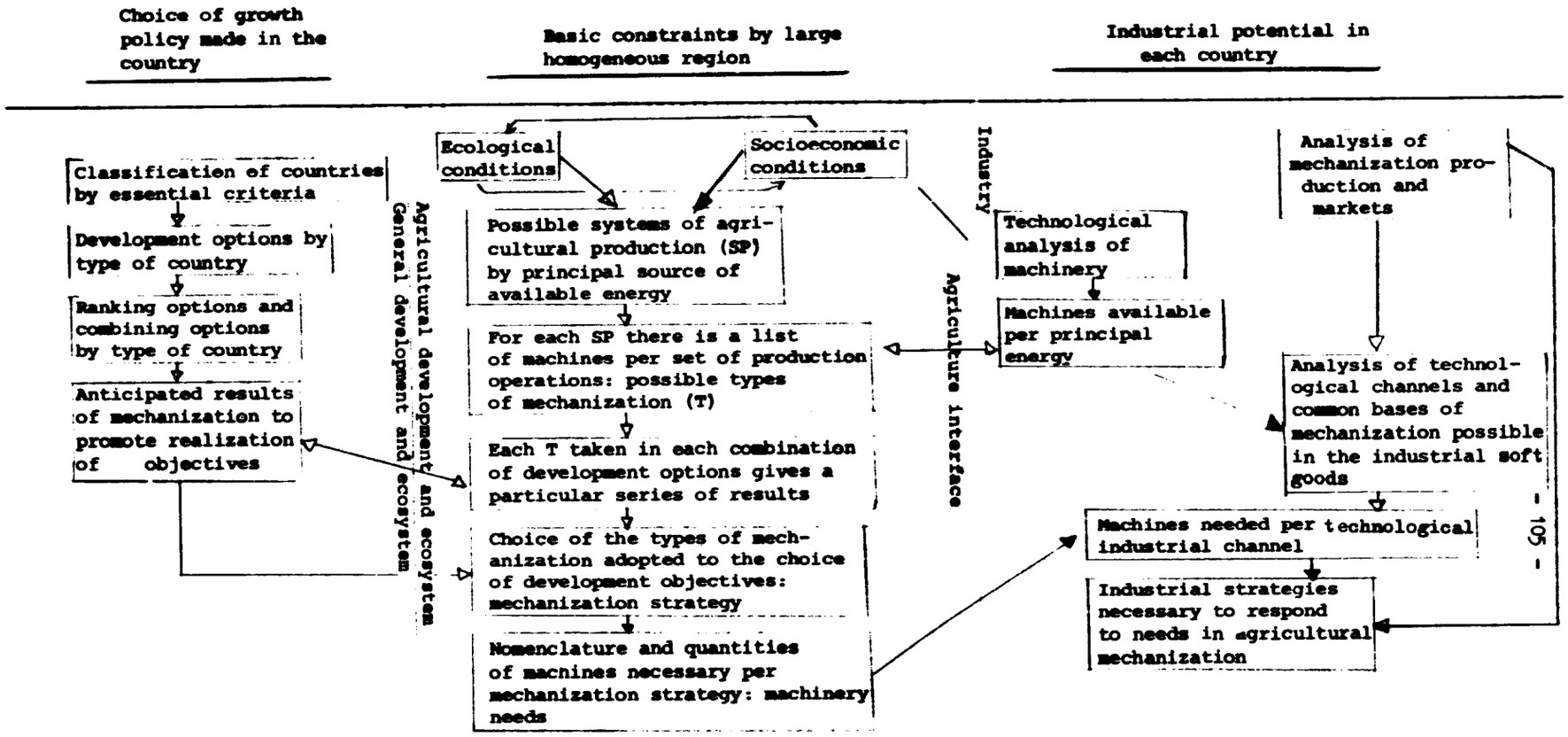
Thus the following sketch makes it possible to outline a method for evaluating machinery needs:

- on one hand, taking into account the ecological and socioeconomic conditions indicated for each homogeneous region in adapted systems of agricultural production, it is possible to define the range of possible mechanizations in each region. These types of mechanization can bring to light technological channels which differ from the dominant trends in agronomy (irrigation, draught animal farming, hand tools, paramechanization, etc...) and can be arranged in each channel by level. Logically, this indicates a pluralism in mechanization, whereas numerous studies only refer to a single model relying on the average 50-70 hp tractor.

- on the other hand, the choice of economic policy made by each state obviously influences agricultural and mechanization decisions. If we insist on the essential factors, the countries that have comparable characteristics (N.I. per inhabitant) useful agricultural land area per person active in agriculture, soil and weather data) tend to choose the same development options among the principal possibilities : maximizing employment, ensuring self-sufficiency in food production, industrial development, balancing foreign trade. In this manner each category of country represents a hierarchy of principal objectives.

From that time on, knowing the results of each type of mechanization and its possible contribution to the realization of economic objectives, it is possible to determine mechanization strategies. This means arrangements in time and space of the types of mechanization. In form, these strategies are designed to be adapted to ecological, economic, social and cultural conditions of an environment which is ready for mechanization. At the same time they express the global economic choices made by the governments involved.

They consequently lead to mechanization models that cannot be, a priori, an exact imitation of the models tested in different contexts in developed countries.


Choice of growth policy made in the country
Basic constraints by large homogeneous region
Industrial potential in each country
Classification of countries by essential criteria
Development options by type of country
Ranking options and combining options by type of country
Anticipated results of mechanization to promote realization of objectives
Agricultural development and ecosystem
General development and ecosystem
Ecological conditions
Socioeconomic conditions
Possible systems of agricultural production (SP) by principal source of available energy
For each SP there is a list of machines per set of production operations: possible types of mechanization (T)
Each T taken in each combination of development options gives a particular series of results
Choice of the types of mechanization adopted to the choice of development objectives: mechanization strategy
Nomenclature and quantities of machines necessary per mechanization strategy: machinery needs
Agriculture interface
Industry
Technological analysis of machinery
Machines available per principal energy
Analysis of mechanization production and markets
Analysis of technological channels and common bases of mechanization possible in the industrial soft goods
Machines needed per technological industrial channel
Industrial strategies necessary to respond to needs in agricultural mechanization

In terms of homogeneous, ecological and cultural zones with quantifiable agricultural land area and active populations, each mechanization strategy defining the types of mechanization at various levels, in precise technological channels, can be concretized in a list of the quantity of machine products which are necessary for each type of country.

Finally, a connection has to be established with the possibilities available in the industrial apparatus of the countries. The definition of the machines to be manufactures is function of the actual needs of agriculture but also of whatever could be manufactures on the spot and of whatever would be interesting to manufacture locally in order to reinforce the national industrial apparatus. Thus, industrial development strategies should be combined with those for agricultural mechanisation so that machinery products could be effectively adapted to national situations.

Certainly, in this method of needs evaluation, the choices of governments in future could be insufficiently known or difficult to realise. However, the hypothesis could be assoumed that, unfortunately, the choices between the main options are relatively limited and that appreciation errors could, at the world level, widely compensate each other. At any rate, and evaluation of demand based on a first approximation of the needs seems preferable to an evaluation based on the extrapolation of the established demand during a previous period.

In this manner FAO seems to adopt a method studying for a given objective the fulfilment of food needs and the needs in machinery products in the case of a medium type of mechanisation. This is also an <u>estimation of desirable requirements</u> rather than a forecast on demands; and this more normative orientation is not without similarity with that taken among the Lima Conference Recommendations in the industrial field.

The methods suggested within the framework of this pre-study is therefore convergent with those being conducted at FAO. Lacking an impossible application at this stage, it aims at laying correctly the problems down in order to direct the policies of the agricultural machinery industry in the Developing Countries It is developed below where the two aspects of the interface types - strategies of mechanisation will be examined successively whereas the interface agriculture-industry will be treated in the next chapter.

A - Ecological and socio-economic data, methodological orientations

At the limit, each agricultural region is a particular case : each ecosystem corresponds and interacts with a society that empirically forges a particular technique suited to its special needs. Each ecologically and culturally homogeneous region will correspond to a specific machinery demand: it is not just by chance that agricultural machinery dealers employ a large number of ethnologists.

However, it is not possible to operate at such a detailed level. As a first approach the large natural region designated in the research programmes of the UNESCO "Man and Biosphere" : prairie ecosystems (steppes, savanas, etc..) forest ecosystems, mountain or coastal ecosystems, arid regions. It is noted that each of these broad ecotypes includes societies with comparable characteristics : in this manner there will be crop or animal farming or less commonly mixed farming - animal farming with systems of organization that are distinct from one another. In this manner mechanization should be integrated into the whole group of extremely complex and varied relationships between the natural environment, production activities and all the mechanisms of social regulation that characterize traditional society. Production related decisions are only rarely the single relevant fact at the household level. Decisions are influenced by other factors affecting the extended family, clan or village. Production decisions in black Africa are based on two considerations. Under the responsibility of the oldest head of the household, provisions are made to satisfy family needs. Other dependents of the family (notably the young who wish to be emancipated) take responsibility for producing marketable products for financial gain. But how can a proper groundnut-cereal rotation be ensured in this context? The social system functions in such a way that production objectives are not limited to maximizing earnings. Social prestige, reducing the labouriousness of the work and greater solidarity of the village community can play important roles. Cash surpluses in the village community are often spent on ceremonial activities such as baptisms, marriages, funerals rather than for the purchase of production goods used to increase surpluses.

This fabric, made up of relationships between ecological and social systems, between social and economic systems can act against the introduction of mechanization : numerous barriers in introducing a new technique or machine are blamed on the large role of social functions and structures. Conversely, when use was made of the specific social role of village blacksmiths in

Mali, it was possible to rapidly set up repair and maintenance workshops for small agricultural equipment.

Consequently, it is not possible to analyze the conditions for introducing mechanization into these societies independently of the conditions required for reproducing the system. The proposal of this method brings us back to a more global problem : is there a form of mechanization which is "appropriate" to social systems which are not yet conceived and set in operation? If mechanization most often transforms the structure and function of social systems through the rapid development of certain social groups and power relationships, to the point where these transformations are irreversible, then there is destructuring, even destruction of the old system. This shows the relativity of the original appropriateness. All the same, it is possible to deduce that the very conditions created by this destructuring are decisive in building a new system, coherent and reproduc ble?

Two conclusions become evident :

i. In terms of methodology there are such a large number of variables in such complex and diverse systems that any method re lying on the analysis of a small number of variables may very well be inoperative. Situation analyses and attempts to find ways to act can make little progress without a systematic orientation : analyses of the particular internal and external relations of the systems being studied, the most important centres of interference, chain reactions, rebound reactions etc...

ii. In terms of mechanization strategies, proposed innovations should find a place within traditional systems : this does not mean that these innovations should be "small", "intermediate", "low impact", nor that their progress should be calculated in terms of profit. It is a serious misconception to juxtapose a turnkey factory with a society that is traditionally based on small-scale production by craftsmen ; there is a greater possibility of success when animal-drawn farming is introduced to nomadic livestock breeders in the process of settling down, than when introduced to farmers who have no tradition of breeding and training animals.

B. Taking into account production systems

In fact, it is the observable production systems that reflect the ecological, social and cultural implications. This is why these production systems themselves must be taken into account as well as their principle determining factors. In each of them it can be observed that the techniques used, the tools or machines, the intermediate items make up a package of homogeneous techniques, no one of which can be altered without altering the rest.

What good is it to mechanize cereal production if the production cost equals an output of 10 Qx/Ha and 7 is the maximum yield : the advantages of mechanization only become apparent when other conditions are simultaneously present, seed quality ,fertilizer improvement. As recorded in Tunisia, the choice of production on irrigated plots differs according to whether the farmers do or do not have cattle herds adjacent to the irrigated area. In the former case forage production can be introduced into the crop rotation. In the latter case market gardening and hort culture are preferable.

In the same fashion the constituents of a given mechanization process cannot be treated separately : not only is the machine-implement relationship organically linked to the system of production, but each part of the unit is defined on the basis of the other parts. Are combine-harvesters designed for yields encountered in temperate zones useful in dry regions?

Under these conditions, it will not be sufficient to think about mechanization in terms of level : the distinction between different types of mechanization adapted to different systems of production is the most important thing. The level of advancement within each type can only be determined afterwards However no sense can be derived by summating the characteristics of each level for a set of countries.

The first approach makes use of classifying types of mechanization on the basis of the system of production to which they belong :

i. Open range livestock herding in which mechanization problems are secondary. Taking into account the most recent advances in applied ecology : improvement of pasture productivity, management of water resources, soil protection, are certainly more effective on a short-term basis. Lack of mechanization - zero mechanization - in this case does not apply stagnation, but production increases by biotechnical means.

ii. Extensive crop farming for self-sufficiency is usually limited to the use of simple tools, which could be improved. However, it would be difficult to introduce mechanization except where it eliminates bottlenecks (sowing in arid regions), where traditional systems provide no technical solution, or where the tse-tse fly makes animal drawn farming techniques impractical.

iii. The most intensive crop farming intended for personal consumption or export generally makes use of animals r light mechanization depending on conditions prevailing in landed property structures.

iv. Modern production systems, regional food production, industrial or export food production, resulting from large development projects, usually benefit when farming operations are mechanized but not always when harvest operations are mechanized.

v. Mixed farming - breeding systems, with integrated animal and crop production to the extent seen in Europe, are not as frequent in less developed countries. However mechanization can be carried out at a slower pace.

