Appropriate Industrial Technology for Agricultural Machinery and Implements

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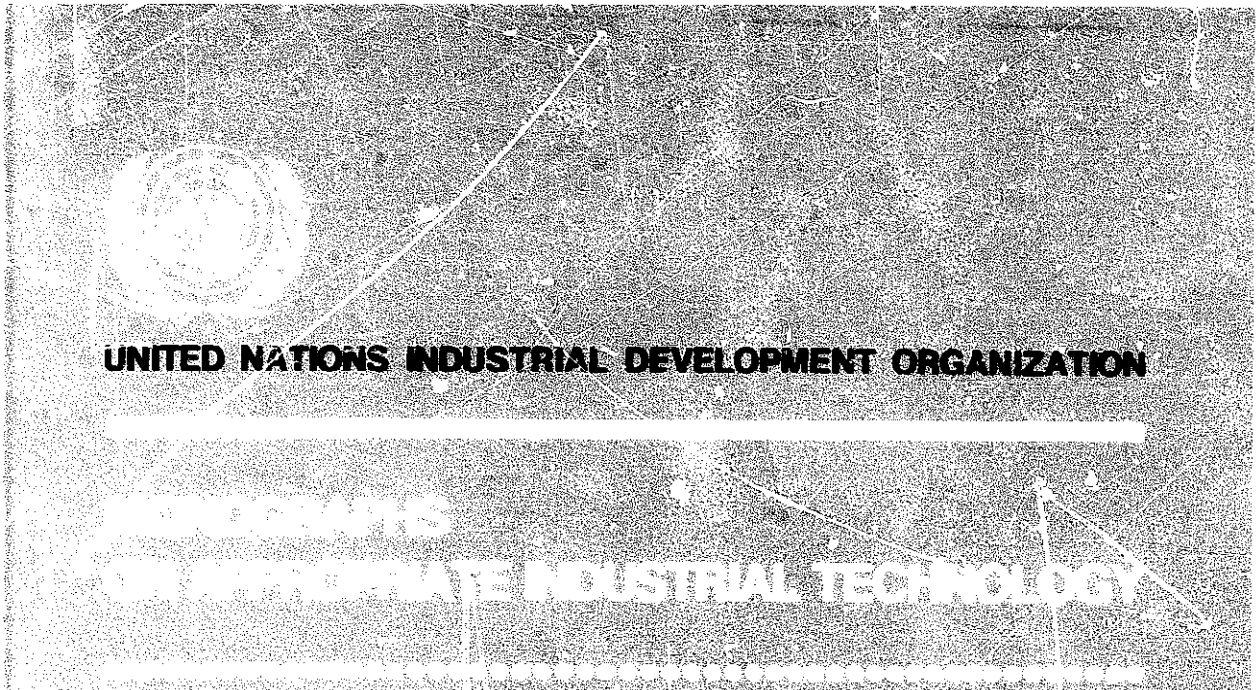

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

No. 4

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR AGRICULTURAL MACHINERY AND IMPLEMENTS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Monographs on Appropriate Industrial Technology
No. 4

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR AGRICULTURAL MACHINERY AND IMPLEMENTS

UNITED NATIONS
New York, 1979

EXPLANATORY NOTES

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

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

A slash (/) is used to indicate "per", for example t/a = tonnes per annum.

A slash between dates (for example, 1979/80) indicates an academic, crop or fiscal year.

A dash between dates (for example, 1970–1979) indicates the full period, including the beginning and end years.

References to dollars ($) are to United States dollars.

References to rupees (Rs) are to Indian rupees. In October 1978 the value of the rupee in relation to the dollar was $1 = Rs 7.90,

The word billion means 1,000 million.

The word lakh means 100,000.

The following notes apply to tables:

Three dots (. . .) indicate that data are not available or are not separately reported.

A dash (–) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units (SI), the following have been used:

Commercial term

c.i.f.	cost, insurance and freight

Organizations

ASTM	American Society for Testing and Materials
CFTRI	Central Food Technological Research Institute
CMERI	Central Mechanical Research Institute
FAO	Food and Agriculture Organization of the United Nations
GTT and TS	Government Tractor Training and Testing Station
ICAR	Indian Council on Agricultural Research
IIS	Indian Institute of Sciences
ILO	International Labour Organisation
INTIB	Industrial and Technological Information Bank
IRRI	International Rice Research Institute
ISI	Indian Standards Institution

EXPLANATORY NOTES *(continued)*

NIAM	National Institute of Agricultural Mechanization
PTC	Pakistan Tractor Corporation
SAE	Society of Automotive Engineers
SIDO	Small-Scale Industries Development Organization
TAMTU	Tanzania Agricultural Machinery Testing Union
TANU	Tanzanian African National Union
UFI	Ubungo Farm Implements Limited
UNESCO	United Nations Educational, Scientific and Cultural Organization

Technical abbreviations and symbols

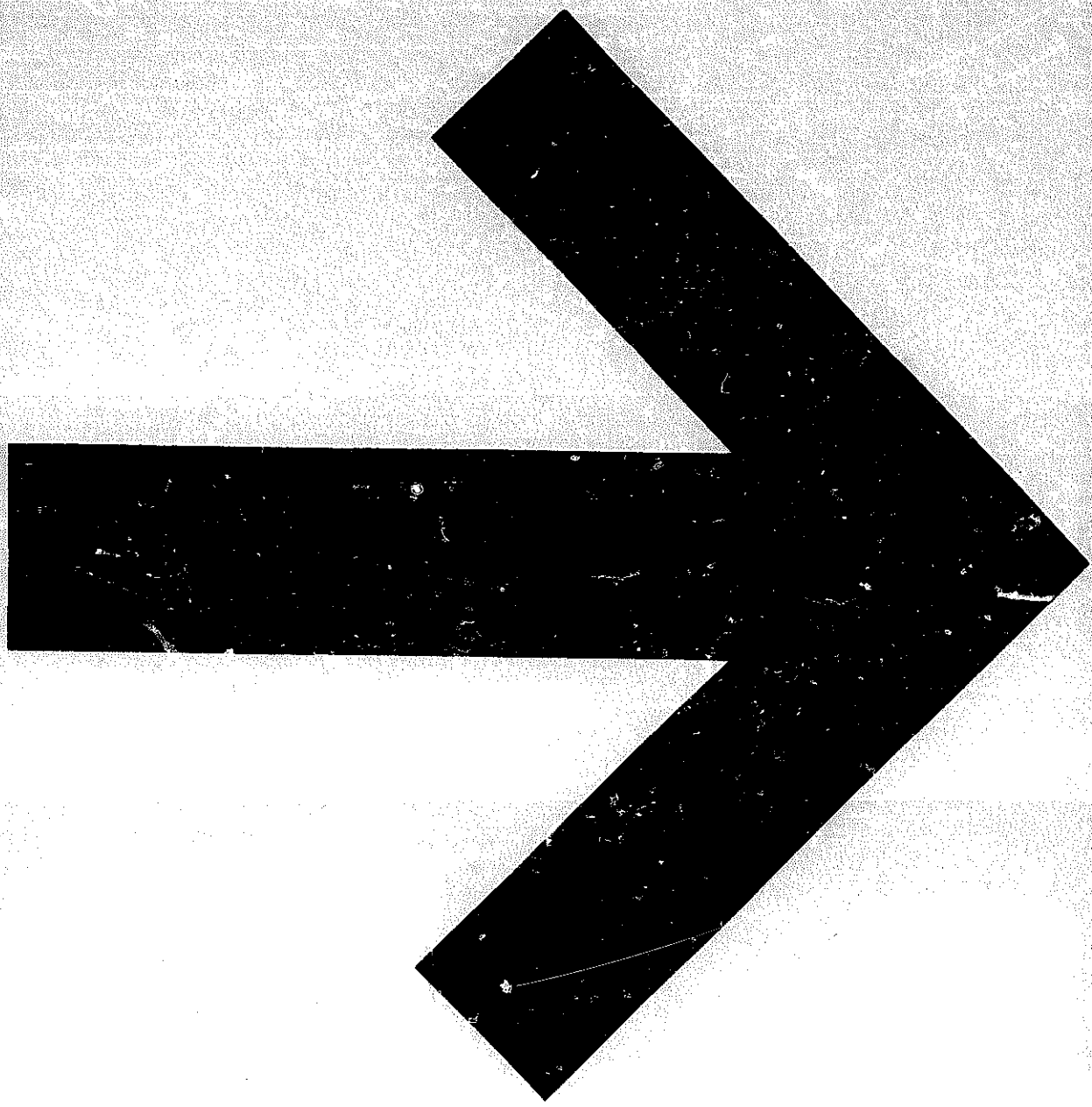
(with approximate metric equivalents)

BS	British Standard
DP	diameter pitch
EOT	external overhead transport
ft	foot (1 ft = 30.5 cm)
gal (Imp)	British Imperial gallon (1 gal (Imp) = 4.546 litres)
gal (US)	United States gallon (1 gal (US) = 3.785 litres)
gph	gallon (Imperial) per hour
hp	horsepower (1 hp = 746 W)
HSS	high-speed steel
in.	inch (1 in. = 2.54 cm)
lb	pound (1 lb = 0.4536 kg)
LH	left hand
mph	mile per hour (1 mile = 1.609 km)
MS	mild steel
psi	pound per square inch (1 psi = 0.069 bar)
PTO	power take-off
R and D	research and development
RH	right hand
rpm	revolution per minute
SWG	standard wire gauge

The concept of appropriate technology was viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries.

It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals. It was noted that, in most developing countries, a major development objective was to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time, some developing countries were faced with considerable shortage of manpower resources; in some other cases, greater emphasis was essential in areas of urban concentration. The appropriate pattern of technological choice and application would need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

Report of the Ministerial-level Meeting, International Forum on Appropriate Industrial Technology



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Foreword

As part of its effort to foster the rapid industrialization of developing countries, the United Nations Industrial Development Organization (UNIDO), since its inception in 1967, has been concerned with the general problem of developing and transferring industrial technology. The Second General Conference of UNIDO, held at Lima, Peru, in March 1975, gave UNIDO the specific mandate to deal in depth with the subject of appropriate industrial technology. Accordingly, UNIDO has initiated a concerted effort to develop a set of measures to promote the choice and application of appropriate technology in developing countries.

Appropriate industrial technology should not be isolated from the general development objective of rapid and broad-based industrial growth. It is necessary to focus attention on basic industrial development strategies and derive from them the appropriate technology path that has to be taken.

The Lima target which, expressed in quantitative terms, is a 25 per cent share of world industrial production for the developing countries by the year 2000, has qualitative implications as well. These comprise three essential elements: fulfilling basic socio-economic needs, ensuring maximum development of human resources, and achieving greater social justice through more equitable income distribution. Rapid industrialization does not conflict with these aspirations; on the contrary, it is a prerequisite to realizing them. But, in questioning the basic aims of development, we also question the basic structure of industrial growth and the technology patterns it implies.

Furthermore, it is easy to see that the structure of industrial growth that should be envisaged and the corresponding structure of technology flows should be different from what they are today; a fresh approach is called for. This does not mean that the flow of technology to the modern sector and the application of advanced technologies are unnecessary. On the contrary, it is essential to upgrade the technology base in general, and it is obvious that to provide basic goods and services, there are sectors of industry where advanced or improved technology is clearly necessary. It would be difficult to envisage a situation where the dynamic influence of modern technology is no longer available for industrial growth and development in general. However, an examination of the basic aims of industrial development leads to the conclusion that there must be greater decentralization of industry and reorientation of the design and structure of production.

Such decentralized industry in the developing countries calls for technologies and policy measures that often have to be different from those designed for the production of items for a different environment, that of the developed countries. As a result, there is a two-fold, or dualistic, approach to

an industrial strategy. Morever, the two elements in such an industrial strategy need to be not only interrelated but also integrated.

In approaching the question of appropriate industrial technology from an examination of basic development needs, a mechanism is necessary to link and integrate appropriate industrial technology to the overall development process. Through such a process the concept of appropriate industrial technology could be placed in the mainstream of the industrial development effort.

It is hoped that these monographs will provide a basis for a better understanding of the concept and use of appropriate industrial technology and thereby contribute to increased co-operation between developing and developed countries and among the developing countries themselves.

It is also hoped that the various programmes of action contained in the monographs will be considered not only by the forthcoming meetings of the United Nations Conference of Science and Technology for Development and UNIDO III but also by interested persons working at the interface over the coming years.

Abd-El Rahman Khane
Executive Director

Preface

To focus attention on issues involved in choosing and applying appropriate technology, UNIDO organized the International Forum on Appropriate Industrial Technology. The Forum was held in two parts: a technical/official-level meeting from 20 to 24 November 1978 at New Delhi and a ministerial-level meeting from 28 to 30 November 1978 at Anand, India.

In response to a recommendation of the ministerial-level meeting, UNIDO, with the help of a generous contribution by the Swedish International Development Authority, is publishing this series of monographs based mainly on documents prepared for the technical/official-level meeting. There is a monograph for each of the thirteen Working Groups into which the meeting was divided: one on the conceptual and policy framework for appropriate industrial technology and twelve on the following industrial sectors:

Low-cost transport for rural areas
Paper products and small pulp mills
Agricultural machinery and implements
Energy for rural requirements
Textiles
Food storage and processing
Sugar
Oils and fats
Drugs and pharmaceuticals
Light industries and rural workshops
Construction and building materials
Basic industries

The monograph on the conceptual and policy framework for appropriate industrial technology also includes the basic part of the report of the ministerial-level meeting and some papers which were prepared for the Second Consultative Group on Appropriate Industrial Technology, which met at Vienna, 26-29 June 1978.

PART ONE

Issues and considerations

Note by the secretariat of UNIDO

INTRODUCTION

World trade in agricultural machinery and the closely allied subgroups represents one fifth of the total trade described under the broad classification "machinery non-electric". Trade has more than quadrupled in value during the period 1967–1975, growing from $4,581 million in 1967 to $19,210 million in 1975. Imports of agricultural machinery and pumps into developing countries accounted for 26 and 34 per cent, respectively, of total world trade in these two sectors. Statistical returns since 1974 have indicated a marked increase in the share of world trade accounted for by imports of agricultural machinery and allied subgroups into the developing countries. In addition to trade that originated in the principal exporting countries and which is reported in international statistics, there are imports of agricultural hand tools, animal-drawn equipment, simple machinery and specialized power-operated machinery that are not reported, as well as internal trade from the manufacture of agricultural machinery for local use.

Projections up to the year 2000 require that the rate of growth be increased, the possibility of which has been demonstrated through the intensification of crop production by increasing the energy inputs into agricultural development. If inputs of mechanical power were to be raised to a modest level of intensification of 0.375 kW/ha, it would mean doubling existing power inputs in Asia and Latin America and increasing them tenfold in Africa.