This summary shows that the analysis of types of mechanization should be carried out on a region by region basis in order to obtain precise specifications. It also shows that each type should be analyzed further to determine which production operations can be mechanized.

C. Mechanization of production operations

In terms of a feasability study, analysis of the operations covered by mechanization will produce the most important information : systems of production, in terms of uniform blocks linked to the social and economic system, can only be operational in a specific country.

The set of technical operations that could be mechanized in agriculture can be classified in four main categories :

Table 37 - ARBITRARY BREAKDOWN OF USEFUL AGRICULTURAL LAND AREA OF THE WORLD BETWEEN THREE TYPES OF AGRICULTURE (1974)

Type of agriculture → / Useful agricultural land breakdown by geographic zone (including grasslands)	Unit ↓	Pure manual farming	Pure draught animal farming	Pure para-mechanized farming	Regional total
- Africa	10^6ha	935	56	20	1,011
	(%)	(92.5)	(5.5)	(2)	(100)
- Asia (except Japan)	10^6ha	775	204	41	1,020
	(%)	(76)	(20)	(4)	(100)
- Japan	10^5ha	0.4	0.5	5	5.9
	(%)	(6.5)	(8.5)	(85)	(100)
- New Zealand	10^5ha	1	2.9	10	13.9
	(%)	(7)	(21)	(72)	(100)
- Australia	10^6ha	410	60	30	499
	(%)	(82)	(12)	(6)	(100)
- Oceana (except Japan)	10^6ha	4	p.m.	p.m.	4
	(%)	(100)			(100)
- South America	10^6ha	355	163	27	546
	(%)	(65)	(30)	(5)	(100)
- Central America (including Mexico)	10^6ha	48	60	12	120
	(%)	(40)	(50)	(10)	(100)
- USA & Canada	10^6ha	20	79	396	495
	(%)	(4)	(16)	(20)	(100)
- Western Europe	10^6ha	17	17	135	169
	(%)	(10)	(10)	(80)	(100)
- Eastern Europe (except USSR)	10^6ha	8	11	57	76
	(%)	(10)	(15)	(75)	(100)
- European USSR	10^6ha	351 (1)	84	234	669
	(%)	(52.5)	(12.5)	(35)	(100)
Total	10^6ha	2,924	737	957	4,630
	(%)	(53)	(16)	(21)	(100)

(1) The estimation of CMEA has to be considered with certain reservations as far as URSS are concerned. The available statistics referring to the degree of mechanization in the state-farms show the following: 1) Vegetable seeding: 90%, 2) Vegetable planting: 55%, 3) Hay cutting: 75 %, 4) Hay harvesting: 82%, 5) Straw collecting: 90%, 6) Flax pulling: 87%, 7) Potatoe cultivating: 93%, 8) Potatoe harvesting: 40%, 9) Beet sugar harvesting: 79%.

Source: Razvitije ekonomiki i culturi SSSR za 60 let sowjezkoj j vlasti; p. 709, published by: Izdadeletwo statistiki 1977.

Beside, out of a total surface pf 548.812.000 hectares, 356.178.000 are cultivated by State-farms and 184.626.000 by Kolkhozes the degree of mechanization of which does not seem to differ from that of the state-farms.

Source: Statistical Yearbook of the Member Countries of the Council of Mutual Economic Assistance, Secretariat of CMEA, Moscow 1977.

i. Land clearing, development, bringing new land under cultivation: heavy and often highly specialized equipment is required for most of this work. It is known that there is an unequally distributed 200 to 250 million hectares in less developed countries that could be brought under cultivation.

ii. Irrigation equipment : if this equipment can be classified in terms of different technical levels, manual irrigation, paramechanization of wells, large dams and irrigated areas, a classification based on the type of results would be much more enlightening. Irrigation can in fact eliminate farm jobs - in China, the labour saved by paramechanization is estimated by the amount of labour necessary for all plowing and weeding. Irrigation also creates employment in the same measure by intensifying agricultural production. Some new and sophisticated equipment, such as drip dressing systems, are investments that economize water use where water is rare.

In this manner, land clearing, development and irrigation are a unified set of operations that can create employment in a global context of agricultural and rural underemployment. However, there are different equipment requirements : on one hand, powerful and specialized heavy machines for a market limited to regions with land that can be brought under cultivation; on the other hand, less expensive simple machines, in the range of motor pumps and piping - which may be combined in certain cases with land development equipment (for dams, which require civil engineering or land clearing equipment) and more sophisticated equipment such as drip dressing systems and automated installations.

iii. Equipment required for cultivation : soil preparations, sowing, plant protection, harvest. This is where classification by levels is most frequently used, it implies a linear progression which starts with completely manual operations and continues through draft animal farming to the use of tractors. It must be emphasized that each of these sets of operations refers back to a compatible system of production, and that as a result they cannot be applied to every situation :

- In every ecosystem where the use of a tractor makes it possible to use technical solutions otherwise impossible in traditional systems of production (bottlenecks, soil types, work time conflicts, etc...) the tractor

will necessarily be used in modernization. This is not the general case and each individual case should be calculated country by country.

- Draught animal farming is difficult to propagate in tse-tse fly regions or in systems that have no tradition of livestock breeding, even if they coexit geographically with groups of livestock breeders.

- Tractors cannot be introduced into systems of production where increases in yields do not exceed the cost of tractor purchase and utilization. This is why the use of tractors frequently follows the use of animal drawn equipment the latter representing the first step in modernization (1), surpluses are immediately reinvested in the following step. On the contrary, it is difficult to conceive of going directly from manual farming to tractor utilization : a new itinerary can be conceived that includes a phase of large increases in production and revenue. With what is presently known, that will be either by irrigation or by mechanization of other production operations.

iv. Mechanization of farmwork and transport operations.

The financial success of commercial carriers in mountainous areas of western Europe shows the importance of these carriers in certain systems of production. It also shows the need for more specialized equipment than the tractor-trailer unit. But in black Africa, for example, the transport of crops, water, wood represents 5 to 6 hours daily work. This work could be used on food crop production and results in a proportional increase in production.

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1) Often tractors can be seen as coexisting with draught animals on the same farm : the farmer speaks to one as he speaks to the other. The Chinese expression "little iron ox" is used for the new arrival, and shows to what point it marks the end of one pedagogy and the start of another. This means that the cost of tractor maintenance is added to that of draught animals and that this additional cost of modernization must be taken into account. This is useful in explaining the failures encountered in introducing tractors as well as for managing strategies for their introduction.

Primary processing also takes a large amount of time, especially where food crops are concerned : in this case, mechanisation makes it possible to improve the quality of the finished product and often to reduce waste. On a larger scale mechanization of farmwork, using light versatile equipment, mills for food and animal feed, saws, concrete-mixers, fans, elevators etc... produce free time which can be used to increase production as well as making it possible to more easily pass through the subsequent stages of modernization and mechanization.

In this manner, even on a worldwide scale, the evaluation of the need for agricultural mechanisation is not a linear progression from a low level to a medium level to a higher level.

It is easy to see that soil working operations are not necessarily the most important, that a tractor is not necessarily the primary need and that mechanisation of irrigation or farmwork can also be the first stages of farm mechanisation. With the first range of possibilities stated, it stands to reason that definitive evaluations can only be made after consideration of objectives as well as choices and priorities decided in the economic and agricultural policy of the country concerned. These decisions are made on the basis of the results of each possible type of mechanisation.

222. Evaluation of mechanization needs and strategies

Apart from constraints inherent in particular social systems and systems of agricultural production, the development of a method of evaluating agricultural machinery and implement needs implies that there must be a corresponding evaluation of development options in the context of political choices and the country's ability to put these programmes into operation.

On the basis of data concerning different types of mechanisation (see above), the importance given to a priority option in development (increasing food production ; increasing employment and earnings ; increasing interindustrual exchanges ; improving foreign trade balance) in each country or for a given economic development region should make it possible to :

1. choose the implements, the agricultural machine or combination of machines (package) (1) which optimize results in terms of development priorities ;

2. evaluate the consequences of each choice in terms of its consequences on other development options that have already been identified and situated in the structure ;

3. Quantify equipment needs on the basis of agricultural data (available land ; irrigable land), ecological data or economic (solvability), social and industrial data.

The latter makes it possible, in addition, to verify that objectives are consistent with means and more precisely that the classification is consistent with the mechanization strategy.

Perfecting this sort of method for estimating agricultural machinery and implement needs implies that the following points be specified :

- the concept of a "machinery package" presume that the use of one machine will not be dissociated from the use of another machine, without risking reduced efficiency for the whole set of machines and instruments. Therefore it must be realized (see above) that the final need evaluation matrix will show the implicit technical complementarity of the individual pieces of equipment.

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1) But also the whole set of intermediate products that make it possible to use fertilizer to its full extent (fertilizer, seeds, herbicides),

- The concept of arranging development options in a hierarchy. The choice of a priority option implies that the other options are secondary. However the orientations resulting from mechanization may be revised on the basis of constraints and contradictions involving the secondary options.

- Indicators can be used to formalize the relationship between a priority development option and the various agricultural machines and implements to be used. These indicators make it possible to choose machines that will be used.

Theoretically a machine package can be defined by a series of technical indicators corresponding to the following development options : food production, employment, industrial development, foreign exchange.

In this manner a set of soil preparation machines and implements will have the immediate effect of increasing food production (strong indicator) but will do very little to create employment, and to utilize existing industrial capacity, and for these reasons will not positively affect the balance of payments (weak indicator).

In addition, the different variables necessary to establish indicators must be gathered. These indicators are established for one machine or group of machines. It suffices therefore to choose the one or more that optimize the development option considered as priority (see 222.1.).

In the second step, the secondary option must then be applied to the same machine(s), to evaluate the effect of the choice on the whole social system of production ; to establish a list of agricultural equipment to be purchased, assembled or manufactured ; in order to quantify machine needs (see 222.2.).

222.1 The option of development - mechanization relationships : elements used to formulate technical indicators

Four relationships are particularly interesting. We take them to be the principal options, and, in terms of industrialization, the most urgent for less developed countries :

- increasing food intake ;
- increasing productive employment (slowing down the exodus from country to city ; creation of industrial employment ; stabilization of tertiary industry manpower) ;
- development of interindustrial exchanges and utilization of national productive capacity ;
- improving a dependent position in terms of foreign trade.

Each of these objectives has its counterpart in the policies of agricultural mechanization.

A. Food production and agricultural mechanization

The pressing importance of increasing and improving food intake in less developed countries is felt at three levels :

- the existence of a large population growth rate ;
- the disappearance of small self-sufficiency farms and the appearance of an additional food demand as a result ;
- changes in the character of food demand - notably in urban zones - and the changeover of an exclusively vegetarian diet to a diet where meat products dominate; protein intake increases with urbanization.

It cannot be argued that in most systems of production the interaction of heavy mechanization has an immediate effect on the increase in work productivity. The changeover to mechanized food crop production is easier when a part of the agricultural production is or was previously destined for industrial processing (cotton, oil seeds...) or exportation. One of the principal trump cards in heavy mechanization has to do with its immediate nature. It is undoubtedly the best package technique - where the agrarian structure permits its use - with the greatest increase in production in the shortest time. This is no doubt what justifies its expansion each time that an urbanization movement becomes strongly pronounced.

In the end, the following facts must always be taken into consideration :

- the use of the mechanization model encourages a rural exodus and consequently the increase in urban demand, even if it justifies its expansion by producing positive results.

- the results stemming from the use of a mechanization model are not always measured by increased production of a particular agricultural product, but rather of a whole set of products. In this manner mechanization that tends to dissociate animal - plant complementarity has a positive or negative effect on nutrition.

- results coming from using a mechanization model that is not only measured in immediate results (increases in food crop production). It should integrate the possibility of reproduction and future enlargement of these models. Consequently the capacity to satisfy future food demands and permit the accumulation of technical capital. It is known, in this regard, that the reconstitution of a traditional agricultural production system is much more difficult than its destruction.

In terms of its capacity to participate in the growth of food production, each machine or group of machines is an indicator. This indicator should take into consideration all data linked to the production and reproduction of systems of production, to the qualitative as well as the quantitative aspects of food crop production.

A first approximation consists of bringing together the utilization of each food crop production machine or group of machines in terms of the amount of protein potential that it represents in a given period of time, as governed by development constraints and options.

B - Employment - earnings and agricultural mechanization

While more than 70% of the population of the third world lives from agriculture, the technical model that is encouraged was essentially conceived on the basis of decreasing agricultural labour.

However, it is justifiable to add that the same model tends, under certain conditions and for certain operations, to promote agricultural employment by facilitating the extension of utilizable agricultural land area ; by eliminating certain bottlenecks during sowing and harvesting operations by facilitating the introduction of new types of crop (multiple harvests) or new varieties.

Consequently it is convenient to distinguish between machines that create work and machines that destroy work. All machines improving the capital investment/men employed ratio or that lower the cost of agricultural employees without reducing production can be placed in the first category. This involves capital savings of intensive farming where the following machines have a particularly beneficial effect : pumps and irrigation equipment, sprayers, light equipment for harvests processing and storing. But, more generally according to the system of production, all mechanization that increases agricultural yields where land is at a premium can be classified in this category.

The machines included in the second category are those that lead to a decline in agricultural employment. Under certain circumstances, a tractor will take the place of 2 to 3 farm workers. One can question the advisability of this measure if other sectors of the economy are not ready to absorb the displaced workers and if the consequences are increased imports, a doubtful increase in agricultural production (the simple introduction of a tractor does not necessarily increase the per hectare yield), and increases in both unemployment and the demand on urban food supply.

The effect is often cumulative in that the tractor, justified in part by the savings in manpower realized by the buyer, is progressively more powerful as manpower is less expensive. The proliferation of heavy machinery that results makes it impossible to return to a means of production based on manpower. Consequently, the new means of production is irreversible once introduced.

The relationship between mechanisation and employment however, cannot be reduced to simply what takes place on the farm. In fact, it is necessary to consider the totality of the jobs created by adopting a machine or group of machines :

- on the farm (see above)
- in terms of the machine (the construction, assembly, distribution and maintenance of equipment) and its use as an agricultural implement (procuring industrial goods : fertilizer, seed and herbicides ; the use of agricultural products : processing and distributing food).

To start out with, it would be necessary to specify the relationship between the agricultural machine or machines and the jobs that it eliminates or creates on the basis of an employment matrix applied to the agro-industrial complex.

C - National autonomy - agricultural mechnisation

Among the mass of agricultural machin s and implements, three categories can be distinguished on the basis of their impact on foreign trade :

- small tools and light machinery, with 70% manufactured by the less developed countries themselves ;
- heavy machinery which is built either completely or in part on location (preparation of the equipment, assembly, integration) ;
- imported heavy machinery.

The adoption of one or another of these types finds its counterpart in the country's balance of payments (a commercial balance for the cost of the machinery and accessories ; a balance of services and capital for patents, the technical assistance rendered, and reimbursement for loans of equipment).

Dependence on foreign trade is also well beyond a strict sectorial approach. Mechanisation can increase, stabilize or decrease the importation of agricultural products.

Mechanisation policy can minimize the cost of the transfer of technology by negotiating the know-how of the many technical innovations relating to mechanization that are no longer covered by patents. Within certain time limits, the same policy can also encourage long-term heavy mechanization, using imported machinery with its immediate technological cost to increase agricultural production.

In any event, a relationship exists between a country's use of one or a group of machines, and the position of that country with regards to its foreign trade. This relationship is shown notably by the formulation of an indicator based on the data of the balance of patents and capital tied to the acquisition of agricultural equipment. Accounts from the patent-rights offices are especially useful in formulating this indicator.

D - Industrial development - agricultural mechanization

Every time the move is made to adopt new agricultural machinery, this movement has a counter effect in the operation of the national industrial complex. In this regard, it is clear that no agricultural equipment can be manufactured, or used for that matter, without reference to the level of industrial development (the technical level and the level of diversification of its products) and the size of the market.

On these bases, it appears that the various categories of equipment used in farming do not have the same long-term effects on national industrial production. Consequently, a relationship exists between the manufacture of each machine or group of machines and its ability to "fill-in" the matrix of interindustrial exchanges (the increase of exchanges). A final indicator combines mechanization with the present and future states of the interindustrial exchange table.

E - Recapitulation of the indicators used to evaluate mechanization strategies

Using this method, there are four :

- indicators linked to food production, based on the capacities of the various machines to increase protein intake ;
- indicators linked to employment, based on the capacities of the various machines to increase or decrease agricultural and industrial employment;
- indicators linked to technological autonomy, based on the capacities of the various machines to lower the cost of latent licensing;
- indicators linked to industrial development, based on the capacities of various machines to increase interindustrial exchanges.

Perfecting these indicators implies calculations based on precise economic development zones (ultimately a country). They must be modified to operate on the basis of the objectives formulated for these zones or countries. One such series of indicators will be calculated for the short term, another for the long term. Within these two categories of indicators one calculation could be made in terms of sectors (agriculture or industry), while another could encourage intersectorial relations (agriculture - industry in the case of machinery) or foreign dependency.

As a result, each machine or group of machines will be characterized by a group of indicators that concretize the relationship between its use and its effects on the options or the variable priorities of development. The list of suggested indicators therefore is neither restricted nor hierarchical. The first series of indicators should make it possible to choose among various categories of machines that are defined by their impacts on food production, employment, technical autonomy, or industrial development, and, if it does not allow quantification, should at least point out the tendencies inherent in each mechani ation option.

To illustrate this proposal the following table may be used. Possible mechanization strategies are listed across the top (machine group 1, 2,...,n). Each of these groups is characterized by a series of effects on the major economic variables. These effects are measured by their indicators (in the columns) according to direction (vector orientation) or order (technical coefficient).

Table 39 - Adopting a machine group; effects on major development options (theoretical example)

Mechanization strategies:	Machine group (MG 1)	Machine group (MG 2)	...	Machine group (MG n)
Development indicators:				
Employment	→	↗		↘
Food production	↗	→		↗
Technological autonomy	↘	→		↘
Industrial development	↘	↗		↘

Machine group (MG 1) increase food production and maintains employment level, but does not promote national industrial development. The group (MG 2) indicates a considerable growth in employment and in industrial development. The advantage of adopting the group (MG 3) has the particular advantage of increasing food production.

222.2. Determination and evaluation of results from the global matrix

A - Presentation of machine need evaluation matrices based on optional development priorities

In consequence, each option considered as a development priority corresponds to :

(i) A machine group that optimizes this option. Thus, if priority is given to employment, the machine package that promotes its maintenance and development will be chosen. The final choice will involve a combination of machines of varying technical level, and not the juxtaposition of machines of the same level.

For each option (employment, technical autonomy) food production, industrial developments), a matrix may be obtained constructed in the following manner :

(1) Along the top, the machine group is characterized according to their major functions. So that going from left to right one can differentiate between : operations which extend the useful agricultural surface area (Op 1), the maintenance of agricultural areas (Op 2), equipment (Op 3), agricultural production proper (Op 4), transportation (Op 5), and processing and storage of the harvest (Op 6). These are 6 major categories of agricultural machines and implements.

(2) Along the side, the machine group characterized according to technical level.

(3) At the line-column intersection, the machines chosen on the basis of the particular priority option retained. The decision is made according to the previously formulated indicators.

As a result, this first matrix shows machine groups useful in agricultural production and corresponding to a given development option.

Table 40 - The kinds of mechanization employed on the basis of development options (theoretical example). Machine group (MG 1)

Option selected: employment — Zone of economic development: (X)

Technical level : \ Production operations:	(Op 1)	(Op 2)	(Op 3)	(Op 4)	(Op 5)	(Op 6)	Group of machines used for agricultural production (MG 1)
1		Hand tools				Tools and simple machines	
2			Light machinery	Drawn implements			
3					Conveyors		
4	Civil engineering machinery						

(ii) A series of consequences affecting other development options

What is at stake in the selection of a mechanization strategy is the minimization of recessive effects brought about by the particular primary option chosen. A second series of matrices allows the impact of this selection to be measured against other development options. This time the previously formulated indicators are used for each machine (or group of machines).

Table 41 - The impact of the selected mechanization priority (MG 1) on other development options (theoretical example)

Impact of (MG 1) on : \ Production operations:	(Op 1)	(Op 2)	(Op 3)	(Op 4)	(Op 5)	(Op 6)
Food production	↗	→	↗	↗	↗	→
Technical autonomy	↘	↗	↗	↘	↘	↗
Industrial development	↘	↗	↗	↘	↘	↗

B - The results and their uses :

The method described has four advantages :

(1) It puts mechanization strategies into the context of development options. Thus, the definition and quantification of machine needs implies the cooperation of the various decision centres with reference, in the case of agricultural mechanization, to the problems of farm production, employment, financing and strategies for industrial development.

(2) Based on the foreseeable strategies for all elements, it allows the formulation of a scenario in accordance with the results recorded in the various matrices.

(3) Successive sets of reiterations make it possible to select a concrete strategy for mechanization.

The results recorded in the matrices justify a new mechanization strategy every time there is :

- a conflict between the theoretical mechanization strategy and its practical application : lack of financial means, long delay before coming into use, inadequate operator training, the non-existence of subcontracting and maintenance services, etc ;
- an incompatibility between the stated objectives of the priority option and the impact of the mechanization strategy on other development options. The negative facts of these secondary options would counteract the positive effect of implementation of the priority option.

The method for evaluating machinery needs becomes then, an instrument in deciding agro-industrial policy.

(4) It allows the creation of an hypothetical classification of mechanization strategies ordered around the following categories of industrial goods :

- hand tools and light equipment constructed from local materials in the area of use. The production units (workshops) are widely scattered and kept to a size similar to that of cottage industry units (craftsmen) in order to best adapt the tool to local conditions, to promote rural employment, and to gradually introduce the craftsmen to industrial production (after-sales service ; adaptation of machinery to local working conditions ; distribution and processing of goods).

- wholly or partially imported heavy machinery, as a function of the size of the market, the urgency of the agricultural work to be done, and the industrial options.

Diagrammatically all specialized machinery (combine harvesters for agriculture, bulldozers, heavy tractors, levellers, and civil engineering equipment for land clearing and reclamation, trucks and conveyors for collection and transport) is imported, while tractors and tractor-drawn equipment are partially and then finally locally constructed in their entirety whenever the size of the national, or even better, the regional, market permits.

Taking into account the general slowing of demand (as much in developed countries as in those in the process of development) and the negotiations between selling and buying countries can take place under conditions which favour the buyers, so long as they are able to present solid and coherent conditions of sale.

The initial commercial negotiations may be the occasion to broach the subject of an entire industrial programme favourable to the buyers. It may include : the participation of the manufacturers in non-specific subcontracting for planned manufacturing ; the creation of a versatile after-sale service system ; the adoption of versatile production equipment that will allow eventual reconversion.

- light machinery based notably on the use of a versatile engine and the accompanying machinery. A universal engine should be used and could conceivably be constructed for a reasonable price no matter what the size of the market. Machines such as this should be manufactured locally, regionally and nationally, to satisfy the same requirements as those mentioned for hand tools.

23. Some tentative conclusions

If the preceding pages have not given a complete outline of a method of evaluation for agricultural machinery needs, they at least make it possible to lay down a few major guidelines, and have already raised numerous basic questions.

i. Bringing mechanization product offer and demand together in terms of agricultural needs, requires a certain amount of reflection as to the appropriateness of the techniques and products involved :

- can the heavy industry of developed countries respond appropriately to the needs of developing agricultural systems without re-examining its own production goals?

- can the appropriateness of products and techniques even be measured without reference to ecological, social, and cutlural contexts as well as to measures adopted under each country's growth policy?

- if such is the case, then a combination made up case by case of products and techniques drawn from various technologies is more likely to be appropriate than any number of precise technological specifications ; a combination adapted to all the various constraints and objectives rather than this or that machine.

ii. If this appropriateness is not nearly a technological affair, then the economic characteristics of the products of mechanization must be integrated into one's thinking :

- notably one must keep in mind the total accumulation of capital that each machine represents as well as its capacity to allow future accumulation. The same is true of the versatile engine, costing one-tenth the price of a tractor. It allows a more than proportional growth in work productivity, it can be a powerful factor in capital accumulation or even a mean of bringing about eventual introduction of the tractor.

- one must also keep in mind the possibilities of using agricultural machinery in farm related activities, such as food processing construction of dwellings and farm buildings, village crafts etc... By taking into account the outside effects of agricultural mechanization, it may be possible to modify previous calculations of investment returns and to enlarge the size of industrial manufacturing units. Also, the widespread use of a versatile engine has more far reaching economic effects than the simple introduction of a tractor.

iii. The method for evaluation of machine needs that has been proposed results from a group of related hypotheses : it allows each country to refuse the transfer of ready-made technical solutions used in countries where the ecological and economic conditions are different ; it allows each country to discuss , step by step, its own needs and to clarify the choices of economic policy which is the context for every mechanization programme.

- It must be made clear that such a method will have to be gone into in depth ; that it relies on the use of a large and varied quantity of information that, a priori, will not always be available.

- At first in any case, this method allow the dynamic description of the kinds of information that must be gathered and maintained in a data bank and that can be useful to the objectives of agricultural mechanization. Rather than listing the principle headings of the catalogue the method defines a problem which in its turn structures the mass of information that is available or will be created.