The growing requirements for foreign exchange to pay for imports of agricultural machinery makes local manufacture a necessity. It is, however, more important that, in predominantly agricultural countries, there be a balance between industrial and agricultural development; that is, the pattern of industrial development should be in close support of the agricultural development, and vice versa, in any given country.

Broadly speaking, there are four categories of farm machinery, which fit recognizable patterns of farm mechanization and which require different levels of manufacturing skills. They are:

(a) Implements and tools that are simple to manufacture and operate. Hand tools, animal-drawn machines and simple processing equipment are in strong demand in most countries. The manufacture of such equipment, either in traditional or improved form, is dominated by small to medium-scale production units, using mainly simple forging, welding and drilling facilities;

(b) Intermediate equipment. Improved designs in ploughs and harrows to speed cultivation, weeders and sprayers, pumps and appropriate irrigation equipment, and trailers for transport are required for the intensification of

cropping. The manufacture of such machines is dominated by medium-sized workshops with machining, forging and welding facilities. Manufacturers of such machinery need well-proved designs and access to a supply of suitable castings, bearings and various grades of steel;

(c) Power-operated machinery. Tractors, power tillers, threshers and dryers, as well as more complex pumping equipment are necessary to meet the timely requirements of cultivation, planting and harvesting, especially where multiple cropping is practised. The manufacture of such machinery, which is dominated by large centralized factories, requires an adequate infrastructure in the metallurgical and capital goods industry such as foundries, forging, heat treatment, precision machining and quality control facilities;

(d) Specialized machinery. Self-propelled harvesting machinery and crop processing equipment with a high potential for saving labour is used in the advanced stage of farm mechanization. The production of such machines needs a skilled metallurgical industry, high capital goods production facilities and well-developed design and engineering capabilities. Machinery for land development also falls into this category.

The share of developing countries in the world production of agricultural machinery varies according to the types of equipment considered. It ranges from 90 per cent of hand tools to 20 per cent for simple tractor-drawn machines and 10 per cent of tractors to a very small figure for the more elaborate machinery. Overall, the proportion is estimated to be about 5 per cent. The policy planning and promotional aspects of the agricultural machinery industry must be assessed country by country and region by region, grouping countries, where possible, into those with similar soils and climatic conditions and perhaps other common agricultural factors such as similarity of crops. In the tropics, the identification of common problems, the sharing of experience between countries relating to the production and use of specialized machinery, the adaptation of machinery on a regional or subregional basis and the role of research and development (R and D) institutes, must be considered.

I. OBJECTIVES

As the agricultural machinery and implements industry deals with a large variety of products, from hand tools, animal-drawn implements, hand-operated machines, irrigation equipment and crop protection machinery to power-operated machinery and equipment, such as tractors, power tillers, engines, harvesters and threshers, the problems of the industry and the policy objectives for the development of this sector vary in nature and magnitude. The industry covers a wide spectrum of technology from small-scale workshops to transnational corporations. It involves the metal working and metallurgical sectors and the automotive and electrical engineering sectors at different levels of product ranges.

In the context of the decentralization of industry and examining alternative technologies with socio-economic benefits in the field of agricultural machinery and equipment, the following would be the objectives:

(a) To provide an industrial input to modernize and mechanize agricultural productivity and production;

(b) To reduce human drudgery by making tools and implements available to replace human labour in agricultural production and farm work;

(c) To attain self-sufficiency in food crops and agricultural raw materials for processing industries;

(d) To develop design and engineering capabilities with a view to promoting the commercial manufacture of agricultural tools, equipment and machinery suited to small- and medium-sized farms;

(e) To facilitate greater dispersal of industrial growth to less developed and rural areas by developing rural industries to produce agricultural tools, equipment and machinery;

(f) To generate employment in the manufacture of tools and equipment and also in activities resulting from intensive and extensive cultivation and increased agricultural production;

(g) To develop national technological capabilities in design and engineering and the manufacture of prototype equipment to meet local manufacturing conditions;

(h) To exchange information on farm mechanization programmes and selected technological developments in the field of agricultural machinery, implements and tools.

II. REVIEW OF ALTERNATIVE TECHNOLOGY

Alternative agricultural mechanization systems

Trends in agricultural mechanization

In general, the trends of agricultural mechanization seem to be highly complex. The various patterns of simple and sophisticated trends in mechanization, those usually practised both in the developed and the developing worlds, postulate that the stages of agricultural mechanization could be considered a system of technological levels.

During the last two decades the developing countries have devoted attention to the mechanization and reorientation of farming systems, considering the relative costs of machinery, equipment, labour and other relevant factors. It is estimated that about 60 per cent of the agricultural producers in developing countries are users of traditional hand tools and simple animal-drawn equipment. In vast areas, the cultivation of crops depends primarily on seasonal rainfall. The cultivation techniques are often based on traditional methods. To a great extent, agricultural tools are modified to meet traditional demands. The overall trend in mechanization in the developing countries can therefore be divided into three distinct technological levels:

Level I: the manual and animal-draught system

Farming is carried out with a wide variety of traditionally designed hand

tools such as shovels, spades, spading forks, digging hooks and hoes, and animal-drawn agricultural implements and allied simple equipment.

Level II: the mixed mechanization system

Farmers partly use hand tools and partly a combination of animal-drawn equipment and walking-type, power-driven equipment such as animal-drawn cultivators and ridgers and simple walking-type power-driven tillers. Sometimes a mixed use of small tractors with subsequent operations with hand tools is also found.

Level III: the advanced mechanization systems

Farming is carried out with advanced power-driven machinery, such as tractors of up to 70 hp (53 KW) with associated equipment such as 2- or 3-furrow disc ploughs, tillers with 9 and 11 tines, tiller seeding and attachments, paddy disc harrows, offset disc harrows, subsoilers, multipurpose blade terracers, reversible ploughs, ridgers and mounted disc harrows. The combine harvester is seldom used.

Although great efforts have been made by many developing countries to produce modern farming equipment, mechanizable forms of agriculture are limited in many of them by geographical, climatic, environmental and agrarian constraints and socio-economic factors.

Mechanization policy at the farm level

In farms below 2 ha, where farming is carried out in a traditional way, using hand tools and animal-drawn equipment with little or no purchase of inputs of level I, the mechanization policy should be based on:

Improved supplies of high-yield seeds and fertilizers and single or double cropping;

High-quality hand tools such as spades, spading forks, digging hooks and hoes, shovels, ploughs and single wheel hoes;

Animal-drawn ridgers, cultivator ploughs and seed drills;

Low-cost simple power tillers;

Effective irrigation and water supply by means of windmills with up to 5 ft (1.5 m) lift or small electric or diesel pumps of up to 15 ft (4.5 m) lift;

Hand-drills, sickles, scythes, forks, and rakes;

Hand-operated threshers, crushers etc.;

Storage bins of up to 3 t capacity.

In medium farms of 2 to 5 ha where farming is done with either animal-drawn implements or small tractor-drawn equipment (level II), the mechanization policy should be broadly based on:

High-yield seeds and fertilizers for double and multiple cropping;

Mechanically powered 5 to 8 hp (3.5 to 6 kW) power tillers and small riding tractors of 15 to 18 hp (12 to 16 kW);

Animal-drawn implements or tractor-drawn implements up to 18 hp (14 kW);

Animal or mechanically powered drillers and seed distributors;

Effective irrigation water supply through diesel or electric pumps up to 6 hp (4.5 kW);

Mechanically powered or animal-drawn harvesters;

Animal or mechanically powered crushers, shellers, threshers etc.;

Storage bins of up to 5 t capacity.

Farms over 5 ha in area are regarded as large, and the mechanization policy for them would be based more on the application of mechanically powered equipment and implements (level III). The elements for consideration are as follows:

Application of seed irrigation fertilizer technology, with multiple cropping;

Application of mechanized cultivation based on conventional four-wheel tractors with a capacity of 15 to 40 hp (12 to 30 kW) having power take off (PTO) attachments to suit the following:

Disc plough: 2- and 3-furrow, 26 in. (66 cm) diameter disc, 3/16 in. (3 cm) thick;

Mould-board ploughs: 2- and 3-furrow, fitted with disc coulters and skimmers;

9- and 11-tine tiller shovels capable of tilling to 9 in. (22 cm);

Tiller seeding attachment;

Paddy disc attachment;

Off-set disc harrow;

Sub-soilers etc.;

Applications of drillers and distributors;

Effective irrigation water supply by diesel or electric pumps over 6 hp (4.5 kW). The water supply to be obtained from the national irrigation channel or network;

Power-driven crop protection equipment;

Power-driven combine harvester 7–15 ft (2–4 m);

Power-driven cleaner, thresher, dryer;

Storage silos, 10 to 1,000 t.

To provide adequate quantities of appropriate tools and equipment to these farms in developing countries, a wide range of simple and low-cost power-driven equipment is needed that can be produced in the rural industries or even at the small-scale or artisan level.

The developing countries in tropical areas are traditional users of hand tools and tillage equipment. Many of these types of equipment are designed locally with traditional methods and technical skills; their application also varies from country to country.

Overall national mechanization policies should be based on achieving a gradual transition in an optimum way so that it would take place at the appropriate level of mechanization, which mainly depends on energy sources, farm size, the skills and attitudes of the farmers, access to credit, markets, and effectiveness of the extension services. Therefore, the trend of mechanization

should be a gradual development from manual farming to manual and animal-assisted farming and from animal- and power-assisted farming to power-assisted farming.

Alternative technologies in the production of equipment

There is a relative change in the pattern of technology at various scales of manufacturing, which is greatly influenced by the product manufactured, its production volume, its method of production and the sizes of the manufacturing enterprises. The present sizes of the agricultural machinery manufacturing units observed in the developing countries are as follows:

Family-type, worker-owner enterprises employing 1–5 persons;

Small-scale enterprises employing 15–100 persons;

Medium- and large-scale enterprises employing more than 100 persons.

In units of the first category, agricultural equipment is manufactured manually, seldom with the application of power tools or machinery. The products are simple agricultural hand tools, hand-operated implements and selected animal-drawn implements. The small manufacturing units are mostly scattered throughout village and urban areas.

In the second category, small-scale enterprises, the manufacture of agricultural equipment is carried out mechanically on a production line basis. The products are animal-drawn implements, medium- or large-volume hand tools, and selected agricultural equipment such as pumps, crop protection equipment, and sprayers. These small plants are normally situated in urban areas, in the industrial estates of specific rural areas, but seldom in the countryside.

In the third category, medium- and large-scale industries, the manufacture of agricultural machinery and equipment is carried out by means of conventional, semi-automatic, automatic and special-purpose machine tools depending on the volume of production, the degree of precision required and the magnitude of investment. The products manufactured are powered agricultural combination machines such as tractors, tillers, ploughs, power tillers, disc ploughs, pumps, sprayers and integrated storage systems. The medium- and large-sized plants or complexes are mostly situated in urban, or rural-urban border areas, or in industrial estates.

III. TYPICAL LEVELS OF PRODUCTION OF AGRICULTURAL MACHINERY

The manufacture of agricultural machinery in the developing countries, including the least-developed ones, also operates at various technological levels. The three principal levels and the facilities that exist within their plants are described below.

Industries at technology level I–the family-operated system

These production units normally operate on the family, artisan or worker-owner basis. Small workshops are scattered throughout the rural and urban areas of most developing countries. The owners are usually local blacksmiths who produce simple hand and animal-drawn implements for local farmers. A number of Governments in Africa, Asia, Latin America and the Middle East have given priority to this sector in their national development plans.

Industries at technology level II–small-scale industries

Between 40 and 50 developing countries are engaged in manufacturing agricultural machinery and implements of this level. Most of these industries are situated in urban areas in rural/urban border areas and in industrial estates.

The number of such enterprises is increasing. Furthermore, in urban areas, there is a definite trend towards family units at technology level I which would be able, with government assistance, to expand their activities and become small-scale units at technology level II. This development is very common in some countries of Asia, Latin America and the Middle East.

Industries at technology level III–large- and medium-scale industries

Between 20 and 25 developing countries are engaged in manufacturing agricultural machinery and implements on this level. Most of these large industries and complexes are situated in or near urban areas or in industrial estates.

Thus it can be seen that there are vast gaps between the three technological levels of manufacturing industries for agricultural machinery, equipment and tools in the developing countries. To some extent, it is possible to improve the levels of technology. For example, with large inputs of capital, management and marketing, improvements in the technology from level II to level III could be achieved. First, however, it will be necessary for the developing countries to modernize their existing industries operating at level I by improving the skills and efficiency of the producers and the quality of their products.

The present problems and future trends of establishments at technology level I

The establishments engaged in manufacturing hand tools and simple implements as described in technology level I exist in greater number in all of the major developing and least developed countries. In most cases they work under great handicaps, some of which are:

(a) Inadequate finance and unstable markets;

(b) Lack of low-cost improved production facilities;

(c) Lack of improved designs;

(d) Lack of suitable materials, particularly high-carbon steel and hardware;

(e) Lack of suitable machinery and equipment, and heat-treatment facilities;

(f) Lack of suitable production technologies.

In order to improve this sector, the following points need special consideration:

(a) Bulk purchase of raw materials and subsequent distribution at reduced prices;

(b) Financial assistance through credit for purchase of raw materials and machinery based on an intermediate level of technology;

(c) Supply of low-cost water and electrical power;

(d) Introduction of product mix operations;

(e) Supply of improved designs.

(f) Intensification of training facilities.

It would be desirable for the relevant governmental and international institutions to offer adequate technical and financial assistance to this sector in order to maintain its steady growth and generate employment.

The present problems and future trends of small, medium- and large-scale industries at technology levels II and III

The problems encountered in industries manufacturing agricultural machinery and equipment at technology levels II and III are somewhat different. The main problems can be summarized as follows:

(a) Lack of sufficient internal markets and export outlets;

(b) Lack of suitable designs. In many cases those supplied by foreign collaborators need modification for local use;

(c) Uncertainties in supply of spare parts, which often lead to machine breakdowns and plant stoppages;

(d) Higher production costs caused by low productivity;

(e) Increasing prices of raw materials;

(f) Lack of technical personnel at the middle management level;

(g) Lack of training facilities, particularly at the operator level;

(h) Insufficient working capital;

(i) Substitution of high-quality parts with lower-quality ones to save money. This is false economy and reduces customer satisfaction.

There is no overall solution to these problems. Individual agricultural machinery manufacturing units must analyse all of the major problems that hinder their production. Financial demands could be met through various institutional facilities available at national, regional or even international levels, but it would be more important to invest adequate funds in training and maintenance. Owing to import restrictions, many developing countries and particularly those in Asia, Latin America and the Middle East, have inherent demands for domestically produced agricultural machinery. Eventually, equipment manufactured locally should conform to accepted quality and price requirements.