CHAPTER III

DEVELOPMENT STRATEGIES FOR THE AGRICULTURAL MECHANIZATION INDUSTRY

3.1. Introductory comments

The previous chapters have emphasized the intermediate situation of agricultural mechanization at the intersection between :

- on the one hand an industrial system : a system of machines, the coherence of which derives from globally accepted industrial standards;
- on the other agricultural systems developing a demand, either existing or potential, for ranges of machines and tools giving evidence of various coherences and rationalities.

This fact forms the starting point which must be taken into account when creating and developing an agricultural mechanization industry. The following preliminary comments are put forward simply to draw attention to some of the aspects arising from it.

3.1.0 Centralization and decentralization of the industry

The agricultural mechanization industry is a highly concentrated one, but it is also necessarily a very decentralized industry.

This starting paradox can be explained as follows :

- The agricultural machinery industry is a very concentrated industry. This statement is based on simple observation of the facts. The statistics quoted and the evolutions analyzed in the previous chapters show that a few major manufacturers - less than 10 - share the greater part of the world market for agricultural machines.

Even if there are still some large production sectors which have escaped them these major manufacturers exercise a determinant influence on the whole of the world agricultural mechanization industry, since :

- they define world standards in the tractor field and also in agricultural machinery systems (shifts to powerful tractors, then to even more powerful tractors, etc.);

- they control the rate of the advance (and hence of the obsolescence) of technical progress;
- they compel the integration of mechanized operations into increasingly complex and centralized systems;
- they form the dynamic nucleus of industrial and agricultural policies of an irreversible character.

At the same time the agricultural mechanization industry is a necessarily highly decentralized industry for the following reasons :

The major manufacturers are far from being able to produce all the machines and tools corresponding to the diversity of the systems of agriculture operating throughout the world.

Simple (animal traction) or more complex agricultural machines are produced in medium or small factories or workshops. Various tools are produced in long runs by modern techniques, but also by local artisans in either traditional or modernized installations.

The nomenclature of world producers of tractors, agricultural machines and tools is significant of this wide decentralization.

Even if the evolution of the industry shows that many of these decentralized production units tend to become progressively centralized one type of decentralization must, necessarily, be permanent. This involves the operations of maintenance and repair of agricultural machines which cannot escape from the decentralization which is a fundamental characteristic of all agricultural systems. Maintenance and repair must be carried out on site in a decentralized manner, even where tractors and machines produced in highly concentrated units are concerned.

This does not take place without contradictions, contradictions which are frequently not overcome, as is shown by the delays and the wastage involved with poorly utilized or non-utilized machines because they are difficult to maintain or impossible to repair.

This sets the limts of a process of accelerated concentration

and, at the same time, shows the value of development of agricultural mechanization which takes a necessary decentralization into account.

3.1.1. The agricultural mechanization industry : a way of entry into the capital goods industry

Those developing countries which possess the capacities for equipment goods production form a small minority. Five developing countries have major capacities, nineteen others have initial capacities in this field. The great majority of the developing countries are entirely dependent on the capital goods industries of the developed countries for their supplies of capital goods.

By contrast all the developing countries and territories are engaged in agriculture, and in most cases the greater part of their population lives from agriculture or, at least, lives in the country. Agriculture is at the centre of the way of life which dominates the African, Asiatic and Latin American continents. It is necessary to forge the links between this wide-spread agriculture and the necessary decentralization of the agricultural mechanization industry as described above. Such a rapprochement suggests that the agricultural mechanization industry, starting from the simplest of steps, offers a practical entry to the capital goods industry which is largely and universally accessible. The openings and entries exist, furthermore, in many directions, many village forges and artisans manufacture the tools which allow many systems of agriculture to continue to exist. Forging is a simple technique; it opens up a basic route for the production of capital goods, and is capable of being improved and modernized; one form of modernization involves making the system more complex by adding the route of welding and electrical welding.

It is accepted that, unless these artisans are re-modelled in a modernized system, they are doomed to disappear, or to serve only folk-lore purposes. But it is this very artisan production, so wide-spread even in the smallest countries, which must remind us that country people continue to design and manufacture tools suited to each soil, and that these simple production capacities and technical know-how are only waiting to be integrated.

At all events, and even if it is felt that traditional artisans are too fixed in their ways to serve as the basis for more dynamic modern forms of production, one must not neglect the other entry which is offered by the necessary decentralization of maintenance and repair operations. How, in fact, is it possible to maintain efficiently agricultural tools without forging and welding facilities and without some engineering capacity to use simple machine tools. This shows how it is possible to progress from simple maintenance and repair work to the manufacture of spares and then to sub-assemblies.

The example of China, despite its specific character, is very interesting in this respect, since the workshops for the repair of agricultural equipment progressively expand (from brigade to commune and to committee) to the production of parts, of production runs of parts, of sub-assemblies, etc., so that the capital goods industry is grafted onto the basis of the artisan and then of the agricultural mechanization industry.

Towards a systematic utilization of the opportunities for entry into the production of capital goods

Undoubtedly the simple form of an agricultural mechanization industry, in its first stage, does not have the character required by models of "motor industries" or of "basic industries". Nonetheless it is capable of forming the first links in a production line for capital goods, provided that it is correctly set up.

Agricultural mechanization (tooling) offers a starting point: whether it involves the traditional artisan producer of tools or simple machines or elementary units for maintenance, repair or the production of spares. In the two cases either one technical route, that or forging, or two technical routes of forging and welding, are available. It is immediately possible to modernize them or to make them more complex by adding the "simple machine tools" or "cast-iron production" routes, etc.

The utilization of the technical routes linked to the existence of agricultural mechanization and tooling is facilitated by a systematic utilization in the direction of capital goods intended for uses and sectors other than agricultural production. As soon as welding is available as well as forging, for example, it is possible

to envisage the production of metal structural work, boilerwork products, etc. The remainder of this chapter will concentrate on the versatility which is opened up by the mastery of these routes.

The problem must now be put forward in therms of the "range of technical possibilities opened up by the mastery of one, two or several routes ...". At the same time it is necessary to adopt another starting point and another perspective by establishing the relationship between the technical possibilities deployed in this way and the needs and also, initially, the needs of the framework within which agriculture is located, that is to say rural and village life. Agricultural production is, in practice, inseparable from the operations of transport, storage and the conversion of its products; its promotion depends on an improved habitat, on collective equipment, etc. Such a rapprochement makes it possible to identify a large number of items of simple equipment, from the plough to the silo and including simple structural and boilerwork products, capable of being produced from the primitively mastered technical routes as a function of the existence of agricultural mechanization or tooling. It may clearly be seen how, on the basis of agriculture and rural life, a to-and-fro movement could be established between the process of increasing complexity of the technical routes and the deeper satisfying of needs or, if one prefers, how one proceeds from agriculture and the agricultural mechanization industry (or artisanate) to the establishment of a capital goods industry.

The point was initially made concerning the high concentration of the agricultural mechanization industry (tractors, complex machines). One must not, however, neglect the interest which is already being shown, and which will increasingly be shown, by the major agricultural mechanization industries in Europe, Japan and America in the "industrial" adaptation of agricultures which have, until now, remained marginal. The recent report presented jointly by the Asiatic Development Bank and the Trilateral Commission[1] is a sign of the attention which will be paid to small-scale irrigation schemes, to miniaturized mchines, to tools, etc.

The alternative which is open is that the satisfying of the needs of agriculture, and more broadly those of rural life, will be essentially induced by the industrial logic of the dominant groups,

(1) see "Le Monde" of 28 February 1978.

whilst the local implementation of their satisfaction could constitute for those countries concerned a possibility of entering into the production of capital goods, starting from agriculture and rural life, but extending in the direction of all the other sectors of economic life.

3.2. Typology of capital goods and agricultural mechanization

3.2.0. Classification of capital goods

The agricultural mechanization industry forms part of the capital goods industry. One may therefore consider using the method of classification of finished goods which is based on the principle of technological production routes and which therefore permits the analogue grouping of products[1].

This general classification is set out in Annex 1. The classification principles are as follows :

- It is necessary to establish a correspondence between the various classes of capital goods and the final demand sectors. This correspondence is necessary in order to be able to establish the demand in terms of value and of volume;

- It is necessary to take into account one of the most important characteristics of the capital goods sector, namely the numerous connections which exist between the products and the technical manufacturing processes. It is possible to associate different products (analogue grouping of products) which may be manufactured using the same manufacturing processes (forging, casting, machining) which make it possible to manufacture parts and sub-assemblies common to different final products.

The first overall survey made it possible to determine eight production sub-routes and so to establish a first analogue grouping of products produced by the capital goods industry. These eight sub-routes are :

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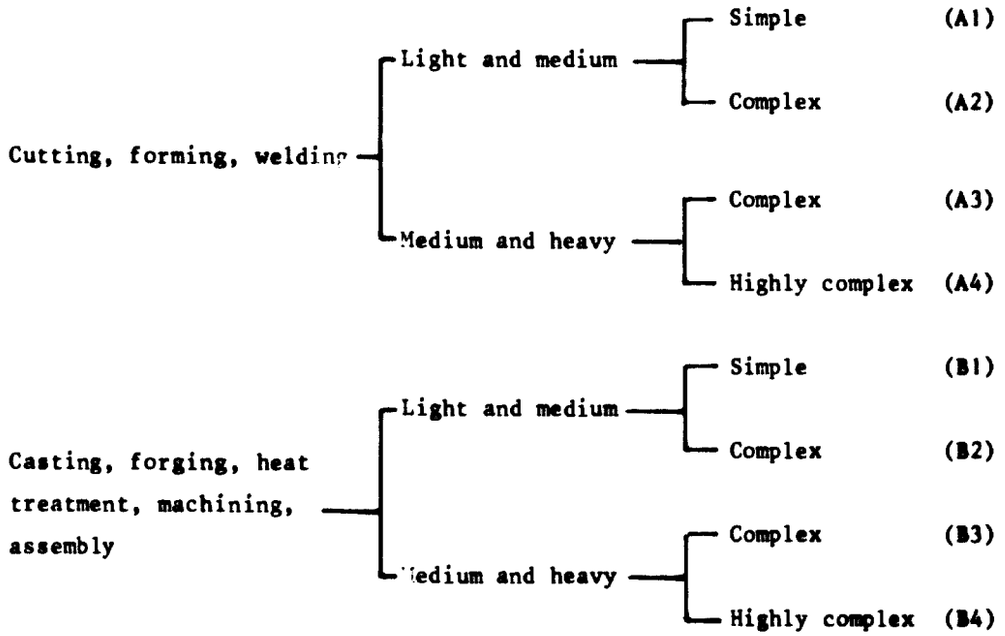
(1) An analysis of the structures of the capital goods industry (Preliminary study) - I.C.I.S., with the collaboration of M. R. Tiberghien, February 1978.



Taking the whole of agricultural mechanization (tooling, equipment, tractors) the routes involved in this first approach are :

- A1, A2 } Cutting, forming, welding, light and medium, simple and complex
- B1, B2, B3 } Forging, casting, mechanical working, heat treatment, assembly; light and medium, simple and complex; medium, heavy and complex

This first methodological approach covers all capital goods, so that it is now necessary, in relation to the final agricultural demand :

- To effect a more precise and concrete approach to the agricultural mechanization industry in terms of technological routes and the analogue grouping of products;
- To identify the problems of organizing the productive apparatus.

3.2.1. Technological production routes and agricultural mechanization

Under the term technological production route one defines all the production operations, linking the products (materials, components, sub-assemblies) and the processes ("basic facilities" - casting, forging, metal forming, machining, etc.) with a view to the production of the final product (assembly) and taking into account the design operations (engineering, design capabilities) and the organization of production and sales (industrial engineering and marketing).

The study of the technological production routes for agricultural mechanization must therefore determine the following factors for all the final products :

- Energy sources
- Iron and steel inputs
- The components used (for example nuts and bolts, springs)
- The elements of the actual manufacturing process :

  Forging
  Welding (metal structural work, boilerwork)
  Casting
  Stamping
  Machining
  Heat treatment
  Assembly

- Marketing and after-sales service
- Design studies.

Table 43 classifies agricultural mechanization products (column 3) as a function of the production sub-routes (column 2). It also includes the characteristics of the organization of maintenance of the equipment (column 4), the location of the activities (column 5) and, as a function of the production sub-routes, some examples of the production possibilities opened up for other capital goods outside the field of agricultural mechanization (column 6).

This table shows three major sub-routes: A1-B1, A2-B2 and B2-B3.

Sub-route A1-B1 corresponds to simple forging work and welding, and some examples are given, taken from an analysis of products in terms of production routes.

For simple forging of the artisan type the source of energy is very frequently wood, in some countries coal or coconut shells, more rarely electricity; the raw material is scrap steel, there is practically no assembling, the manufacturing techniques are rudimentary and frequently heat treatment is carried out by guesswork so that the quality of the products leaves something to be desired. The final products are mainly hand tools (pick-axes, shovels, rakes, woodcutting axes).

The simple welding operations require some knowledge of welding but the main problem is that of electrical supplies for the welding unit. Mastery of this sub-route makes possible the production of small metal-framed storage units, small silos, carts, tanks and small farm equipment (hen-houses, drinking troughs).

Sub-route A2-B2

Whereas the previous sub-route corresponds to work of the artisan type mastery of this sub-route already represents a qualitatively large step forward since it requires, even if not in the form of complex work, the mastery of :

- simple mechanical machining (use of slide lathes, milling machines, drilling machines, planers);
- casting ordinary cast iron and forging;
- heat treatment.

Table 43 - Correspondence between production sub-routes and the final demand from agriculture. Organization of maintenance, possible location of the activities and the production of other types of capital goods.

Production sub-routes (1)		Complexity (2)	Final demand products from agriculture (3)	Organization of maintenance (4)	Location of the activities (5)	Production of other types of capital goods (6)
Type	Principal characteristics					
A1	- Recovered steel - Simple forging of artisan type - Simple heat treatment - Little assembly work	1	Hand tools : pick-axe, rake, shovel, woodcutting axe	Minor maintenance	Village and/or region	Hand tools for the building industry
B1	- Simple welding of ordinary steel		Small buildings, small silos, cart, tank. Small farm equipment			
A2 B2	- More complex iron and steel inputs (alloy steels) - Casting ordinary cast iron - Forging - Simple to complex mechanical machining - Heat treatment - Little assembly - Some quality control - Production drawing office	2	Plough, harrow, roller, rake, trailer, weeder, portable sprayer, swill preparation equipment, grain cleaning machine, hand-operated pump	More complex maintenance involving mechanical machining. Production of spares.	Region and/or country	Grinding machine Shell remover Dumper Cement silos
B2 B3	- Sophisticated steels - Complex to highly complex forging and casting - Complex to highly complex mechanical machining - Heat treatment - Considerable assembly work - Quality control - Marketing and after-sales - Study and design offices	3a	Seed drill, fertilizer distributor, sprayer, cultivator, mower	Major maintenance	Country or group of countries	
		3b	Simple prime movers, pumps, valves Tractor			
		3c	Special machines, self-propelled binder, sprayer.			

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B1	- Simple welding of ordinary steel		Small buildings, small silos, cart, tank. Small farm equipment			
A2 B2	- More complex iron and steel inputs (alloy steels) - Casting ordinary cast iron - Forging - Simple to complex mechanical machining - Heat treatment - Little assembly - Some quality control - Production drawing office	2	Plough, harrow, roller, rake, trailer, weeder, portable sprayer, swill preparation equipment, grain cleaning machine, hand-operated pump	More complex maintenance involving mechanical machining. Production of spares.	Region and/or country	Grinding machine Shell remover Dumper Cement silos
B2 B3	- Sophisticated steels - Complex to highly complex forging and casting - Complex to highly complex mechanical machining - Heat treatment - Considerable assembly work - Quality control - Marketing and after-sales - Study and design offices	3a	Seed drill, fertilizer distributor, sprayer, cultivator, mower	Major maintenance	Country or group of countries	
		3b	Simple prime movers, pumps, valves Tractor			
		3c	Special machines, self-propelled binder, sprayer.			

The iron and steel inputs become more complex, involving the use of some alloy steels. It should be noted, however, that it is not necessary that all parts should be made locally (complex parts of relatively simple equipment) but can be either imported or be obtained from a better equipped production unit located at country level (see below on the relationships between production units).

The products manufactured can include the following : ploughs, disc harrows, rollers, seeders, grain cleaning machines, portable sprayers and hand-operated pumps.

Sub-route B2-B3

This sub-route represents an increase in complexity over the previous route: the use of alloy steels, electrical and hydraulic components and complex parts, the need for a quality control department, a design office, a marketing department and an after-sales service. Assembly operations also become more complex.

It will however be necessary, by a subsequent in-depth study of production routes, to identify in a more precise manner what analogue grouping of products can be carried out since, as can be seen from the table, the list of products is varied and the complexity differs between a seeder, an elevator and self-propelled machines.

3.2.2. Questions linked with complexity

It should be pointed out that, irrespective of the criteria retained to define the complexity of a product, reference will almost always be made to existing products. Such products are, for the most part, defined in the industrialized countries and hence as a function of the socio-economic conditions which prevail in these countries.

The complexity of a product is defined by :

- the nature of the iron and steel inputs -

  - cast iron
  - ordinary steel
  - alloy steel

- the nature of each of the elements in the production process -
  - general or precision machining
  - casting ordinary or SG cast iron
  - casting ordinary or alloy steel
  - artisan-level forging, universal forging, forging alloy steel
- the place and complexity of the assembly work
- the importance of quality control
- the management of spares
- the importance of study and design offices.

As was pointed out in Chapter I a fundamental trend in the agricultural mechanization industry is the diversification and increasing complexity of the products.

Mechanical equipment is made more complex by the addition of components which are not entirely mechanical. A sophisticated tractor - whether high-power or miniaturized - is no longer a simple mechanical object. It is now a system consisting of mechanical, electrical, electronic and hydraulic sub-systems.

Mechanization which made the engine the central component of the machine is today changing direction. The complex machine - such as the self-propelled machine - is characterized by the increasingly total integration of the elements of which it is composed.

Modern specialized agricultural machines represent a technological line different from that of the previous tractors.

The complexity of the systems which they form is not the simple addition of the complexity of their components but a multiple of this.

The applications of systems analysis methods should one day make it possible to measure the complexity of capital goods by the quantity of information contained in their technologies and the quantity of energy and work which is necessarily integrated into their manufacture.

However in this preliminary study the analysis has been simplified by considering only three principal levels of complexity :

Level 1 corresponds to the capabilities of artisan forgers who exist in practically all the developing countries and whose work makes possible the manufacture of most hand tools even if the quality, in certain cases, leaves something to be desired. The minor welding work corresponds to this level of complexity but poses the problem of the source of energy.

Level 2 assumes capabilities and countries which already have an embryonic capital goods industry. This level implies, in particular, mastery of the use of machine tools, requiring skilled labour, and mastery of casting and non-artisan forging.

Level 3 includes at least three sub-levels 3a, 3b and 3c.

It is possible to illustrate each of these sub-levels by means of some typical products :

Sub-level 3a : seeder, drill, sprayer, cultivator, elevator, conveyor;
Sub-level 3b : pumps, prime movers;
Sub-level 3c : self-propelled threshers and binders, special machines, bulldozers, solar engines and pumps, machines using new technologies (drop-by-drop watering).

In the present state of the dominant techniques tractors are located between sub-levels 3b and 3c. But the manufactures of tractors poses a question which may be transposed in the case of other items of equipment. Reference is frequently made to miniaturization as a factor in the reduction of complexity; this leads to the ideas advanced concerning the use of mini-tractors or power-cultivators. In fact where the manufacture is concerned the complexity appears to be just as great (large number of parts, special machnining, use of alloy steels, etc.)[(2)].

Trials on the adaptation of a tractor designed for developed agricultures do not appear to be convincing. Even the most economic and intelligent solutions remain relatively complex and expensive.

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(2) These machines also appear to be more fragile, and to have a shorter working life, than conventional tractors.

Prices of the new models are much higher than the second-hand cost of normal models in the developed countries.

It seems, therefore, that it is necessary to be more radical in the direction of simplification.

In fact it is a question of producting a tractor of a new technical line rather than of returning to the relatively simple tractors of a quarter of a century ago. The first trials have already been carried out[3] with the cooperation of UNIDO[4] and others are proposed.

Such a tractor could be produced using basic imported components (engine, transmission) or parts produced locally, and by simple techniques (simple welding, metal construction) where the rest of the tractor is concerned (chassis, tracks, hubs, etc.).

In the same way an analysis of the various operations which are suitable for mechanization and of the principal components of the machines and tools used shows, in each case, that their most frequent common denominator is a simple engine.

The specifications for the latter arise from the same considerations as that for a simple tractor, and in the case of a simple multi-purpose engine could be as follows :

- it should be inexpensive so as to require only a small prior accumulation, being a tenth of the price of a simple tractor, and should therefore be produced in long runs;

- its maintenance must be easy as a result of a design directed to this end, and possibly modular as is being envisaged at the present time in the automobile industry;

- its servicing must be simple, within the capabilities of all users, allowing its widespread use, as was seen at the beginning of the mechanization of European agriculture;

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(3) PANGOLIN simplified agricultural tractor - Industrial Development Office of the Republic of the Ivory Coast.

(4) TIMTABI tractor.

- the choice between diesel and petrol should be made on the basis of the best compromise between production cost, servicing costs and operating costs; by contrast efforts should not be made to adapt it to different fuels (wood, groundnut shells, farm gas, etc.) so as to retain its simple character and its multi-regional suitability; however the engine should not prejudice the more economical possibilities of the utilization of renewable resources (solar energy, wind power, etc.);

- it must show proof of great flexibility in use, capable of being coupled to other similar units to provide multiple powers from a unit power which can be small, about twenty horse-power for example, and it must be light and fitted with handles so that it can be moved about easily;

- finally it must be capable of being connected to all those agricultural machines which are able to be motorized and for all those possible applications which only require a low power: irrigation, certain harvesting machines and the transport, converting and storage of products. The shaft of the engine should therefore be provided at one end with a pulley (see the Ivory Coast PANGOLIN) or a toothed wheel transmitting the power to the wheels of a conveyor of the dumper type and, at the other end, with a power take-off (pulley or shaft) for coupling to the widest possible range of tools or machines used in a region, the economic characteristics of which are to be analyzed.

3.3. A typology of the developing countries from the point of view of agricultural mechanization

Table 44 summarizes the information available on 64 countries in regard to the production of hand tools, simple machines or equipment using animal traction, engines and tractors.

The still approximate nature of this information, which should be verified, must be emphasized. The information must be interpreted with caution. If the production of hand tools and simple machines is, without doubt, integrally local manufacture, the same is certainly not the same for the production of engines, tractors and combines.

Certain countries (in particular India and Brazil) appear to have integrated on a national scale the production of diesel engines, for example, and even to have improved this by the introduction of R & D.

But in many cases, particularly when the local companies are the subsidiaries of multinational companies, manufacture consists essentially of assembly with a varying level of incorporation of national components.

Up to the present it has not been possible for the International Centre for Industrial Studies to collect the information which is needed to evaluate the true situation.

But, irrespective of the reserves which must be made concerning the information and the sample of the countries in Table 44, this will not be of a nature to affect the following statements :

1. Practically all the developing countries manufacture hand tools used in agriculture;

2. More than half of the sample of countries studied (33 countries) manufacture simple items of equipment and equipment for animal traction;

3. But only 13 countries manufacture engines, without knowing in fact the contribution of national components and engineering. This production is only seen in the case of countries with populations of over 10 million inhabitants. This means therefore that 84 countries (plus 18 territories) with less than 10 million inhabitants and 19 countries with more than 10 million inhabitants, or a total of 103 countries, do not produce engines intended for use in agriculture. This statement clearly

reinforces the suggestion which has already been made to attempt to produce a simple and multi-purpose engine in the developing countries;

4. The production of tractors of 10 HP and above, according to the available statistics[1], appears to be carried out in only 8 countries[2] In the case of combined machines the statistics are contradictory as between production and exports. It is probable that their production is in the hands of a smaller number of countries than in the case of the tractors.

These findings also reinforce the previous proposal to design, test and manufacture simple tractors, of a new technological line and capable of being produced over a much larger geographical area.

5. This classification confirms that found in the case of capital goods in general[3]. It leads, even more forcibly than in the case of capital goods taken overall, to the conclusion that the industrialization policy for the developing countries must be differentiated. The problem cannot be limited to the 5 or 6 countries which already possess an industry but must be extended to the research into specific solutions for the hundred countries which do not possess one. All these countries engage in agriculture, and it is this which dominates their way of life.

As has been explained it is advisable to initiate this development of the agricultural mechanization industry without destroying the existing bases of know-how in the production of simple machines, or even of hand tools, no matter how rudimentary these may be. It is a matter of starting from these bases and of successively introducing those technological routes which will make it possible to progressively enlarge the range of products manufactured.

Tables 45, 46 and 47 give the "national profiles" of the supporting industries for agricultural mechanization in Africa (15 countries), Asia (10 countries) and in Latin America (9 countries).

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(1) United Nations Yearbook of Industrial Statistics, 1975.

(2) The statistics for production and foreign trading are not coherent. For example six countries (Pakistan, Singapore, Thailand, Kenya, Malaysia and the Ivory Coast) appear to have exported tractors (Yearbook of International Trade Statistics, 1975) whereas these do not appear in the production statistics.

(3) ICIS - An analysis of the structures of the capital goods industry - document cited above.

Here again the information is to be treated with caution and should be supplemented and corrected. It is nevertheless given in order to suggest an approach to a process of increasing information which is then capable of being made progressively more complex.

Iron and steel production has been broken down into three categories: long products, flat products and alloy steels. This classification, although very simple, is not without value[4].

If it is true that a small number of developing countries produce a wide range of iron and steel products it also appears that a large proportion of the developing countries which have an iron and steel industry do not produce either flat products or special or alloy steels. Yet equipment goods require flat products, particularly sheet, and alloy steels in the manufacture of engines and other parts. The existence of an iron and steel industry need not be, however, a prior requirement for creating an agricultural mechanization and capital goods industry. But it is obvious that the "forging" route and mastery of the handling of machine tools are prerequisite conditions.