IV. Policy

It is necessary for each national Government to define an agricultural mechanization plan and programme; the elements of technological development should be a part of the national technology development plan. In the development of such a plan, the following policy aspects may be given due consideration:

(a) The promotion of appropriate farm mechanization and the review of long-term trends in relation to production;

(b) The promotion and co-ordination, at the national level, of the development and manufacture of small- and medium-size agricultural machines and tools;

(c) The study of problems associated with providing credit, training, repair and maintenance, organization and service facilities for farm mechanization.

Since R and D, as well as design and engineering capabilities, cannot be developed by small- and medium-scale manufacturing units, it becomes the responsibility of the Government to establish or strengthen a national agricultural machinery development institute that should have the following functions:

(a) Testing and evaluation;

(b) Design and development;

(c) Fabrication of prototype equipment to meet local manufacturing conditions;

(d) Selection, evaluation and supply of suitable designs and prototypes of appropriate machinery;

(e) Adaptive R and D of machinery for local manufacture;

(f) Promotion of local manufacture of appropriate agricultural machinery, tools and equipment;

(g) Serving as a clearing house for the collection, analysis and dissemination of information;

(h) Organization of training programmes.

In order that these activities may be co-ordinated, it is suggested that a suitable linkage be established with the relevant Government departments and organizations.

At the regional level, a co-ordinating focal point with suitable linkages could be established for regional institutes on the lines of a network. The regional network for agricultural machinery established at Los Baños in the Philippines is an example of this.

In the exercise of regulatory measures by the Government, financial and credit policies should be reviewed so that the production programmes will meet policy requirements, and the production of equipment not included in the national technology development plan will be discouraged. Standardization and the enforcement of quality control would also become the responsibility of the national Government. The enforcement of the use of test codes for various types of equipment and also for testing and certification is important.

V. Role of international co-operation

The technological aspects in which international co-operation would be required are in strengthening the capabilities of national institutes to test, evaluate, design, develop and fabricate prototype equipment to suit local manufacturing conditions and to establish appropriate methods for testing and evaluation. Such co-operation may also help to build up their capability to select and evaluate suitable designs and to analyse prototype product performance.

Also the R and D capabilities of the national institutes could be strengthened through the provision of consultancy services, training facilities and available designs and prototypes of the required agricultural machines and tools.

The developed countries and their institutional and manufacturing agencies might assist in the development of specific items of equipment such as walking tractors, low-cost riding tractors, transportation equipment and simple engines suitable for use in developing countries.

The developed countries could also consider allocating resources for the promotion of design and engineering capabilities and product development in the developing countries. They could assist in the establishment of pilot and demonstration units for the small- and medium-scale production of equipment and eventually in the establishment of commercial manufacturing units.

Within the framework of the national agricultural machinery development plan, international co-operation could also take the form of assistance to the developing countries to develop local manufacturing programmes through licensing, starting with assembly and moving on to a progressive increase in the domestic production of components. Such measures would call for the development of local supporting industries such as foundries, forges and gear plants to bring about technology transfer including training, management and adaptation of technology to suit local conditions.

The dissemination of R and D, new design and engineering developments, prototypes, farm mechanization policies and the exchange of experiences would be extremely useful to the manufacturing units in developing countries.

The establishment of decentralized repair and maintenance service facilities, with appropriate training facilities and extension services, would also fall into the domain of international co-operation. The developed countries and their institutions could assist both technically and financially in this respect so as to be consonant with the social and cultural values of the developing countries.

Report of the Working Group

There is considerable diversity between various developing countries as to the level of mechanization that can be appropriately introduced. Conditions such as crops, agricultural practices, sizes of farms, population densities, levels of employment, wage structure, industrial development, and the time frame for mechanization are all important and will dictate the level of mechanization. It is also accepted that most developing countries will have mixed levels of mechanization technologies for a long time. A judicious upgrading of the technology for mechanization is therefore necessary to increase food production and achieve socio-economic goals.

Thus for each country the appropriate mechanization technology mix will have to be arrived at keeping in mind the prevailing economic, human and social constraints and the necessity to incorporate available sources of energy. In most developing countries, farms can be broadly categorized in three groups according to size: small, medium and large. Appropriate mechanization strategies will have to be applied for each group.

The overall trends in mechanization in developing countries can be divided into three distinct levels.

Level I: Manual systems; where farming is carried out with traditionally designed hand tools, for example, shovels, spades, forks, hoes, sickles etc.

Level II: Mixed mechanization systems; where farmers partly use hand-operated tools and partly a combination of animal-drawn equipment and walking-type power-operated equipment, for example, animal-drawn cultivators, animal-drawn ridgers and simple walking-type power tillers. Sometimes small tractors suppiemented by hand tools are also used.

Level III: Advanced mechanization systems where farming is carried out with advanced power-operated machinery, such as large tractors with associated equipment.

MANUFACTURE OF AGRICULTURAL MACHINERY AND IMPLEMENTS

1. Product groups

The agricultural machinery appropriate for a country must be compatible with its political, economic, agricultural and industrial systems. Broadly speaking there are four categories of farm machinery, which conform to

recognizable patterns of farm mechanization and require different levels of manufacturing skill. The four categories are as follows:

(a) Implements that are simple to manufacture and operate

Hand tools, animal-drawn machines and simple processing equipment. Manufacture of such equipment, either in traditional or improved form, is dominated by artisan level to small and medium production units, using mainly simple forging, welding and drilling facilities.

(b) Intermediate machinery that is relatively easy to manufacture and operate

Better ploughs and harrows to give quicker cultivation, weeders and sprayers to control pests and disease, pumps and appropriate irrigation equipment, simple threshers and dryers for grain processing, trailers for transport etc. Manufacture of such machines is dominated by small- and medium-sized workshops with machining, forging and welding facilities. Manufacturers of such machinery need well-proven designs and access to a supply of suitable castings, bearings and steels.

(c) Powered machinery that requires a higher degree of manufacturing technology

Simple and low-cost tractors, power tillers as well as more complex pumping equipment necessary to meet the time requirements of cultivation, planting and harvesting, especially where multiple cropping is practised. Manufacture of such equipment, which is dominated by large centralized factories, requires an adequate infrastructure in the metallurgical and capital goods industry, such as foundries, forging, heat treatment, precision machining and quality control. There is scope for multinational, regional and subregional co-operation in the manufacture of powered machinery.

(d) Tractors, engines and allied machinery that require a relatively higher degree of manufacturing technology

Medium and large tractors, self-propelled harvesting machinery and crop processing equipment with a high potential for saving labour and avoiding losses. Production of such machines needs a skilled metallurgical industry, high-capital production facilities and good capability in R and D. Machinery for land development is also in this category. There is scope for increased multinational, regional and subregional co-operation in this area.

II. Future trends in developing countries

The following are the trends in agricultural machinery application and local manufacture in developing countries.

The least developed among the developing countries will emphasize products which will involve small-scale production and intermediate technology. They will give more emphasis to local production of hand tools, simple hand-operated machines and animal-drawn implements. There will be more flow of information and assistance from more developed countries among the

developing to the least developed countries in the manufacture of these items, as most of the industrialized countries have discontinued hand-operated machines and animal-drawn equipment. Such countries will continue to import tractors, engines, pumps and power equipment on a limited scale.

In the middle group of developing countries, in addition to hand tools, hand-operated machines and improved animal-drawn implements, there will be emphasis on the local manufacture of certain tractor-drawn simple implements, irrigation pumps, power threshers, small engines and selected crop protection equipment. Import of tractors and other power equipment will be continued. Countries will look for foreign collaboration in the manufacture of small engines and in some cases, of pumps. Countries will emphasize improvement of the existing metal working industry and a diversified production programme for agricultural machinery and implements production. They will continue to import steels, though small foundries will be set up for iron casting. They will also emphasize development, adaptation, and prototype manufacture of hand-operated machinery and animal-drawn as well as simple tractor-drawn implements. They will encourage co-operative usage and hiring stations for tractors and power machinery, emphasize establishment of repair and maintenance workshops, mobile servicing units and training of mechanics.

In the more developed among the developing countries emphasis will be given to local assembly and manufacture of a full range of agricultural machinery and implements including tractors. Combine harvesters, balers, mowers and hay conditioners, if required in small numbers, may continue to be imported. Due to the increased demand, these countries will emphasize expansion of production to pumps, small engines, crop-protection equipment and tractor-drawn implements. In addition to expanding production volumes of tractor-drawn implements such as cultivators, harrows and mould-board ploughs, emphasis will be given to manufacture of disc-ploughs, multi-seed drills and fertilizer distributors, row crop planters and specialized equipment for selected crops, and seed treaters, dryers as well as storage bins and grain-handling equipment and trailers. Although medium and large four-wheel standard tractors will generally be assembled and manufactured with foreign collaboration, serious attention will also be given to the development and identification of small low-cost tractors for local manufacture. Certain selected countries will also introduce local manufacture of combine harvesters.

III. Levels of technology and production

Considering alternative technologies in production of farm equipment, there is a relative change in the pattern of technology at various scales of manufacturing which is greatly influenced by the product manufactured and volume of the product. Present sizes of the agricultural machinery manufacturing units observed in the developed countries are:

First level: family type of ownership units

Manufacture of agricultural equipment is carried out in traditional family-type units by manual operation seldom using power. Products

manufactured are simple agricultural hand tools, hand-operated implements and selected animal-drawn implements. Establishments are mostly scattered from urban to village level.

Most of these units are small workshops scattered in the rural and urban areas of developing countries. Most of the owners are local blacksmiths and produce simple hand and animal-drawn implements for the local farmers. A number of Governments in Africa, Asia, Latin America and the Middle East have given priority consideration to enlarging this sector by including them in their national development plans.

In most cases however they suffer from great handicaps such as lack of finance, assured markets, power, proper design, suitable raw material, particularly high carbon steels etc.

Second level: small-scale industries

Manufacture of agricultural equipment is carried out mechanically on a commercial basis and products manufactured are: animal-drawn implements, medium or large volume hand tools, and selected agricultural equipment, mainly pumps, crop protection equipment etc. These small plants are situated in urban and semi-urban areas.

Between 40–50 developing countries are engaged in manufacturing agricultural machinery and implements in industries of technology level II.

An increasing number of industries at technology level II are coming up in developing countries. There is also the trend of family enterprises in urban areas (technology level I) to enlarge their activities and form small-scale industries at technology level II with governmental assistance.

Third level: medium- and large-scale industries

Manufacture is carried out by conventional, semi-automatic and special-purpose machine tools on a high-volume, high-precision and high-investment basis. Products manufactured are engines and motors, tractors, power-tillers, pumps, sprayers etc. These industries are mostly situated in urban or semi-urban areas and in industrial estates.

Between 20–25 developing countries are engaged in manufacturing agricultural machinery and implements at this level.

IV. Research and Development

Development of agricultural machinery does not reflect their special relationship to total agricultural production.

R and D work does not usually reach the farmers. Market research, industrial extension and agricultural engineering extension links are absent.

Professional associations and societies in areas of agricultural machinery have been formed in some countries but are in the formative stages.

POLICIES AND PLANNING AT NATIONAL AND REGIONAL LEVELS

Within the framework of national development plans, and with due consideration to the allied agricultural development and industrialization plans, a national agricultural mechanization plan should be prepared. Socio-economic considerations should form the basis of such plans. The agricultural mechanization plan should be translated into viable agricultural machinery and implement development programmes on a short- and long-term basis. It should consider national requirements and give due consideration to possible regional co-operation.

In the formulation of the plan, the following areas should receive attention:

(a) Appropriate farm mechanization and review of long-term trends in relation to production;

(b) Programmes for development of trained manpower for R and D, manufacturing, repair and maintenance, operation and extension should be organized;

(c) Local manufacture of agricultural machines and tools;

(d) Development of supporting industries, such as foundries, forges, heat-treatment shops and the promotion of integrated metallurgical and ancillary industries;

(e) Problems of credit, training, repair and maintenance and service facilities for farm equipment.

Policy planning and implementation machinery for agricultural equipment should be established at the national level and should include ministries such as agriculture, industry, planning, finance, labour and employment and the research groups.

In developing country organizations, scientists and technicians working on appropriate technology should be freely permitted to exchange information, drawings and experimental data. Governments of developing countries should not restrict this free flow of useful information between developing countries through enactment of laws and other restrictive regulations.

National Governments should put more emphasis on education and expand it in rural areas, with special attention to technical education, with the objectives of raising the productivity of operators and technicians and of improving product quality so as to work towards creating an industrially-conscious rural community.

Designs, testing and development centres at national and regional levels should be set up in close co-operation with agricultural institutions, and small and medium manufacturers, to inspire and guide a continuing programme of work on the evaluation and production of the types of agricultural machines tailored for the specific conditions in any developing country. The objectives of such centres should be adaptation and transformation into manufacture and commercialization.

Rationalization of manufacturing programmes, standardization, quality control and import substitution, enforcement of test codes, testing and

certification are important. Appropriate institutions should be strengthened or established.

With reference to agricultural tools, manually operated products, animal-drawn implements and simple machinery, national Governments of developing countries should upgrade and install their own manufacturing so as to become self-sufficient on a priority basis. Manufacture should preferably be undertaken in rural areas through rural artisans and small industries.

Regarding intermediate types of agricultural machinery and implements, developing countries should be encouraged to adapt, develop and locally manufacture selected products with emphasis on co-operation among developing countries for technology transfer from the relatively more advanced developing countries.

Regarding more sophisticated equipment such as tractors, engines and combine harvesters, Governments of developing countries and manufacturers, industrialized countries and selected developing countries should be encouraged to foster long-term arrangements to transform pure imports into phased local manufacture with emphasis on production technology, training, repair and maintenance under licensing agreements.

Developing countries which propose taking up manufacture of sophisticated equipment may do so under arrangements with some of the other developing countries which have already established the manufacture of similar products using technologies which may be more appropriate to developing countries.

Developing countries should be assisted by the United Nations Industrial Development Organization (UNIDO) through its activities such as the development and transfer of technology, the Industrial and Technological Information Bank (INTIB), sectoral studies, technical assistance and above all the First Consultation Meeting on Agricultural Machinery, 15–19 October 1979, Stresa, Italy. The objective of the consultation system is to promote co-operation between developing and industrialized countries and among developing countries themselves.

The need for development of agricultural machinery production would have to be assessed on a national as well as a regional basis. Countries having similar soil, climatic conditions and crops would greatly benefit through a common or complementary production programme. Identification of common problems, sharing of experience, adaptation of machinery on a regional or subregional basis and the role of R and D institutions, need to be considered.

PROGRAMME OF ACTION

Integrated programme at national levels

The Governments of developing countries should undertake an in-depth analysis of the options for agricultural mechanization and formulate programmes for the development and manufacture of appropriate agricultural machinery and implements with due consideration to policy and planning, and to the financial, R and D, institutional, technological, manufacturing and service

levels. It is recommended that appropriate United Nation Agencies such as UNIDO, the Food and Agriculture Organization of the United Nations (FAO), and the International Labour Organisation (ILO) should consider preparing "model case studies" for the benefit of other developing countries.

Manufacturing and promotion of hand tools, animal-drawn implements and related machinery

UNIDO should, through specific case studies in selected developing countries, develop manufacturing profiles and guidelines on development and manufacture of simple agricultural tools and machinery. Based on past and present work, UNIDO should in co-operation with interested developing countries and industrialized countries establish rural pilot manufacturing plants in some least developed countries for local production of simple agricultural tools and implements.

In the promotion of the above two activities, UNIDO should not only make aware the following criterion to the Governments of developing countries, but also incorporate it in the programme of action:

(a) Manufacture of simple hand tools needs to be encouraged in countries where such equipment is being currently imported;

(b) More productive results could be achieved in this category of equipment by improving manufacturing quality rather than R and D on new equipment. Efforts should be limited to introducing and testing tools from other areas and countries with similar agro-climatic conditions.

Manufacture of simple hand tools should be organized on a decentralized basis in the rural areas. Rural artisans and small entrepreneurs should be encouraged and assisted by the Government in an effort to develop production of simple hand tools in the rural areas.

Government policies must be reoriented to assist artisans in the rural areas. Major efforts are needed to encourage and revive production of hand tools by village artisans through provision of loans at concessional rates, technical assistance, provision of simple design and marketing assistance. Availability of requisite materials is one of the major constraints faced by rural artisans, which may be overcome by establishment of raw material banks.

Manufacturing and promotion of intermediate equipment such as power tillers, low-cost tractors etc.

There is a need to undertake an analysis of the successful development and manufacture of indigenous designs of equipment in this category achieved in many developing countries and to publish the results. Investment promotion and technology transfer activities for countries wishing to manufacture such equipment should be organized through workshops and exchange of technical personnel and entrepreneurs and prototypes as done earlier in Swaziland by UNIDO in co-operation with the Government.

There is a need to explore possibilities of co-operation between small and medium manufacturers of the industrialized as well as developing countries for

co-operation in product development, manufacturing and market extension of appropriate products. UNIDO, in co-operation with manufacturers' associations of industrialized countries and entrepreneurs of developing countries should endeavour to promote this co-operation.

The establishment of supporting industries such as small foundries, forges, heat-treatment units and integrated metal-working plants is very important to promote this category of equipment. UNIDO should promote this integration by taking specific countries as case studies.

Manufacturing and promotion of tractors, engines and related equipment

Within their national objectives, Governments of developing countries should analyse the feasibilities and technological alternatives. Governments may be assisted, upon request, by UNIDO in co-operation with FAO. UNIDO should analyse the experience of developing countries in this field through case studies, and make their findings available to other developing countries.

UNIDO should prepare model tenders and specifications for international bids for setting up manufacturing plants in developing countries and assist in the evaluation of offers and negotiations for technology transfer.

UNIDO should also develop guidelines for local manufacture under licence and technology transfer agreements covering aspects such as royalty, patents, training, management, technical services, fees, contributions of various parties, penalties etc. to serve as a guide to developing countries.

As a model, UNIDO, in co-operation with the Economic and Social Commission for Asia and the Pacific (ESCAP) should develop a complementary production programme for the Association of South-East Asian Nations (ASEAN) group of countries at the request of ASEAN. Such a study may serve as a model for regional co-operation in other areas with appropriate adaptation. In this case UNIDO may also organize a workshop for regional organizations and groups.

Design, development and commercialization

There is a need for international co-operation in promotion, establishment and strengthening of R and D, and also in commercialization of the results of such R and D. The international agricultural centres such as the International Centre for Agricultural Research in Dry Areas (ICARDA), the International Centre for Corn and Wheat Improvement (CIMYT), the International Centre for Tropical Agriculture (CIAT), the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA), the International Laboratory for Research and Animal Diseases (ILRAD), the International Livestock Centre for Africa (ILCA), the International Potato Center (CIP), and the International Rice Research Institute (IRRI) etc. can play an important role in this field.

Such centres may serve as links between manufacturers in developing and developed countries. International organizations, including UNIDO, should take the initiative in this direction.

It is essential to encourage international manufacturers to earmark certain resources and funds, preferably as a percentage of sales in developing countries,

to promote possible adaptation and local manufacture of appropriate equipment which is not produced in industrialized countries, but is greatly needed in many developing countries. UNIDO should promote this concept.

Regional level

Networks, such as the Regional Network for Agricultural Machinery (RNAM) should be established in other areas to disseminate information on agricultural machinery and to provide prototypes.

A full-fledged agricultural engineering research centre should be established to provide high level R and D and assistance to national centres. The network of international agricultural research institutions can be instrumental in this effort.

Regional and international networks should provide training opportunities for R and D workers with emphasis on practical application.

A journal should be published relating to R and D in agricultural machine design.

Regional and international research centres in co-operation with UNIDO should organize annual international meetings and workshops for increased co-operation.

Travelling rural exhibitions of appropriate agricultural machinery and implements that are manufactured locally, and by neighbouring countries, should be organized in co-operation with relevant United Nations organizations and regional commissions, with a view to educating farmers and assisting in market extension by the local small and medium manufacturers.

National level

Funds allocated for development of agricultural machinery should be increased.

Linkage between R and D institutions, and manufacturing units and extension agencies should be strengthened so that the technology developed eventually reaches the farmers. Training should be provided in product development and commercialization. Market research, industrial extension and agricultural engineering extension should be organized.

R and D work on tractors and other machinery should emphasize their possible extensive use in all seasons through the use of power take-off, belt pulleys for operating pumps and other mechanical work such as operating threshers, grinding mills and electrical generators.

Patents should be recognized as important instruments for encouraging innovation and providing recognition. However, the Governments and the developing countries should foster full exchange of such patents among developing countries when they are developed in public sectors.

At simple and intermediate levels, information and drawings should be freely available to all developing countries.

Agricultural machinery and engineering professional associations and societies should be strengthened. FAO, ILO, UNIDO and the regional commissions should foster regional co-operation.

Alternative sources of energy should be promoted in agricultural mechanization.

Alternative sources of energy

There is a need to encourage developing countries to manufacture locally equipment to produce and apply alternative sources of energy, such as bio-gas to drive engines, windmill pumping sets and solar dryers. FAO, UNESCO and UNIDO should foster this activity.

Repair and maintenance

Establishment of decentralized repair and maintenance facilities with appropriate training and extension services should be promoted. United Nations agencies, including FAO, ILO and UNIDO, should promote and help this activity.

Information analysis and dissemination

In addition to information dissemination that may arise out of the above recommendations, UNIDO should undertake programmes of analysis of the development of agricultural machinery manufacturing in developing countries. The UNIDO Industrial and Technological Information Bank (INTIB) should play an important role here.

First Consultation Meeting on Agricultural Machinery Industry

Major aspects of the local manufacture of simple equipment, evaluation of advanced technologies, long-term licensing agreements, bilateral and regional measures, creation of agricultural machinery committees, R and D, training etc. should be refined during preparatory activities for the First Consultation Meeting on Agricultural Machinery.

PART TWO

Selected background papers

Interlinkage in agricultural machinery industry for rural industrialization in developing countries

*A. K. Mitra**

CONTENTS

Annexes

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I. PRESENT MANUFACTURING STATUS IN DEVELOPING COUNTRIES

Agricultural machinery and implements are important inputs to the whole agricultural process (see annex IV). The agricultural machinery industry therefore offers a greater choice of technologies appropriate for the rapid growth of industrialization in the developing countries, most of which have given priority to mechanization in agriculture and in many cases to the local development of agricultural machinery and equipment manufacture. The establishment of manufacturers throughout the countryside has been of great significance in opening further avenues of employment. Products range from hand tools and animal-drawn equipment to power-operated equipment such as tractors and power tillers. Manufacturing technology and related problems vary in kind and magnitude for different product mixes and volumes of production.

Classification of manufacturing units

Manufacturing units in all developing countries can be classified at the following technological levels:

(a) Family type (1–5 persons): mainly manual operations; products consisting of simple hand tools and hand-operated and animal-drawn implements;

(b) Small- and medium-scale (30–200 persons): manufacture in urban areas is mechanized, with batch production of animal-drawn implements, hand tools, pumps, crop protection equipment, sprayers etc.;

(c) Large-scale (more than 200 persons): machinery and equipment made with conventional, semi-automatic, automatic and special-purpose machine tools on a high-volume, high-precision and high-investment basis. Products include tractors, tillers, ploughs, power tillers, disc ploughs, pumps, sprayers, storage bins etc. Plants are mostly in the urban areas, rural-urban borders or industrial estates.

Summary of national facilities

The following countries have facilities to manufacture at all three levels: Algeria, Argentina, Brazil, China, Democratic People's Republic of Korea, Egypt, Hungary, India, Indonesia, Iran, Iraq, Israel, Mexico, Nigeria, Pakistan, Poland, Romania, Turkey and Yugoslavia.

Those with facilities at the small- and medium-scale as well as at family enterprise levels are as follows: Afghanistan, Albania, Bangladesh, Burma, Chile, Colombia, Ecuador, El Salvador, Ghana, Kenya, Lebanon, Libyan Arab Jamahiriya, Madagascar, Mali, Philippines, Senegal, Singapore, Sri Lanka, Sudan, Swaziland, Thailand, Tunisia, United Republic of Tanzania, Uruguay, Venezuela and Viet Nam.

Finally, the following countries manufacture only in family type units:

Bolivia, Burundi, Central African Empire, Chad, Congo, Democratic Kampuchea, Democratic Yemen, Ethiopia, Fiji, Ivory Coast, Jordan, Lao People's Democratic Republic, Liberia, Malawi, Malaysia, Morocco, Nepal, Paraguay, Peru, Rwanda, Saudi Arabia, Sierra Leone, Somalia, Togo, Uganda, United Republic of Cameroon and Zambia.

Fuller details on industries operating at these levels are given in tabulated form below:

	FAMILY-TYPE PRODUCTION UNITS
Product	Spades, shovels, spading forks, ploughs, digging hooks, hoes, animal-drawn equipment
Design	Mostly for local need either by modifying equipment from a national supplier or by manufacturing cheap local replacements for conventional equipment
Investment	Very small, sometimes up to $100, particularly in least developed countries
Finance and working capital	Little assistance received from financial institutions, inadequate working capital, mainly dependent on money lenders with high borrowing rates
Marketing	Depends solely on local need, cheap tools sometimes supplied by undercutting prices; no systematic sales outlet
Management	None (family type operation)
Working area	100 to 300 ft^2
Facilities	In many cases limited supply of water and electricity
Material used	Mostly mild steel (MS), EN1 series; occasional use of MS sheets, round and angle sections
Machinery	Small hand tools, e. g. hammer, anvil, chisel, hack-saw, small coal-fired furnaces with hand-operated blowers, pedal-operated grinding wheel, occasional welding, drilling and bending
Production technique	Objects and parts produced manually; hand forgings predominant; no application of jig tools or batch production methods
Material processing	Due to the lack of proper steel and facilities, carburizing, hardening or tempering is not done
Quality control	Non-existent; only a conventional ruler is used for measuring
Employment	1 to 5 persons; sector provides considerable rural employment

	SMALL- AND MEDIUM-SCALE PRODUCTION UNITS
Product	Animal-drawn implements, e. g. ploughs, tillers, hoes, diggers, pumps, sprayers etc.; small hand tools on batch production
Design	Use of local design, adaptation of well-known products, indigenous design supply from a research and development centre, according to customer requirements
Investment	Varies from $5,000 to $80,000 or more
Finance and working capital	Available from private sources or through government institutional loans; banks extend working capital; interest rate varies from country to country
Marketing	There is a greater demand for these products, but little export opportunity except for pumps and sprayers

Management	Mostly run on line management; individual ownership or partnership; in many countries scientific managment exists with different levels or responsibility, particularly in Asia, Latin America and the Middle East
Working area	10,000 to 50,000 ft²
Facilities	Adequate power and water supply
Material used	Various shapes of grade 17 castings and various steels, e. g. EN1, EN8, EN16, EN32 and EN42, which are imported or acquired locally, are commonly used. Use of galvanized MS sheet, round, flat, angle and hexagonal sections is common; springs, bearings and hardware are imported, except in a few Asian and Latin American countries
Machinery	Power-operated hammers, presses, drilling machines, milling machines, electric and gas welding sets, conventional machine tools and equipment, limited inspection equipment, electrical-, coal- and oil-fired furnaces, pneumatic systems and spray paints usually available; hand-operated flat roller benders and angle benders also commonly used
Production technique	Application of welding jigs and fixtures are commonly used in manufacturing; production more on a job shop basis with minimum batch size; assembly and sub-assembly often introduced to increase production, incentive schemes applied
Material processing	Proper heat treatment facilities are available particularly in Asia, Latin America and the Middle East; scientific carburizing and hardening
Quality control	Inspection system in most firms; micrometers; height gauges, callipers common; quality deteriorates because of lack of correct material; many Asian countries and some in Latin America produce their own raw materials
Employment	Generally from 30 to 200 persons

LARGE-SCALE PRODUCTION UNITS

Product	Power combination machinery e.g. engines and tractors of 5 hp, 25 hp, 35 hp and 65 hp, tillers, 2–3 furrow disc ploughs, power tillers, pumps, sprayers, drillers, distributors, storage bins, conveying equipment, threshers, shellers etc.
Design	Most procured under licensing or collaboration agreements with larger (foreign) manufacturers, modifications of designs often allowed because of local manufacturing constraints
Investment	Mostly from $10,000 to $100,000 or more; capital is raised through joint ventures with equity and loans from financial institutions or local or international banks
Finance and working capital	Available from banks against the security of raw materials and work in progress; main sources are national and international institutions, Governments and local banks
Marketing	Country-wide network of outlets; operations generally segregated from factory operations; production regulated according to demand
Management	Entire managment clearly identified and based on horizontal and vertical integration; divided into general administration, personnel, purchase and marketing, factory administration, machine shop, tool room, manufacturing shop, heat treatment shop, assembly and sub-assembly shop, inspection and quality

	control department, metallurgical laboratory, including design, planning, work study, production and metal control, stores operation
Working area	Administrative area of 2,000 to 10,000 ft²; manufacturing area of 50,000 to 300,000 ft² or more
Facilities	Adequate power and water; separate air and steam, mostly centralized distribution, cranes, forklifts, trucks, hoists, stillages, pallets, bins etc. often used
Material used	Most of the shape castings procured from outside under mehanite or grade 17 specification; malleable iron and spheroidal castings often used; steel rods of various sections (EN1, EN1(a), and EN8) used; special high-carbon steel including EN16, EN24, EN32 and EN42–46 spring steel extensively used; many parts and materials purchased, e.g. bearings, brakes, wheels, hydraulic system, hardware instruments, electrical parts, piping, wire, fittings. MS16, 18, 20 SWG sheets often used
Machinery	*Simple machines:* lathes (capstan and turret or copying), drills, multispindle drills, universal milling machines, power forges and hammers, boring machines, threading and tapping machines, broaching machines *Special purpose machines:* unit head machines; special tailor-made machines, e.g. for axle housing, gear boxes, centre housing; precision boring and fine-boring machines; single spindle and multispindle bar and chuck, automatic duplex or triplex milling machines *Toolroom:* jig-boring, jig-grinding and lapping machines, die-sinking machines, tool and cutter grinders; inspection equipment, height gauges, optical equipment etc. *Gear cutting:* hobbing machines, bevel gear generators, lapping machinery, carburizing plants, hot-press quenching machines *Heat treatment:* carburizing plants, induction hardening machines, cyanide baths etc. *Treatment plant:* pickling plants, degreasing plants, galvanizing plants, phosphating plants, paint booths, paint dipping plants *Manufacture:* press brakes, eccentric presses, hydraulic presses, shears, carbon dioxide welding, submerged arc welding, conventional welding, bending and tube-bending machines; conveyors, electrical installation, steam and water installation, electrical substations etc.
Production technique	Based on continuous operation for high volume and on batch flows; process sheets, standard time, incentive scheme; application of jig tools, fixtures for machining and manufacture; production forecast and controlled by planning, scheduling, manufacturing and follow-up inspection and quality control; design specifications adhered to at all levels
Material processing	Carburizing and nitriding for case hardening, through hardening and tempering; shot-pinning, induction hardening etc.
Quality control	Special sections with modern precision equipment, spectroscopic analysis of raw material, visual, optical and electronic inspection equipment; statistical controls are introduced in mass production with a given level of tolerance; physical and chemical controls being incorporated
Employment	Plant producing about 5,000 tractors and 3,000 mixed units of equipment per annum employs a work-force of about 1,500, though numbers vary from country to country

The extent to which the appropriate level of technology can be improved will mainly depend on how the infrastructure of supporting mechanical and metalworking industries will develop.