Here also the capacities of the developing countries differ very considerably.

It would be of value to refine these profiles by studies on site with the companies concerned. But it is necessary to start from typologies, very rough at the beginning but then progressively becoming more detailed. The next step would then be to proceed to a classification by levels of difficulty of the various types of casting and of typing the complex world of machine tools. The true situation regarding the existing capabilities of the countries could then be identified.

Comparison of the "profiles" obtained in this way with those needed to produce the defined types of machines would provide information at an operational level for delimiting with precision the necessary training programmes, country by country. In this way it would be possible to avoid the disadvantages of excessively generalized programmes of the omnibus type, based more on the technical availability of the trainers than by the specific needs of the developing countries.

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(4) New trends in the iron and steel industry - ICIS study produced with the collaboration of M. P. Judet, February 1978.

The value of having a classification by products, showing analogies in respect of their production routes, is also reinforced. This would make it possible to organize the training activities which would open up to the maximum the versatility of activities.

This combination of typologies of agricultural mechanization (see the previous chapter) with typologies of countries has another important consequence in the organization of information, and of technological information in particular, which is necessary for the developing countries.

The relatively more rapidly developing countries need information to improve their capabilities, to extend their production ranges and to improve their productivity. This only concerns a restricted number of countries.

By contrast the great majority of the developing countries need information when making strategic decisions such as to enter or not to enter into a new activity and, if to do so, how.

This information is of a strategic nature, not tactical.

The one does not exclude the other, but it must be appreciated that to give priority to one to the detriment of the other is implicitly to make a political choice. Applied to the problem of agricultural mechanization these considerations mean that if the principal political choice (and not exclusively under compulsion) is to develop agricultural mechanization at various stages in those countries which do not at the present time have an industrial base, or only an inadequate base, it will be necessary to pursue, to make more complex and to refine the typology of the technological routes for agricultural mechanization and the production profiles of the countries.

Table 44

MANUFACTURE FACILITIES FOR AGRICULTURAL MACHINERY IN DEVELOPING COUNTRIES

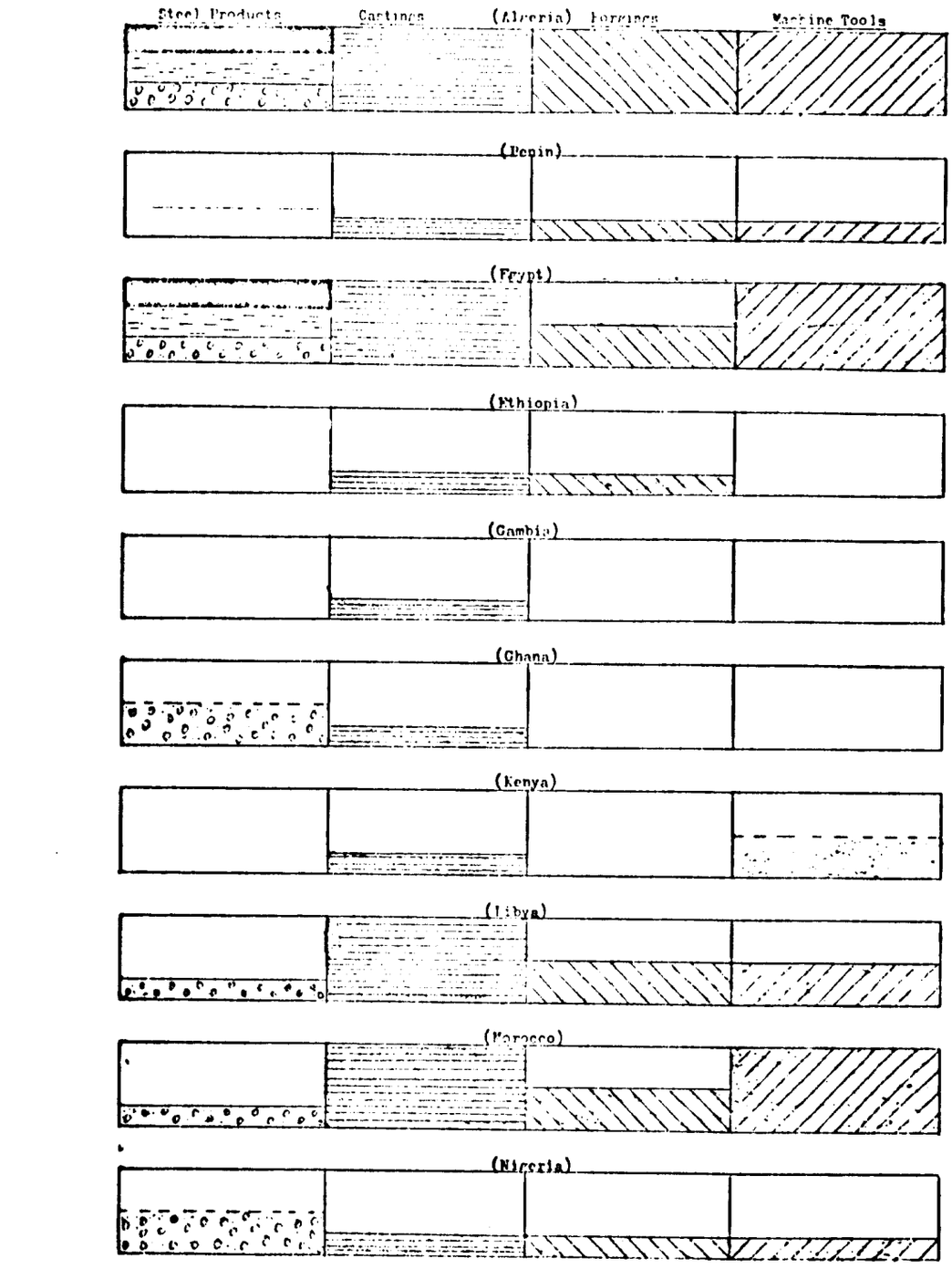
(1974)

	(10^3) Population	GNP/cap.	Handtools	Farm Machinery	Engines	Tractors
500,000 to 1,000,000						
Fiji	564	840		—	—	—
1,000,000 to 5,000,000						
Burundi	3655	90	•	—	—	—
Central African Empire (ldc)	1748	210	•	—	—	—
Chad (ldc)	3952	100	•	—	—	—
Congo, People's Republic of the	1300	470	•	—	—	—
El Salvador	3887	410	•	—	—	—
Jordan	2620	430	•	—	—	—
Lebanon	3065	1070	•	—	—	—
Liberia	1500	390	•	—	—	—
Libyan Arab Jamahiriya (ppc)	2352	4440	•	•	—	—
Malawi (ldc)	4958	130	•	—	—	—
Paraguay	2484	510	•	—	—	—
Rwanda	4058	80	•	—	—	—
Senegal	4869	330	•	•	—	—
Sierra Leone	2911	190	•	—	—	—
Singapore	2219	2220	•	•	—	
Somalia (ldc)	3100	90	•	—	—	
Togo	2176	250	•	—	—	—
Yemen, People's Democratic Republic of (ldc)	1632	220	•	—	—	—
Zambia	4781	520	•	—	—	—
5,000,000 to 10,000,000						
Bolivia	5470	280	•	—	—	—
Cameroon	7120	250	•	—	—	—
Ecuador	6952	480	•	•	—	—
Ghana	9610	430	•	•	—	—
Ivory Coast	6387	460	•	—	—	•
Democratic Kampuchea (ldc)	7725	70	•	—	—	—
Madagascar	8560	180	•	•	—	—
Mali (ldc)	5560	80	•	•	—	—
Saudi Arabia (ppc)	8008	2830	•	•	—	—
Syrian Arab Republic	7177	560	•	•	—	—
Uruguay	2754	1190	•	•	—	—
Yemen, Arab Republic (ldc)	6379	180	•	—	—	—
Tunisia	5460	650	•	•	—	—
10,000,000 to 30,000,000						
Afghanistan (ldc)	16311	110	•	•	—	—
Algeria (ppc)	15215	730	•	•	•	•
Argentina	24626	1520	•	•	•	•
Burma (ldc)	29521	100	•	•	•	•
Chile	10608	830	•	•	—	—
Colombia	23125	500	•	•	—	—
Ethiopia (ldc)	27240	100	•	—	—	—
Iraq (ppc)	10770	1110	•	•	•	—
Kenya (ldc)	12910	200	•	•	—	•
Malaysia	11702	680	•	—	—	•
Morocco	16291	430	•	—	—	—
Nepal (ldc)	12320	110	•	—	—	—
Peru	14953	740	•	—	—	—
Sri Lanka	13393	130	•	•	—	—
Sudan (ldc)	15227	230	•	•	—	—
Tanzania (ldc)	14351	160	•	—	—	—
Uganda (ldc)	11186	240	•	—	—	—
Venezuela (ppc)	11632	1960	•	•	—	—
Zaire	24071	150	•	—	—	—
30,000,000 to 50,000,000						
Arab Republic of Egypt	36350	280	•	•	•	—
Central America (less Mexico & El Salvador)	40154	n.a.	•	—	—	—
Iran	33100	1250	•	•	•	•
Korea, Republic of	33459	480	•	•	•	—
Philippines	41433	330	•	•	—	—
Thailand	40760	310	•	•	—	•
Turkey	39167	750	•	•	•	•
Over 50,000,000						
Brazil	103981	920	•	•	•	•
India	595586	140	•	•	•	•
Indonesia	128800	170	•	•	•	—
Mexico	57899	1090	•	•	•	•
Nigeria (ppc)	73044	280	•	—	—	—
Pakistan	67213	130	•	•	•	•

• Produced
--- Not produced

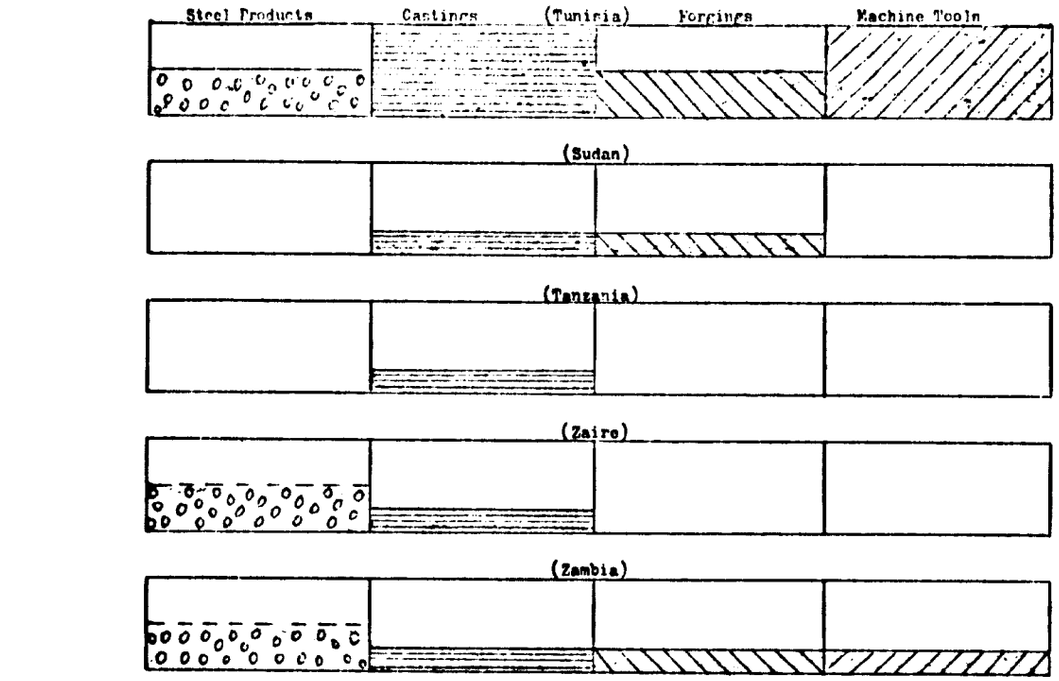
Table 45

NATIONAL PROFILES OF AFRICAN SUPPORTING INDUSTRIES FOR AGRICULTURAL MACHINERY MANUFACTURE



(Table 45 continued)