Most developing countries will continue to depend on imported material and parts except for some new industries in Asia and Latin America.

II. CHOICES IN MECHANIZATION LEVELS

Technological progress in agriculture tends to create a regional imbalance as well as to widen disparities between rich and poor farmers, particularly in the developing countries. Technological development is not uniform, as all regions do not grow the same crop and differ widely in terms of social and economic conditions. Until now such progress in agricultural standards of developing countries has been mostly related to cereals. The development or enlargement of agricultural crop production therefore requires definite government policies to promote, establish and regulate the requirements for both agricultural and engineering industries manufacturing agricultural and allied machinery products.

During the last two decades the developing countries have made great progress in the field of agricultural production, and much attention was paid to mechanization in general and choices and appropriate levels of mechnization in particular.

Yet in all developing countries there is a relative degree of misallocation of resources in agriculture. Because of this, agriculture is incapable of achieving the necessary increase in production. Integrated planning of agricultural development implies the following:

(a) Integration of economically oriented projects into regional planning (horizontal) as well as into sectoral, macroeconomic and microeconomic planning (vertical);

(b) The existence of a suitable institution which can be developed to plan techno-economic projects at the national, regional and farm levels.

An important aspect after the planning of techno-economic projects is a Government's specific policy in the promotion and co-ordination of resources through mechanization for increased food production. Obviously the framework of such a policy would be, on the one hand, to identify the input resources and their subsequent availability and supply at the farm level, and, on the other hand, to improve the farm managment plan to utilize the resources for optimizing agricultural production, as shown in figure I, taking into account the interrelationship between agricultural production input and output as indicated in the flow chart presented in figure II.

The ever increasing demand for food grains, particularly cereals, can only be met by intensification of agricultural production through widespread adoption and application of the following measures:

(a) Enlargement of agricultural crop-bearing land in conjunction with a definite policy for landholdings and land reform;

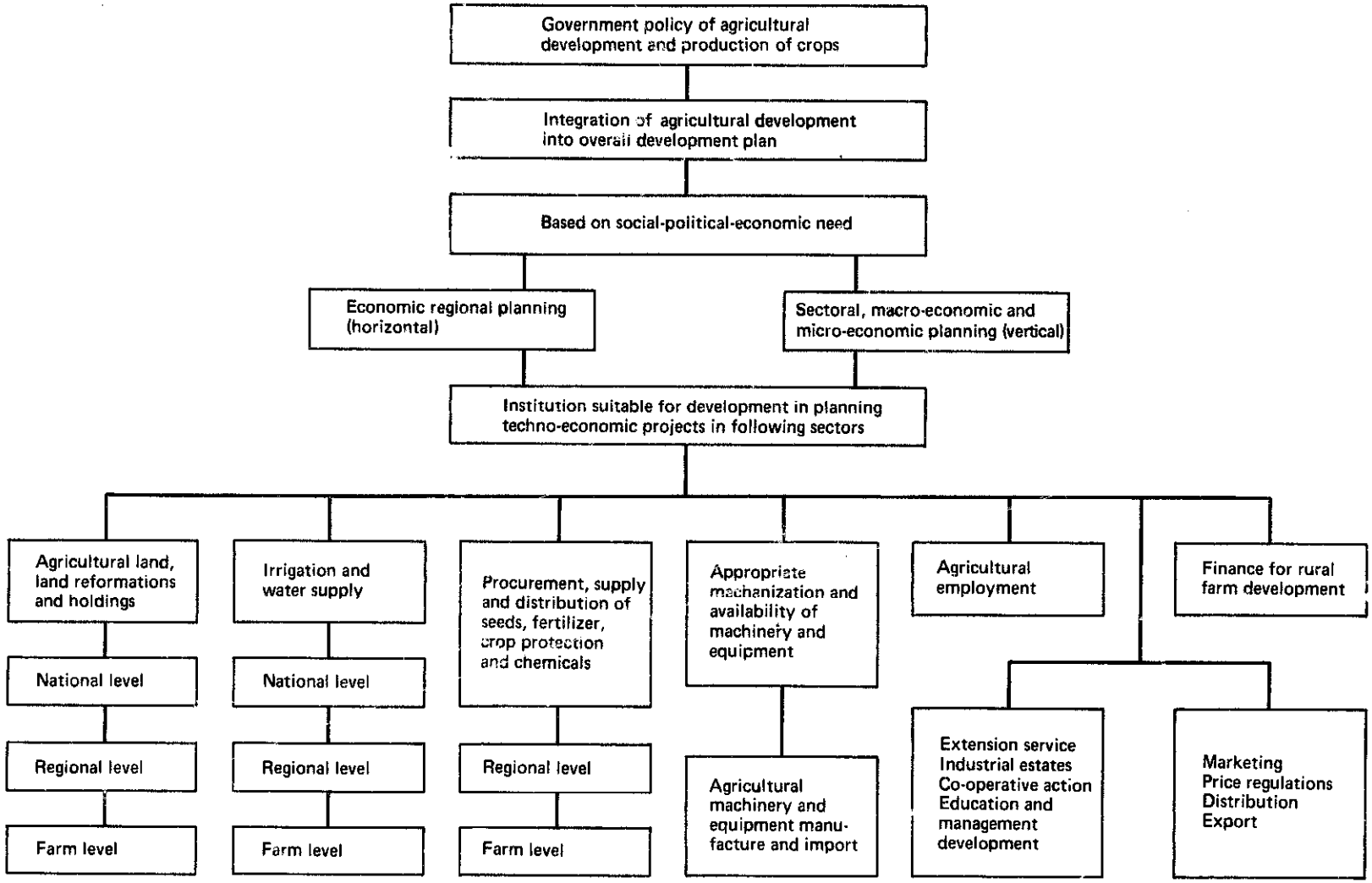


Figure I. Government policy of agricultural development and promotion of crops

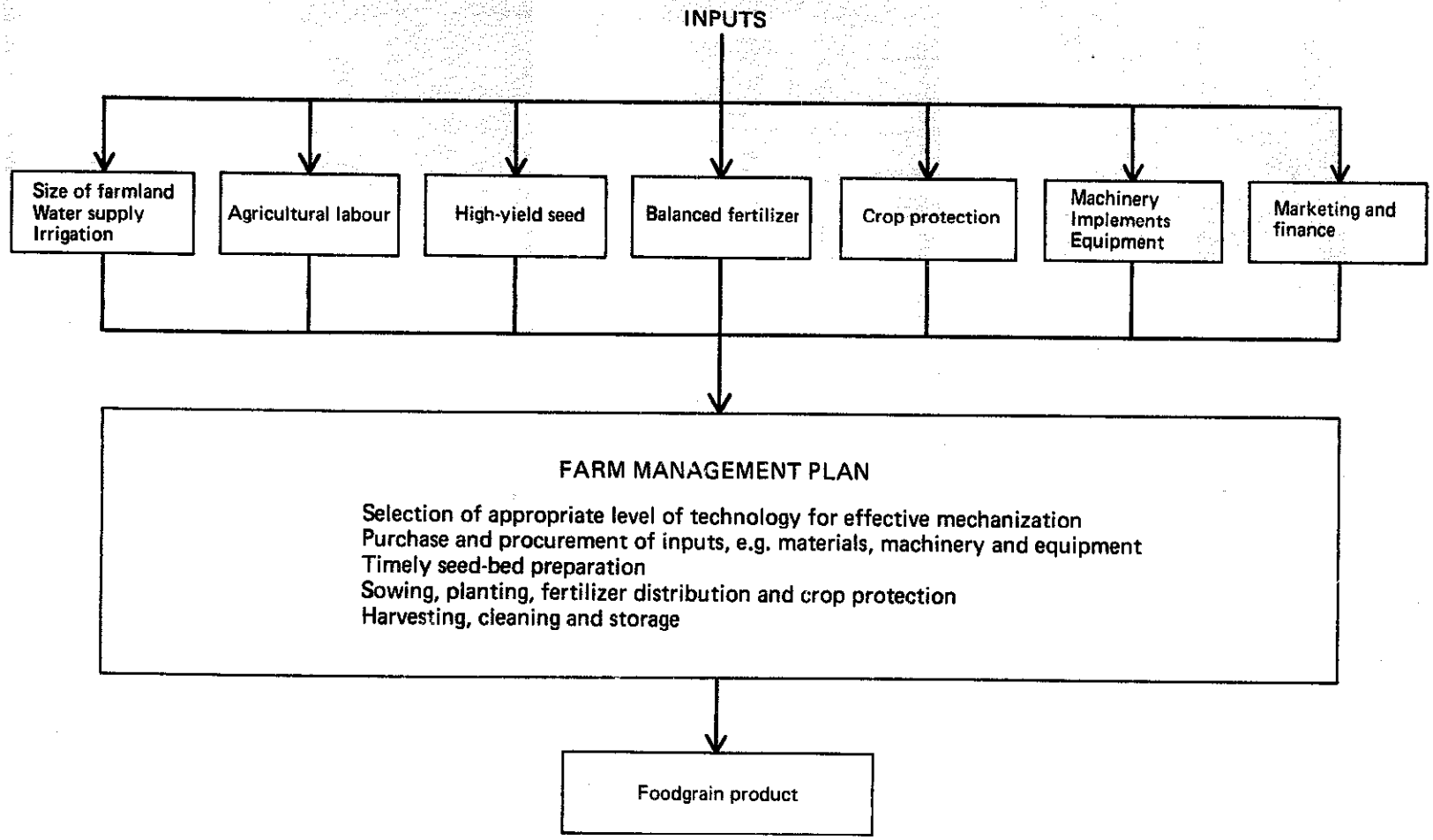


Figure II. Flow chart of input and output of agricultural production

(b) Meeting agricultural labour requirements through the supply of labour from urban and rural markets;

(c) Introduction of new high-yielding seeds;

(d) Effective irrigation and an adequate supply of water;

(e) Application and distribution of nitrogenous fertilizer;

(f) Introduction and scientifically planned application of mechanized machinery inputs for the cultivation of soil and related agricultural operations;

(g) Adequate supply of new varieties of crop protection agents resistant to the major pests and diseases;

(h) Adequate facilities for drying, milling, transport and storage of food grains;

(i) Sufficient facilities for marketing and distribution;

(j) Adequate mechanisms for price regulation.

The overall considerations outlined above form the basis for establishing a national agricultural mechanization policy.

Mechanization levels

A distinction between four levels of mechanization may be made as follows: firstly, the level at which simple but improved manual and animal-drawn tools and implements are used; second, the level at which manually operated, animal-drawn and simple low-power operated implements and equipment are used; third, the level at which relatively more advanced power machinery is used; and fourth, the level at which complicated and specialized machinery and equipment is used. In principle, it may be stated that the first level may be suitable for farm holding sizes up to 2 ha, the second level for 2–5 ha, the third level for 5–50 ha and the fourth level for over 50 ha. In practice, however, the size ranges of the levels may overlap.

However, considering the inputs for agriculture, namely water, seed fertilizer and pesticides, the methods of application to the soil in terms of agricultural field operation may vary in accordance with the appropriate and desirable degree of mechanization. The possible alternatives, taking into account the inherent constraints imposed by the sizes of the landholdings, should therefore be investigated with reference to different field operations.

Possible mechanization choices in field operations

Irrigation

The equipment required for water supplies and irrigation could be divided into four levels of technology: simple equipment such as manual- or animal-operated pumps and simple windmill units, animal-drawn large pumps and small power-operated pumps (3–5 hp), medium power pumping units (5–15 hp) and large power (over 1,000 hp) irrigation systems. As stated before, the mechanization levels in terms of technology vary independently of the production function, but are closely related to farm sizes. The choices of mechanization patterns according to technology levels and farm sizes are indicated in table 1, and specifications of pumps are given in tables 2 and 3.