(continued)... NATIONAL FACILITIES OF AFRICA SERVICING INDUSTRIES FOR AGRICULTURAL MACHINERY MANUFACTURE



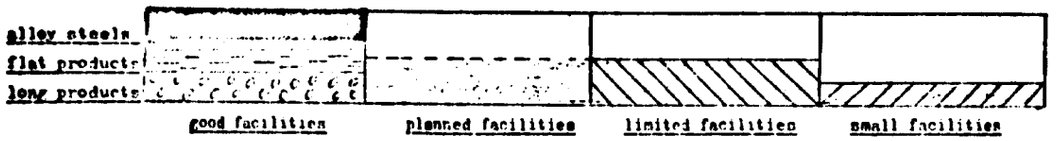


Table 46

NATIONAL PROFILES OF ASIAN SUPPORTING INDUSTRIES FOR AGRICULTURAL MACHINERY MANUFACTURE

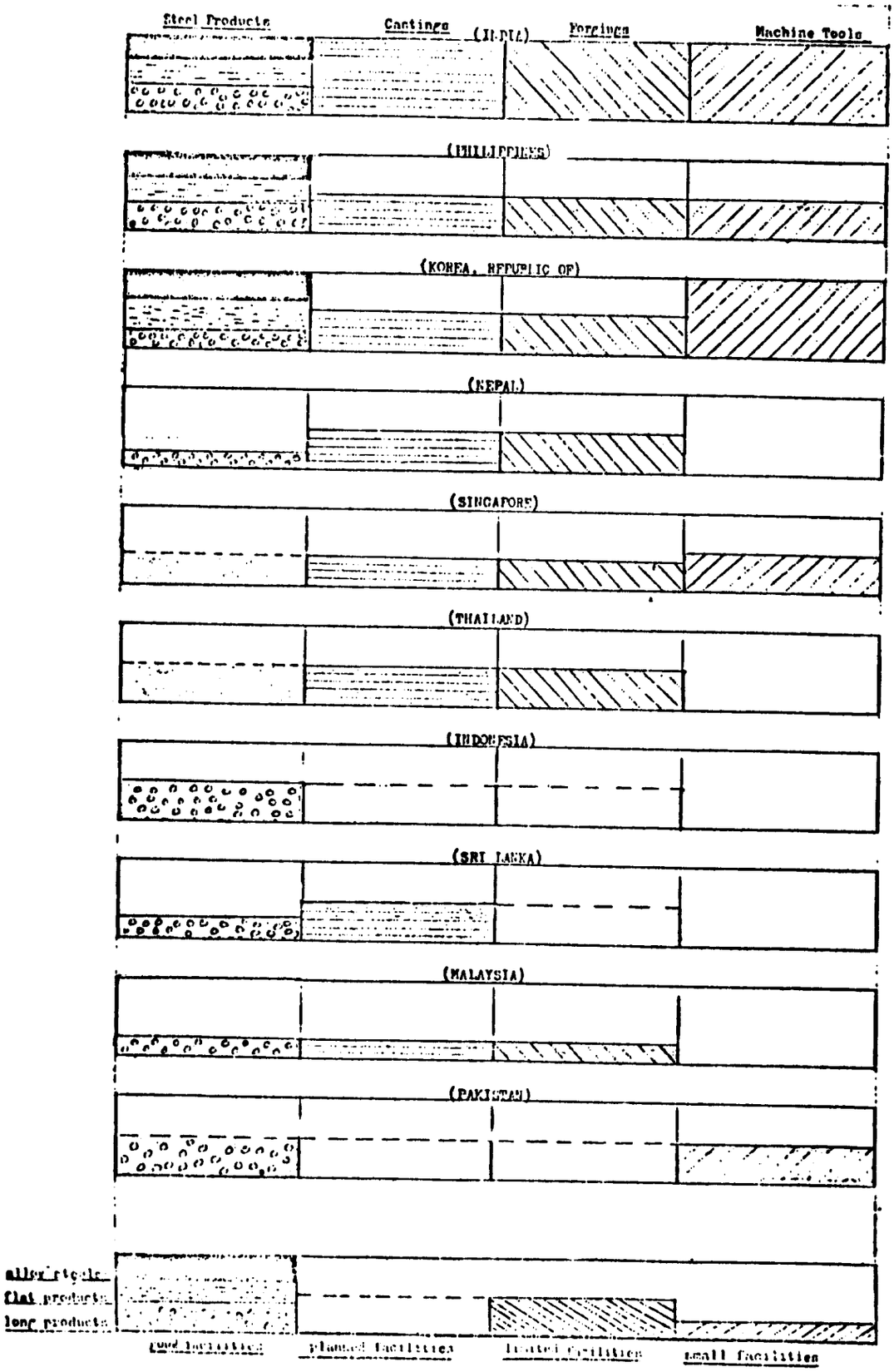
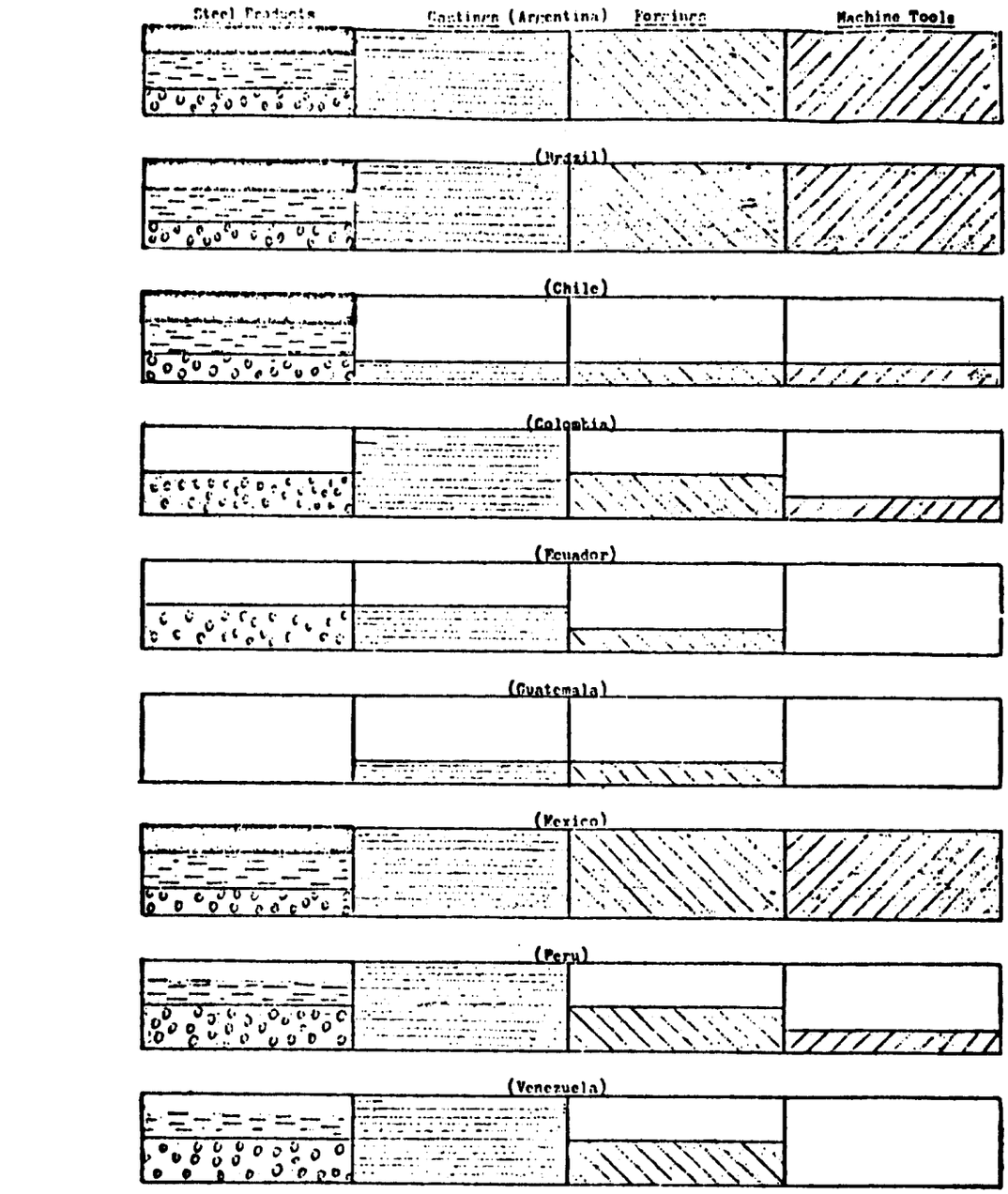
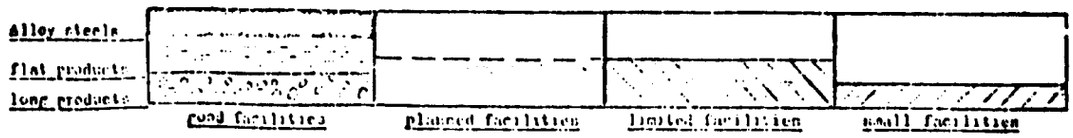


Table 4/

NATIONAL PROFILES OF LATIN AMERICAN SUPPORTING INDUSTRIES FOR AGRICULTURAL MACHINERY MANUFACTURE





3.4. Policies for entry into and/or development of an agricultural mechanization industry

The strategies should differ according to the countries, but they should take into account the following factors :

- The dispersion of the users encourages installing a largely decentralized production apparatus. This option would facilitate the operations of marketing and maintenance. However these units should be able to rely on the support of a more centralized organization, responsible to the Public Authorities, in respect of supplies of raw materials, studies, the design of the equipment and the promotion of national engineering capabilities in this field.

- This decentralization is not incompatible with the criterion of profitability. In between the production of conventional hand tools by improved artisan techniques and the manufacture of sophisticated equipment (tractors and self-propelled machines) by specialised production processes there is room for a whole range of equipment produced by small or medium sized units.

- The analogue grouping of products on the basis of common technological routes suggests that it would be possible - and necessary - to approach from a new angle the decisions to invest and studies of feasibility, profitability being evaluated less at isolated product or operation level but more in terms of groups of analogous products.

- Maintenance and servicing is a sufficiently important problem to be taken into account in a global strategy for the installation of production units.

- A strategy for entry into or the development of agricultural mechanization should be integrated within an overall strategy for the development of the capital goods industry.

- The other basis of this strategy would be the critical evaluation of the demand for machines by eco-development zone (see Chapter II). This would determine the orientation of programmes for the industry.

3.4.1. The case of countries having practically no agricultural mechanization industry

In these countries an agricultural mechanization industry cannot rely on extensive "mechanical" experience but only on the experience of local artisans who produce hand tools, together with some acquired experience from automobile engineering since the maintenance of cars is entrusted to artisan-type workshops.

The stages could be as follows :

Stage 1

- Improvement of artisan techniques by support from the Public Authorities at the level of raw materials supplies and manufacturing techniques.

- The installation of structural steel work and boiler work units which will necessitate apprenticeship in welding and finding a solution to the problem of the energy needed for the welding units.

- At the same time, and given that imported materials will be used, it will be essential to solve the problem of supplies of spares and to install the first maintenance and servicing units. It is at this stage that the need to train workers to use machine tools will undoubtedly be felt. These maintenance units could be both a means of training personnel needed for the operation of future production units and also the basis in respect of mechanical machining needed to manufacture spares or the components needed for the products manufactured during stage 2.

Stage 2

- This involves launching the production of products of complexity level 2, so implying mastery of routes A2 and B2, that is to say :

  - Cutting, forming and welding, light and medium, complex
  - Casting, forging, heat treatment and machining, light and medium, complex.

- A start could be made on the production of related products which do not form part of the agricultural demand so as to make the investments more profitable and to make an entry into the more generalized manufacture of capital goods.

- At the same time a policy of selective imports should be defined, restrictive in the case of productions to be promoted but open in the case of specific elements which cannot be made locally.

- In this stage it will be necessary to establish, at a centralized level, the initial capabilities for the study and design of agricultural mechanization and to initiate a structure for a national engineering capability.

3.4.2. Countries which have an embryonic capital goods industry

These countries already have production capabilities. It is therefore necessary to list them in detail so as to identify the existing production routes and, if necessary, their level of under-utilization since this is frequently found to be the case.

The development of the agricultural mechanization industry can then the carried out in two directions :

a) Downwards. This involves ensuring that the simple techniques are effectively mastered and that the establishment of a more complex industry will not eventually disrupt the existing industrial fabric.

b) Upwards. This involves developing the more complex products and ensuring efficient linking with the rest of the capital goods sector.

Study and design capabilities should be reinforced, in particular in the field of adaptation of equipment to local realities.

These are the countries in which the question will soon be posed of manufacturing tractors and complex machines, the technologies for which are held by the major manufacturers. If the decisions to do so are taken then choices must also be made as to the degree of national integration of the production. Assembly using imported components may be envisaged, but with a plan for integration clearly

established with the foreign partner, otherwise the country will always be in a position of dependence. Furthermore the production apparatus which is established for these assembly activities must be used to meet other needs.

Obviously the above considerations only form, within the scope of this preliminary study, the elements necessary for relection. The same applies to what follows.

3.4.3. Problems posed by the organization of the productive apparatus

Table 44 sets out a preliminary sketch of what could be the links between the productive apparatus and the possibilities of analogue grouping of products, their complexity and the dispersion of the users.

The concept has been put forward that the production apparatus could be located at country, region or village level.

This raises a general problem of management in the design, establishment and linking of the industry.

a) The organization of production units

- At village level one can speak of a modernized artisan-type mode of production in small units around the forge. The problems which generally arise are those of regular supplies of good quality raw materials, technical assistance in improving the quality of heat treatments, and assistance in marketing. It is also possible to consider that assembly activities are possible, using assemblies and sub-assemblies obtained from other units at regional or country level.

- At regional level the production of simple to complex equipment involving forging, casting, mechanical machining and heat treatment, could be carried out in integrated units. These units, based on the analogue grouping of products, would be of the multi-purpose type. This presents the question as to whether each region should be autonomous in respect of the products which it needs or whether units relatively specializing on some products should be established in each region. The answer to this will undoubtedly

depend on the size of the country and of the market.

- At country level the units which are installed will meet the needs for the whole of the territory, and this poses problems of marketing and after-sales service.

Two strategies are possible :

- The establishment of units which each correspond to one product, or of multi-purpose units based on the analogue grouping of products.

Furthermore, and irrespective of the strategy adopted, it will still be possible to choose between integrated units including all the elements in the production route and the so-called "main" units producing the final product from supplies of parts, components or sub-assemblies obtained from "intermediate" units. This is therefore a choice between integration and the establishment of a network of sub-contractors.

b) The links which are necessary between the three levels of localisation

- It is necessary to study the possible links between the various levels of maintenance. It is broadly possible to distinguish between minor maintenance at village level, more complex maintenance at regional level, and major maintenance at country level.

It is necessary to go further than this and to evaluate under real conditions the work to be carried out, the equipment needed (number of machines), the level of skill required from the workers and the system of training.

Where manufacture is concerned decentralization does not necessarily imply complete autonomy at each level. For example it is possible to envisage assembly operations at village and region level, using the existing production tools and on the basis of sub-assemblies or components supplied either from centralized units to the regional units or from regional units to the village units.

c) The organizational network

The capital goods industry requires, in general, a national environment which constitutes its external infrastructure: engineering capabilities, universities, economic development and programming institutions, systems for standards and information, etc. One characteristic of under-development is, precisely, the absence of such an infrastructure.

However the installation of a capital goods industry creates the encouragement to develop such an infrastructure and can be a factor for the integration of the national industries.

Its fabric, its structure and the density of its links will be specific for each country.

In this context the agricultural mechanization industry could, as has been analyzed here, form the first thread of this fabric.

Although characteristics and methods may be common to a number of countries the design of this fabric must be original and specific if it is to be in accordance with the specific needs of the rural populations. As a consequence the organizational forms and the linking of the levels of activities are to be established case by case. This is why it is of value to have individual studies on each of the countries which have been produced along similar methodological orientations. It would also be of interest to study in more detail the experiences of countries which have developed from practically nothing on the basis of original formulae for the agricultural mechanization industries, such as Bulgaria, Jugoslavia and China.

Institutional innovation may perhaps be a condition for avoiding unconsidered and mimetic transfers of the dominant models of agricultural mechanization.

It is undoubtedly also one of the organizational and psychological conditions for leaving room for unconfined critical analysis - or even for the imagination - in bringing forward innovatory solutions.

To illustrate this claim it is only necessary to consider the possibilities of a policy of substitution in this field.

Substitutions in respect of products and in the field of production meet, in effect, five objectives: to adapt the product to local realities, to reduce the complexity of manufacture, to make maintenance simpler, to facilitate standardization and to make decentralized manufacture possible.

To achieve this one can, for example, consider :

- substitutions in respect of energy sources (use of non-conventional forms of energy).

- substitutions in the iron and steel inputs so as to reduce the grades of steel needed and to facilitate standardization, the more so since the grades of steel frequently correspond only to the maker's "make" and not to technical considerations.

- substitutions in the production process: the use of "Meccano" techniques would facilitate welding and would replace casting, the technique of folding could replace stamping, etc.

Definitively, therefore, the entry of many of the developing countries into the agricultural mechanization industry is a burning necessity, and would be a logical consequence of implementing the "basic needs" policy.

This results in new obligations for the community of international organizations, and for UNIDO in particular: to assist these countries in taking the initial options of entering into these activities, to obtain strategic information, to implement active methodologies both for evaluating the agricultural demand and also for making an accurate diagnosis of the industrial capabilities of the countries, to forge the instruments of action such as that of typologies of technological routes, to test new and innovatory solutions such as simple and multi-purpose tractors and engines, to compare the experiences of countries and to study diversified strategies.

3.5. CONCLUSIONS

1. For the greater number of the developing countries the agricultural mechanization and equipment industry is the way to enter the capital goods industry. Its double importance can therefore be seen: firstly in the fact that it gives to agriculture the tools which are necessary for its development and secondly in that it reduces the dependence of the developing countries by establishing a capital goods industry.

2. The agricultural mechanization industry is not concerned solely with the manufacture of tractors and self-propelled machines; between such equipment and hand tools there is a wide range of items of equipment involving simple to complex manufacturing processes.

3. Whilst the model of heavy tractorization is widespread in the developing countries it will be difficult for all but a few countries to acquire an agricultural mechanization industry since the equipment involved is very complex and is constantly being changed. On the contrary a model of multi-purpose motorization, whilst not in any way excluding the use of sophisticated equipment, could facilitate the stages of industrial progress.

4. Analysis in terms of production routes and of the analogue grouping of products makes it possible to mark out routes between the stages of industrial progress. These must be examined in greater depth. This analysis suggests that mastery of the agricultural mechanization industry is achieved by way of mastery of the production routes; it also suggests that the profitability of an investment should no longer be evaluated at the level of an isolated product or operation but rather on the basis of groups of analogous products.

5. The organization of the agricultural mechanization industry depends greatly on the dispersion of the users. This constraint imposes a largely decentralized production and maintenance organization. Such an organization would, in addition, make it possible to form an enlarged industrial fabric, the essential basis for the subsequent production of capital goods.

6. Research should be undertaken not only in the direction of miniaturization but also in the direction of the simplification of equipment (for example a simple tractor) and the versatility of equipment (for example engines), following new technological lines. Thus simplification and versatility are important factors in technological autonomy.

7. It is essential to consider the unity which is formed by the agricultural mechanization industry and the capital goods industry. Increasingly detailed information should be compiled so as to produce lists of related products, the production of which could be envisaged alongside that of agricultural equipment. This would make it possible to provide instruments for action for the use of the policy makers in the developing countries.

Annex - Classification of products as a function of final demand and production sub-routes

Final demand	Analogue grouping of products (Revised CTCI nomenclature)	Route A (cutting, forming, welding)				Route B (casting, forging, heat treatment, machining, assembly)			
		Light & medium		Medium & heavy		Light & medium		Medium & heavy	
		simple A1	complex A2	complex A3	highly complex A4	simple B1	complex B2	complex B3	highly complex B4
A. Custom-built equipment 1 - Medium and heavy equipment for the basic industries	Metal structural work (691), storage tanks (392), boilers, heat exchangers (711-1/711-2), furnaces (719-13).			X	X				
	Machinery for cement (719-14, 719-19), machinery for glass (718-52), machinery for the petroleum, petrochemicals and chemicals industries (719-19), rolling mills and converting furnaces (715-21, 715-22), large gantries (719-3), electric furnaces (729-92), machines for foundry work (715-21).								
	Gas and steam turbines, hydraulic turbines (711-3, 711-6, 711-81), large thermal engines (711-5), large pumps (719-22), alternators (722-1), large compressors (719-22), railway equipment (719-66), reducers (719-61), large valves (719-92).				X				X
	Transformers, isolator switches, circuit breakers for high and very high tension (722-2).			X	X			X	X

Classification of products as a function of final demand and production sub-routes (contd.)

Final demand	Analogue grouping of products (Revised CTCI nomenclature)	Route A (cutting, forming, welding)				Route B (casting, forging, heat treatment, machining, assembly)			
		Light & medium		Medium & heavy		Light & medium		Medium & heavy	
		simple A1	complex A2	complex A3	highly complex A4	simple B1	complex B2	complex B3	highly complex B4
B. Standardized equipment 2 - Equipment used by certain branches	Small equipment and tools for agriculture and the building industry (695-1)	X				X			
	More complex equipment for the building industry and agriculture: concrete mixers, dumpers, preparation of aggregates (718-51), machines for preparing and cultivating the soil (712-1/712-2), building site cranes		X				X		
	Trucks, buses (732-2 to 732-8), tractors (712-5), agricultural machinery (712-2, 712-9), public works and building equipment (718-4)						X	X	
	Machine tools (715-1), machines for the agriculture and food industries (712-3), machines for the textile industry (717-1), machines for the leather industry (717-2), printing machinery (718-2), machinery for paper and board (718-11 and 718-12)							X	X

Classification of products as a function of final demand and production sub-routes (contd.)

Final demand	Analogue grouping of products (Revised CTCI nomenclature)	Route A (cutting, forming, welding)				Route B (casting, forging, heat treatment, machining, assembly)			
		Light & medium		Medium & heavy		Light & medium		Medium & heavy	
		simple A1	complex A2	complex A3	highly complex A4	simple B1	complex B2	complex B3	highly complex B4
3 - Equipment used by all branches	Pumps (719-21), valves (719-92), compressors (719-22), thermal engines (711-5), centrifuges (719-23), electric motors (722-1)						X		
	Lifting and handling equipment (719-3), air conditioning equipment (719-12), gas and liquid filters and separators (719-23), heat exchangers, others		X				X		
	Tanks, vessels, building structures, boiler works for all branches	X	X						
	Manufacture spare parts and maintenance					X	X		

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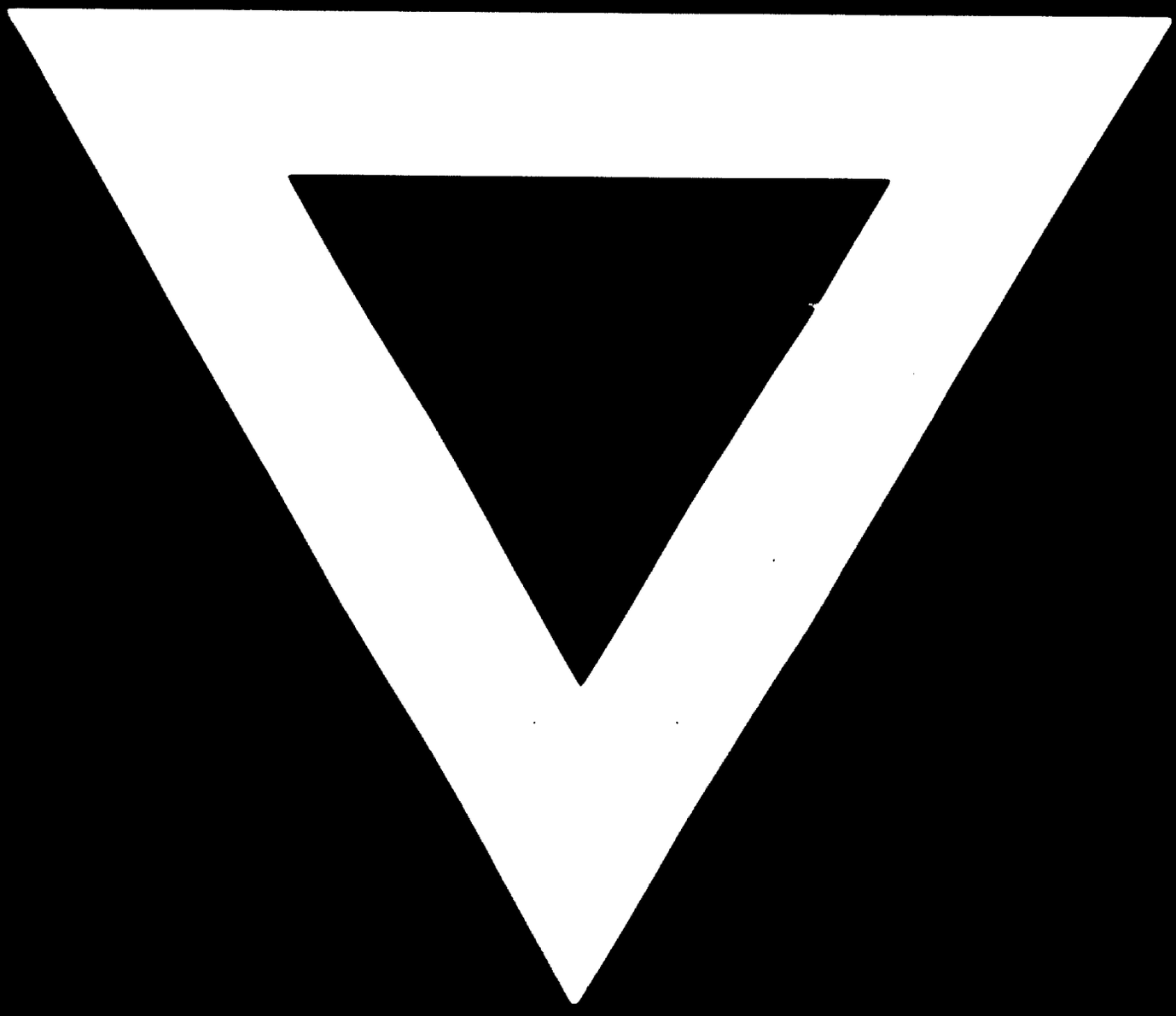

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