TABLE 1. MECHANIZATION LEVEL FOR WATER SUPPLY AND IRRIGATION

Choices for different farm sizes

Technology level			
I	*II*	*III*	*IV*
Lever-type hand pump	Hydraulic ram	Engine-driven pump (over 6 hp)	Diesel or electric pumping plant (1 000 hp or more)
Rotary hand pump	Animal-drawn pump	Electric-motor-driven pump (over 6 hp)	Control structure
Animal-drawn pump	Engine-driven pump (up to 6 hp)		Measuring device
Windmill pump	Electric-motor-driven pump (up to 6 hp)		Siphons
Hand-operated diaphragm pump			Head gates
			Spiles
← Water from well, borehole, stream, canal or channel →		← Water from stream, river, catchment area, dams, ground water storage →	
		← Project delivery system →	
← Farm delivery system →			
Farm size: < 2 ha			
← 2–5 ha →			
← 5–50 ha →			–
		← 50–1 000 ha →	
		← 1 000 ha →	

TABLE 2. WATER SUPPLY EQUIPMENT: MANUAL, ANIMAL, ANIMAL-DRAWN OR WIND-POWERED PUMPS

Type	*Description*	*Lift (ft)*	*Discharge (gph)*	*Delivery (ft)*
Manual	Hand pump (lever-operated)	20 24	400 600	– –
Manual	Lift and force pump (lever-type)	30	1 000	40
Manual	Foot-operated diaphragm	30	1 000–1 4000	50–60
Manual	Semi-rotary pump (foot valve is required to lift more than 6 ft)	30	200–1 300	75
Manual	Wheel or rotary pump (can be used in deep well)	. 100	500	–
Manual	Foot-operated pump	8–12	4 000–4 500	–
Animal	Chain pump	40	3 000–4 000	–
Wind	Windmill pump velocity, 4 mph	–	Specially designed	–

TABLE 3. ENGINE-OPERATED WATER SUPPLY EQUIPMENT

Type of engine	*Description*	*Total head (ft)*	*Discharge (gph)*
Petrol	Lightweight centrifugal pump with engine	53	88
Diesel, single cylinder, 3–5 hp	Centrifugal pump coupled with engine	90	Up to 6 000
Diesel, 5–10 hp	Centrifugal pump with water-cooled engine	80	Up to 10 000

Soil cultivation

Equipment for soil cultivation, which includes seed-bed preparation, could be divided into three levels based on manual, animal and mechanical power resources. The choices of mechanization patterns, and the connection between technology level and farm holding size, are indicated in table 4.

Seed fertilizer application and crop protection

Intensification of land use can be achieved as irrigation facilities are increased by introducing multiple cropping, providing more labour for irrigation, and changing from natural grazing to fodder. Inputs for crops are high-yield seed, fertilizer, chemicals for plant protection, machinery and equipment for sowing, distribution, spreading and many other related operations. Before introducing mechanization, a close look is needed at how to make the inputs available both in the appropriate quantity and quality, taking into account the costs of undertaking research and of providing extension services, marketing facilities and credit.

The application of seed, fertilizer and crop protection products could be achieved through four technology levels, namely simple manual equipment, animal-drawn equipment, low- to medium-horsepower tractor-operated machinery, and higher horsepower integrated equipment. The mechanization level for soil cultivation, depending on farm size, is shown in table 5.

A government policy to ensure that farmers obtain the seeds, fertilizers etc. at the right time and price should provide for certified units developing and producing high-yield seeds; facilities for advising small- and medium-scale farmers; financial assistance to seed breeders, farmers, co-operatives and growers associations; extension services and research and development (R and D). For fertilizers, the policy should allow for imports where necessary, and the setting up of production plants in the private or public sectors, through co-operatives or joint ventures, and even in villages, should studies show them to be worthwhile. For crop protection, the policy should include education to farmers on seed treatment and crop protection; training in the use of crop protection techniques and allocation of funds for the establishment of crop protection units. These units would need to be supplied with a sufficient number of staff, chemicals and equipment to provide an effective extension service.

The machinery required to intensify the production of crops should be selected according to levels of technology, generally at a higher mechanization level than at present.

TABLE 4. MECHANIZATION LEVEL FOR THE APPLICATION OF INPUT MATERIAL

Choices for different farm sizes

Input material	*Operation*	*Technology level* I	II	III	IV
Seed	Sowing Planting	Walking stick planter	Animal-drawn seeder	Walking tractor-drawn seed drill, up to 7.5 hp	Rider tractor-drawn seed drill over 30 hp
		Manual wheel seeder	Animal-drawn multi-hopper seeder	Rider tractor-drawn seed drill, up to 30 hp	
		Manual seed drill and wheel hoe			
		Manual multi-hopper seeder			
Fertilizer	Distribution	Manual single fertilizer drill	Animal-drawn seed-cum-fertilizer drill	Walking tractor-drawn seed-cum-fertilizer drill, up to 7.5 hp	Rider tractor-drawn seed-cum-fertilizer drill over 30 hp
		Manual seed-cum-fertilizer drill (two, three or four rows)		Rider tractor-drawn seed-cum-fertilizer drill, up to 30 hp	
Crop protection products	Spreading	Hand-held granules applicator	Same as level-I	Motorized granules applicator	Aircraft-operated
		Hand-type plunger-duster	Continuous-pressure hand or shoulder sprayer	Shoulder-type power duster with wide dusting attachment	Blower/sprayer
		Rotary hand duster		Shoulder-type blower duster	Same as level III
		Hand pump sprayer		Shoulder-type power spray	

Farm size:

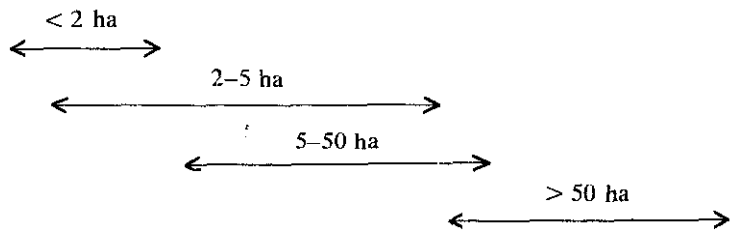
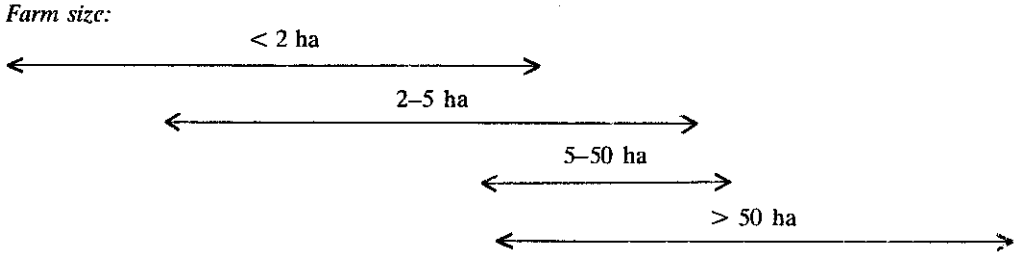


TABLE 5. MECHANIZATION LEVEL FOR CULTIVATION OF SOIL AND SEED-BED PREPARATION

Choices for different farm sizes

Technology level		
I	*II*	*III*
Hand cultivating tools, hand spades, digging forks and hoes, hand cultivators	Animal-drawn equipment (integrated unit or tool bar attachment)	Rider tractors (four-wheel), 15–70 hp with PTO (power take-off) shaft
Push-type hand tools, wheel hoes, hand-pushed cultivators, manual weeders (sizes of these hand tools vary widely in different countries)	Cultivator tines	Disc plough, 2 and 3 furrows
	Fixed mould-board ploughs	Mould-board plough, 2 and 3 furrows
	Reversible mould board ploughs	Tiller, 9 and 11 tines with seeding attachment
	Ridging ploughs	Paddy disc harrows
	Disc harrows, adjustable harrows	Off-set disc harrows
	Fixed-tooth harrows	Sub-soilers
	Root crop lifter, land levelling blades	Multi-purpose blade terracers
	Animal-drawn wetland puddlers	Reversible ploughs
	Animal-drawn rollers	Mounted disc harrows
	Two-wheel walking tractors with power tillers, cultivators, rotary cultivators, motor hoes, harrow ridgers, puddlers, up to 7–8 hp	Ridgers
		Rice puddlers (preferably between 30 and 70 hp)

Farm size:



Harvesting

For harvesting of crops, the three levels of available technologies are simple hand-operated tools, animal-drawn and low-horsepower mechanical equipment, and tractor-drawn or self-propelled combines. The role of technology and the size of farm in the choice of mechanization is shown in table 6.

Threshing, shelling and cleaning

These operations could be divided into three technology levels: simple hand-operated methods, animal-drawn or low-horsepower mechanical equipment, and high-horsepower machinery. The relationship between mechanization choices with technology levels and farm sizes is given in table 7.

Crop drying and storage

The three technology levels for crop drying and storage are as follows: simple natural drying and storage in bags or jars; power-operated batch drying and silo storage; and integrated continuous drying and large-scale silo systems. The mechanization choices with reference to technology level and farm size are given in table 8.

TABLE 6. MECHANIZATION LEVEL FOR HARVESTING OF CROPS

Choices for different farm sizes

Technology level		
I	*II*	*III*
Hand tools: Machetes Harvesting knives (sickles, plain and serrated edge) Grass hooks (short and long handles) Scythes Hand-held rice cutters (Sizes of these hand tools vary widely in different countries)	Hand-operated power reaper engine capacity up to 50 cm^3 Hand-operated power brush cutters, engine size up to 40 cm^3 Power reaper-cum-brush cutter, engine size up to 55 cm^3 Two-wheel walking-type harvester binder, engine size up to 10 hp (one-wheel 1 row reaping; two-wheel 1 row reaping; two-wheel 2 row reaping) Two-wheel mower tractor, up to 9 hp	Scoop-type trailed combine harvester with auxiliary engine, 20 to 30 hp, 7 ft cut Narrow-body wide-cut combine harvester driven by tractor PTO, engine of 35 to 50 hp, 12 ft cut Self-propelled combine harvester engine of 50 to 150 hp, 16 ft cut Forged harvester

Farm size:

< 2 ha

2–5 ha

5–50 ha

> 50 ha

TABLE 7. MECHANIZATION LEVEL FOR CROP THRESHING, SHELLING AND CLEANING

Choices for different farm sizes

	Technology level		
Operation	*I*	*II*	*III*
Threshing	Hand-operated rotary thresher Paddle-operated rotary thresher, up to 1 000 kg/d	Animal-drawn stone threshing roller Animal-drawn serrated disc thresher	Power-operated thresher, up to 5 hp, 400 kg/h

Operation	Technology level I	II	III
Shelling	Hand-operated sheller 150 kg/h	Power-operated sheller up to 2 hp, 600 kg of maize per hour	Power-operated sheller, 2 hp up to 6 hp, maximum of 1 500 kg of maize per hour
Cleaning	Fan-type hand winnower	Power-operated winnower, up to 1 hp, 500 kg/h	Power-operated winnower, 1–5 hp, maximum of 1 000 kg/h
	Bicycle-type paddle winnower		Motorized thresher-cum-winnower, up to 7 hp, 1 000 kg of rice per hour, 1 000 kg of maize per hour
Farm size:	< 2 ha	2–5 ha	5–50 ha, > 50 ha

TABLE 8. MECHANIZATION LEVEL FOR CROP DRYING AND STORAGE

Choices for different farm sizes

Operation	Technology level I	II	III
Drying	Natural drying by *(a)* Exposure to sunlight *(b)* Application of hot air from burning wood	Batch dryer with oil-fired burner and motorized blower, 1 t of grain per 6 h, 7 hp motor	Continuous dryer with oil-fired burner and motorized blower, 50 t/d
Storage	50 kg jute sacks Wooden containers, capacity of up to 200 kg Underground pit, capacity of up to 3 t (not suitable unless there is a concrete wall)	Circular grain silos of wooden construction and steel ribs, capacity of up to 5 t Plastic silos, capacity of 2 t Sheet-metal storage bins, capacity of up to 1 t	Concrete silos, capacity of 5 to 50 t Steel silos, capacity of up to 1 000 t Mobile silos, capacity of up to 20 t
Farm size:	< 2 ha	2–5 ha	5–50 ha, > 50 ha

Current mechanization patterns

The mechanization pattern depends on the available power applied to agricultural field operations through manual, animal and mechanical (plus solar and wind) power sources at different technological levels, varying from simple tools and implements to intermediate equipment and complicated machinery. As the mechanization pattern is normally a function of the size of the holding, there is a limited choice of different categories of agricultural tools, implements and machinery to be applied for each operation. An attempt has been made to give an objective view of the technologies applied by developing countries in different farming operations. The system followed from seed-bed preparation to crop storage is outlined in figures III, IV, V and VI which contain current line mechanization charts for Africa south of the Sahara; Latin America; the Middle East and northern Africa; and South Asia respectively.

Government policy on line mechanization

"Mechanization is often erroneously associated with large-scale tractorization in farm operations. Moreover, the development of mechanization has frequently been focused on only one option such as either tractor purchase or tractor-hire schemes, instead of examining a range of alternative packages of mechanical technology. However, there is considerable scope for improved, manually operated, and, to a certain extent, large power-operated agricultural tools, implements and machinery in most of the developing countries. The scope for development in each category depends on techno-economic viability and the purchasing power of the farmers, as well as on the Government's policies for rural, agricultural and industrial development in general and for agricultural mechanization in particular.

It is very important that government policy should be framed for developing rural agricultural and off-farm activities. Expansion of direct activities could achieve a great absorption of labour. Incentives for small-scale and family type off-farm industries would enable products to be marketed in urban areas. Reduction of differentials in rural and urban wages would reduce migration of rural labour. Education schemes, improvement of living conditions and provision of facilities to supply necessary commodities would make rural life more attractive. The rural labour force has always included a segment engaged in off-farm activities. An objective of rural devlopment in a majority of developing countries is to create additional rural non-agricultural employment. This policy not only raises productivity, but reduces migration to urban areas.

Credit and marketing policies are of paramount importance for agricultural transformation. Marketing requires physical infrastructure, financial institutions offering credit on reasonable terms, a communications network, entrepreneurial and managerial skills, research facilities and the minimum of administrative constraints.

In most developing countries there is good scope for a mixed mechanization system, involving improved, manually operated and animal-drawn tools, implements and machinery, low-cost intermediate power equipment, and

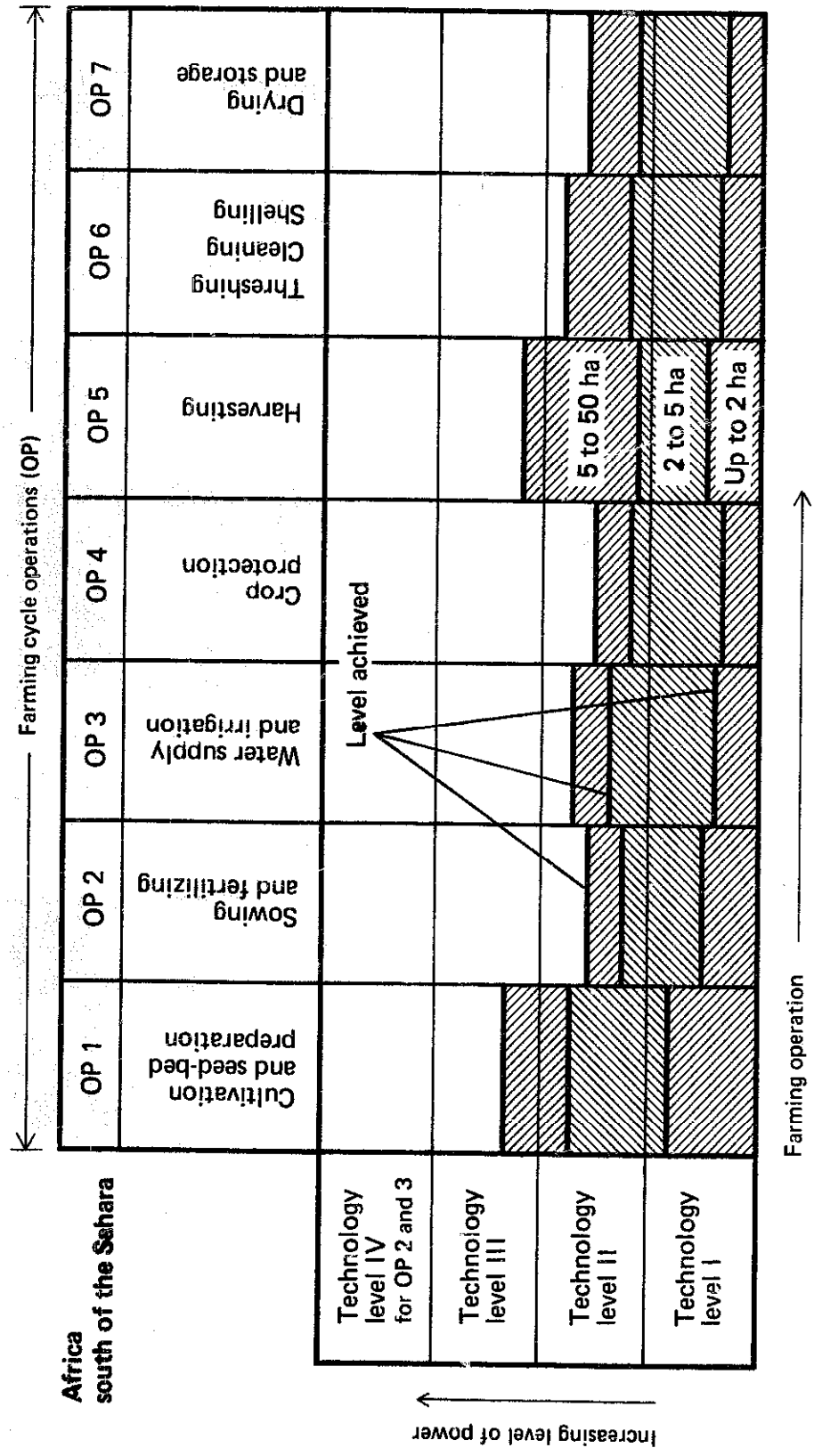


Figure III. Line mechanization chart. Africa south of the Sahara

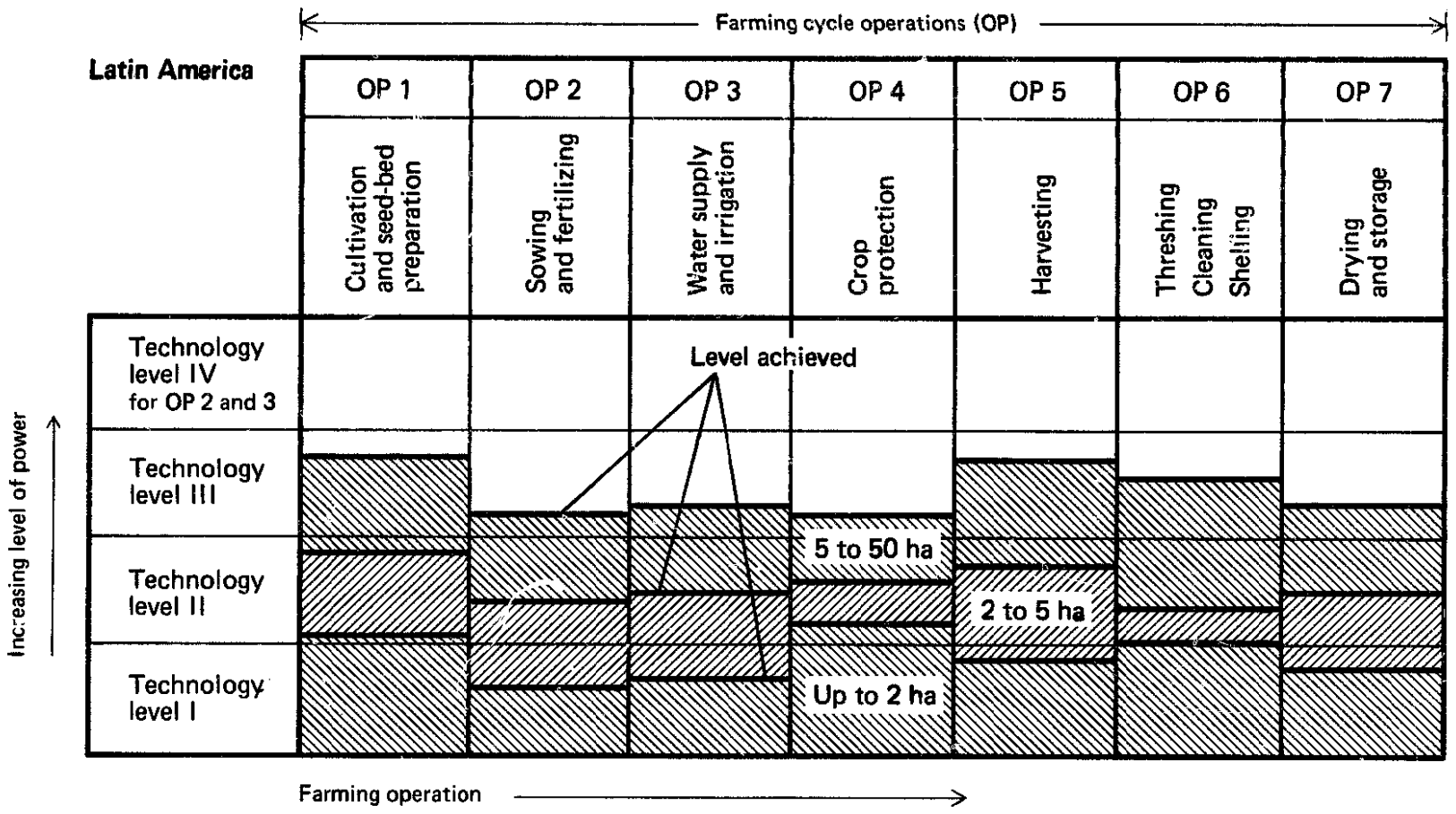


Figure IV. Line mechanization chart. Latin America

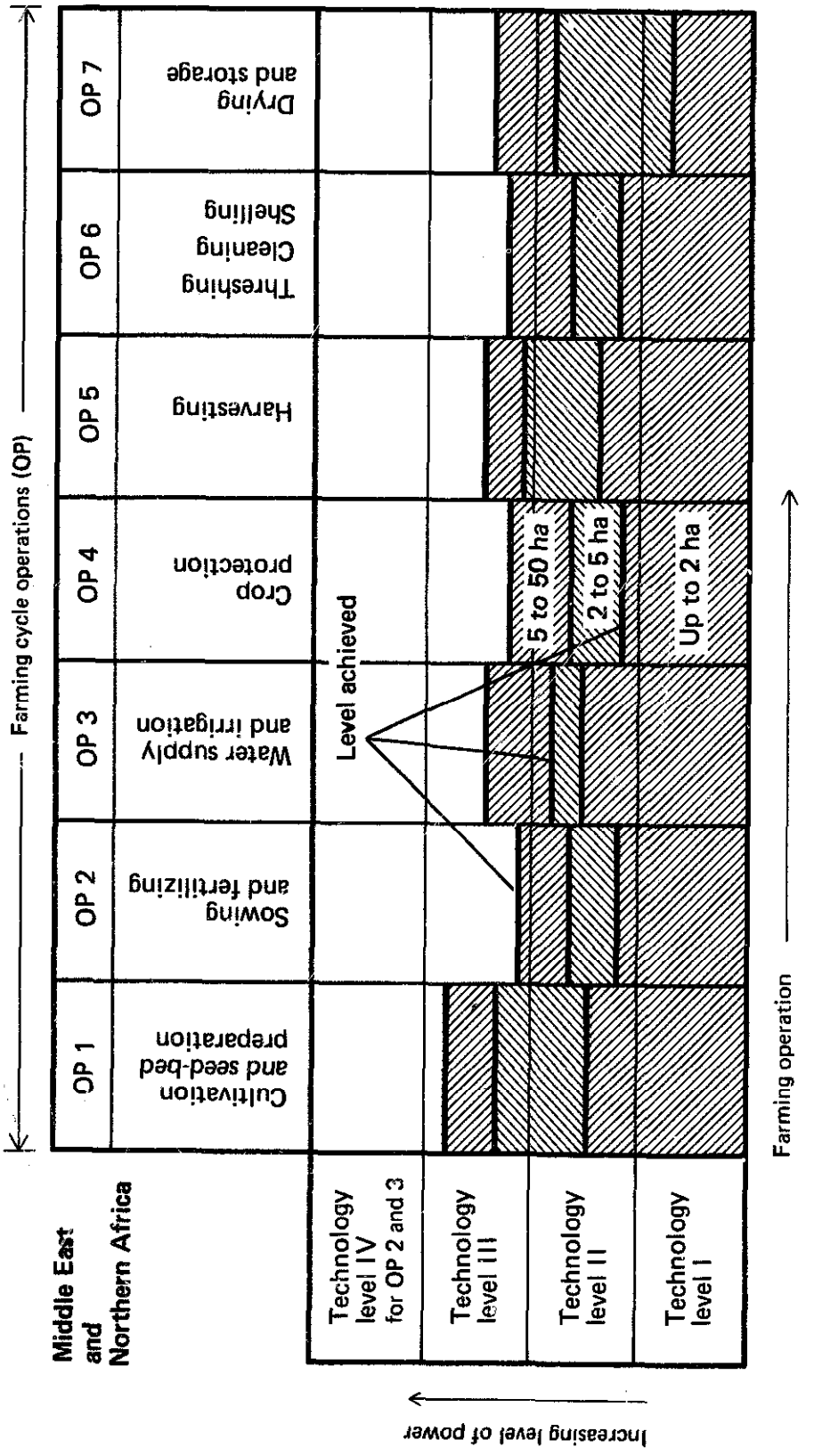


Figure V. Line mechanization chart. Middle East and northern Africa

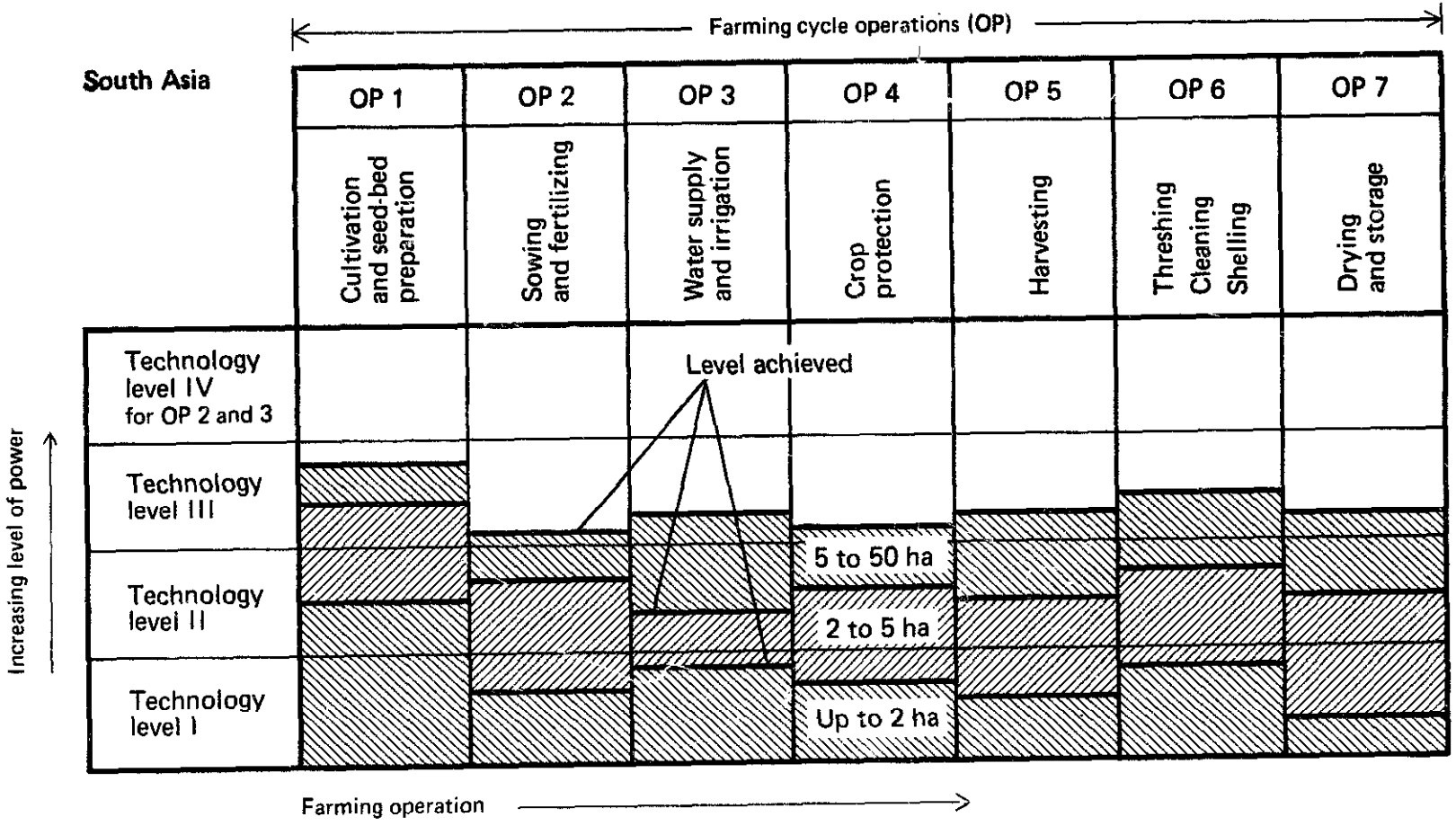


Figure VI. Line mechanization chart. South Asia

appropriate, relatively large-horsepower machinery. However, as in most cases the size of the farmholding is a function of farm income at any level of agricultural technology, there is a need to examine the most suitable improved technology levels or system of agricultural mechanization at different sizes of holdings. The machinery and equipment required for crop production at various technology levels are outlined below.

TECHNOLOGY LEVEL I

(Farm area up to 2 ha)

Farming operation	*Machinery and equipment with possible specifications*
Cultivation, and seed-bed preparation	Manual cultivating tools: hand spades, digging forks and hoes, hand hoes, hand cultivators
	Push-type hand tools: wheel hoes, hand-pushed cultivators, manual weeders
Sowing and planting	Manual walking-stick planters, manual wheel seeders, manual seed-drills and wheel hoes, manual multihopper seeders
Fertilizer distribution	Manual seed-cum-fertilizer drills (two, three, four rows), manual single fertilizer drills
Water supply and irrigation	Lever-type hand pumps, rotary hand pumps, animal-drawn pumps, windmill pumps
Crop protection	Hand-held granules applicators, hand-type plunger dusters, rotary hand dusters, hand pump sprayers
Harvesting	Hand tools: machetes, harvesting knives, sickles (plain and serrated edges), grass hooks (short and long handle), scythes, sickles, hand-held rice cutters
Crop cleaning	Fan-type hand winnowers, bicyle-type pedalled winnowers
Crop threshing	Hand-operated rotary threshers, pedal-operated rotary threshers, 400 kg of grain per hour
Crop shelling	Hand operated shellers, 150 kg/h
Crop drying	Natural drying by sunlight, drying by wood fire
Crop storage	50-kg jute sacks, wooden containers up to 200 kg, underground pit with a capacity of 3 t, cemented rooms or closed sheds

TECHNOLOGY LEVEL II

(Farm area 2–5 ha)

Farming operation	*Machinery and equipment with possible specifications*
Cultivation and seed-bed preparation	Animal-drawn equipment, integrated or tool bar attachments for: cultivator tines, fixed mould-board ploughs, reversible mould-board ploughs, ridging ploughs, disc harrows, adjustable harrows, fixed tooth harrows, root crop lifters, land levelling blades
	Animal-drawn wetland puddlers
	Animal drawn rollers

	Two-wheel walking tractors with power tillers, cultivators, rotary cultivators, motor hoes, harrows, ridgers, puddlers, up to 7–8 hp
Sowing and planting	Animal-drawn seeders
	Animal-drawn multihopper seeders
Fertilizer distribution	Animal-drawn seed-cum-fertilizer drills
Water supply and irrigation	Hydraulic rams, animal-drawn pumps (equivalent to 2 hp), engine driven pumps up to 6 hp, electric-motor-driven pumps up to 6 hp
Crop protection	Same as technology level I and continuous pressure hand or shoulder sprayers
Harvesting	Hand-operated power reapers, engine capacity up to 50 cm^3
	Hand-operated power brush cutters, engine capacity up to 40 cm^3
	Power reapers-cum-brush cutters, engine capacity of 55 cm^3
	Two-wheel walking-type harvester-binders, engine capacity up to 10 hp
	Two-wheel mower-tractors up to 9 hp
	Small four-wheel riding tractor up to 15 hp
Crop cleaning	Power-operated winnowers up to 1 hp, handling 500 kg/h
Crop threshing	Animal-drawn stone threshing rollers Animal-drawn serrated disc threshers
Crop shelling	Power-operated shellers up to 2 hp, handling 600 kg of maize per hour
Crop drying	Batch dryers with oil-fired burners and motorized blowers, 6 hp motors, handling 1 t of grain per 6 h
Crop storage	Circular grain silos of wooden construction and steel ribs, capacity of up to 5 t
	Plastic silos, capacity of 2 t
	Sheet metal storage bins, capacity of up to 1 t

TECHNOLOGY LEVEL III

(Farm area 5–50 ha)

Farming operation	*Machinery and equipment with possible specifications*
Cultivation and seed-bed preparation	Four-wheel rider-tractors with hydraulic systems and PTO, diesel or petrol engines of 15–80 hp
	Disc ploughs, two-furrow and three-furrow
	Tillers, 9 and 11 tines, with or without seeding attachments
	Paddy disc harrows
	Off-set disc harrows
	Sub-soilers
	Multi-purpose blade terracers
	Reversible ploughs Mounted disc harrows
	Ridgers

	Rice puddlers
	(Above implements should be associated with tractors of 30–70 hp)
Sowing and planting	Rider tractor-drawn seed-drills, over 30 hp
Fertilizer distribution	Rider tractor-drawn fertilizer-cum-seed-drills, over 30 hp
Water supply and irrigation	Engine-driven pumps and electric-motor-driven pumps over 6 hp
Crop protection	Motorized granules applicators, shoulder-type power dusters with wide dusting attachments,
	Shoulder-type blower dusters,
	Shoulder-type power sprays
Harvesting	Scoop-type combine harvesters trailed with auxiliary engines, 20–25 hp, 7 ft cut
	Narrow-body wide-cut combine harvesters driven by tractor PTO, 35–50 hp engines, 12 ft cuts
	Self-propelled combine harvesters, 50–150 hp engines, 16 ft cuts
	Forge harvesters
Crop cleaning	Power-operated winnowers, 1–5 hp, handling a maximum of 1 000 kg/h
	Motorized threshers-cum-winnowers up to 7 hp, handling 2 000 kg of rice per hour, or 4 000 kg of maize per hour
Crop threshing	Power-operated threshers up to 5 hp, handling 400 kg/h
Crop drying	Continuous dryers with oil-fired burners and motorized blowers, handling 50 t/d
Crop storage	Concrete silos, capacity of 5–500 t
	Manufactured steel silos, capacity up to 1 000 t
	Mobile silos, capacity up to 20 t

TECHNOLOGY LEVEL IV
(Farm area over 50 ha)

Farming operation	*Machinery and equipment with possible specifications*
(All operations require machinery at technology level III, except for the following)	
Water supply and irrigation	Technology level III and diesel or electric pumping plants, control structures, measuring devices, siphons, check dams, headgates, spiles etc., 1 000 hp and more
Sowing and planting	Rider tractor-drawn seed-drills, over 30 hp
Fertilizer and distribution	Rider tractor-drawn fertilizer-cum-seed-drills, over 30 hp
Crop protection	Aircraft-operated blower-sprayers

III. TECHNO-ECONOMIC MANUFACTURING PROFILES

The production of different types of agricultural machinery and equipment requires different infrastructure facilities, e. g. factories, machine tools and

equipment, labour force and manufacturing techniques. Close relationships exist between production volume, choice and capacity of machine tools and equipment, and size of investment required. Most industries in developing countries are labour-intensive, therefore the selection of machine tools and equipment influences the deployment of the labour force, particularly in the least developed countries where automation is a social and industrial taboo.

The techno-economic profiles for the manufacture of agricultural machinery and equipment attached in annexes I, II and III highlight the following four important aspects:

(a) Careful selection of product grouping based on manufacturing sophistication;

(b) Convenience and viability of manufacturing these products at different levels of rural industry;

(c) Methodical selection of machine tools and equipment for optimizing employment potential, particularly in rural areas;

(d) Basic minimum investment required for particular levels of industry (craftsmanship and small-scale, medium- or large-scale industry).

To illustrate the complete range of techno-economic profiles for agricultural machinery products is beyond the scope of this paper. Therefore, only three are evaluated as described below:

(a) A profile for the manufacture of selected simple hand tools deals with mixed implements, e.g. spade, tined hoe, fork and sickle, with a production turnover of 4,000 units of all types. The machinery selected is either manually operated (where no electricity supply exists), or consists of power-operated machine tools at handicraft level employing four to ten persons (annex I);

(b) A profile for the manufacture of selected animal-drawn implements describes the production of mixed implements, e. g. single-wheel hand hoe, animal-drawn disc harrow, animal-drawn mould-board plough, with an annual production turnover of 3,000 units of all types (annex II). The machinery selected is relatively more sophisticated. This type of industry can be installed at the rural small-scale level employing about 70 persons;

(c) A profile for the manufacture of advanced agricultural power machinery, e.g. tractors, foresees an annual production of 3,500 units (annex III). The machinery selected requires conventional and special-purpose machine tools. This type of industry can be installed at urban-rural border areas employing about 500 persons.

Each profile gives basic information on plant size required for the particular production line, and discusses the salient features of the industry, its marketing problems and outlets. The estimated capital needed to establish a plant of a specific capacity and the approximate annual costs by categories of running the plant at full capacity are also indicated. A plant layout, with approximate requirements of machinery, equipment, tools, jigs and fixtures is provided.

In addition, the profiles are an indicative analysis of the factors a potential investor in any such undertaking would have to consider. In some cases this may be simple, in others more complex, requiring full-scale feasibility studies by experts. The profiles indicate the major factors to be considered in making such

studies and recommend systematic guidelines for estimating costs based on local conditions.

Conditions in different areas or countries vary and can create constraints on the effective operation of plant, machinery and equipment, the use of materials, power, fuel, water and transport and the availability of finished and semi-finished parts of various sizes both in quantity and quality. The local costs for raw material, labour, plant and machinery may also vary. Therefore, the techno-economic profiles indicate an order of magnitude in terms of costs, and a way to assess a situation and facilitate investment decisions.

The technological criteria at three industry levels are broadly based on machine tools requirements, production techniques, supporting services, and a minimum factory manufacturing programme.

A summary of important technological criteria is given in figure VII. An attempt has been made to illustrate the basic differences at various industry levels.

A comparative study of techno-economic profiles for the manufacture of agricultural implements at three levels of industry is given in table 9.

TABLE 9. COMPARATIVE TECHNO-ECONOMIC PROFILES FOR THE MANUFACTURE OF AGRICULTURAL IMPLEMENTS

Item	*Handicrafts or village-level industry*		*Rural small-scale industry*	*Rural medium- and small-scale industry*
	Plant with no electricity	*Plant with electricity*		
Product	Spade, hoe, fork, sickle	Spade, hoe, fork, sickle	Single-wheel hand hoe, animal-drawn disc harrow, animal-drawn mould-board plough	Four-wheel tractor
Material	Carbon steel, wood, hardware, sheet metal and sections	Carbon steel, wood, hardware, sheet metal and sections	Mild steel, cast iron, carbon steel, hardware, wood, paints, sheet metal and sections, sub-contracted parts	Grey cast iron, malleable iron, high carbon steel, free cutting steel, forge steel, spring steel, sheet metal sections, paints, bought finished and imported parts
Manufacture of components	Indigenous	Indigenous	Indigenous	Indigenous (40%), locally finished (30%), imported (30%)
Annual production (units)	4 000	12 000	10 000	3 600
Manpower	4	9	66	514
Machinery and equipment	Simple, manually operated machines and tools	Simple, power-operated conventional machine tools	Medium power-operated conventional machine tools	Conventional, automatic and special-purpose machine tools

TABLE 9 *(continued)*

Item	*Handicrafts or village-level industry*		*Rural small-scale industry*	*Rural medium- and small-scale industry*
	Plant with no electricity	*Plant with electricity*		
Production techniques	Manual operation	Manual operation with limited batch-size production	Batch size production with jigs and fixtures	Continuous, batch-size and split batch production with jigs, tools, fixtures, advanced cutting tools
Factory area (ft^2)	300	1 200	42 000	144 500
Fixed capital investment ($)	6 100	21 200	388 200	5 800 000
Working capital investment ($)	2 100	6 500	127 500	2 750 000
Total investment ($)	8 200	27 700	515 700	8 550 000
Electric power (kVA)	–	38	75	3 000
Annual manufacturing cost ($)	8 890	28 875	553 500	13 380 000
Annual sales turnover ($)	10 000	30 000	640 000	14 000 000
Profit before taxes ($)	1 100	1 125	36 500	620 000
Investment/ labour ratio ($ per worker)	2 050	3 077	7 813.63	16 624.20
Marketing and sales	Directly to farmers	Through wholesale distributors or directly to farmers	Through agents or wholesale distributors	Country-wide distributors or agents with adequate facilities for spare parts supply, servicing and training

The comparative study reveals wide gaps between industries scattered in village, rural and rural-urban areas in terms of plant size, employment, investment requirements, and in particular the methodology and application of manufacturing techniques. In order to bridge the gaps, where the investment-labour ratio varies from $2,050 at the handicrafts level to $16,634 in the industries located in the rural-urban border areas, a closer and integrated

Industry level	*Machine tools*	*Production techniques*	*Supporting industries*	*Minimum factory manufacturing programme*
Craftmanship	Mostly manually operated machine tools, application of simple conventional machines, e.g. for turning, drilling, grinding, welding etc.	More manual operations based on job shop production with limited batch size; dominant feature is hand forging with heat treatment	Hardware industries Woodworking industries	Mostly to customer's requirements; minimum batch production can be introduced; large product mix is essential
Rural small-scale industry	Conventional machine tools, e.g. drilling, milling and arc welding machines, hammer forge, inspection tools etc.	Based on minimum batch production with advanced heat treatment facilities; process planning, method study, setting of standards, quality control etc. can be introduced; use of jig, tools and fixtures, particularly welding fixtures	Disc manufacturing industry Foundry and steel industry Hardware industry Jig and tool manufacturing industry	Minimum economic batch size of production programme is required; medium product mix is essential
Rural medium- and large-scale industry	Conventional, automatic and special-purpose machine tools are required, e.g. drilling, milling and boring machines, bar automatic and chuck automatic machines, and unit head special-purpose machine tools	Continuous, batch and split batch production system incorporating economic batch loading, process planning, estimation, setting of standards, quality control and rigid inspection, production and material control, wide application of jigs, tools, fixtures, including welding fixtures, advanced tooling (high speed and carbide) etc.	Foundry (grey cast iron malleable, spheroidal iron) Forging and die casting Tyres, wheel and rim manufacturing unit Sheet-metal and press work industry Gear cutting and transmission shaft manufacturing units Electrical and instrument manufacturing units Steering wheel and automotive parts manufacturing unit Hardware industries Rubber manufacturing industries Paint manufacturing industries	A minimum manufacturing programme is required, with economic batch loading of each part to be manufactured

Figure VII. Summary of technological criteria at three industry levels

rural development plan is envisaged, particularly in the industrial sectors, through the following measures:

(a) Greater subcontracting arrangements from the small- and medium-sized industries to the handicrafts or village blacksmith-type of establishment. The subcontracted items can be levers, hooks, elbows, hardware, tines, shovels, links, pins, hubs, brackets, welded parts etc;

(b) Creation of greater industrial co-operation, where the medium-sized industries could offer machinery, equipment, raw materials, designs, processing sheets, cost calculations etc. to the small-scale rural units for the supply of simple parts for their assembly line. For this, mutual consideration must be extended for the relative price adjustment in cost calculations. Larger industries should not exploit small establishments owing to their large infrastructure and political and social influence. Through such co-operation, the larger industries will procure parts at cheaper prices, and small units can create further avenues of off-farm employment;

(c) Greater incorporation of supporting ancillary engineering industries in rural or rural-urban areas in order to enlarge rural off-farm activities and to facilitate higher production by increasing available indigenous components. The handicrafts and small-scale industries, even the medium-size industries, cannot afford to install these supporting ancillary industries within their plants because of the relatively high investment-labour ratio and the sophisticated level of the technology.

The following supporting industries are needed in order to facilitate the agricultural machinery and implement manufacturing operations in rural areas:

Integrated foundry, forging and die-casting plants
Agricultural disc manufacturing plants
Integrated sheet metal and press-work plants
Toolroom and tool maintenance plants
Woodworking and pattern-making plants
Integrated plants for galvanizing, perkerizing, electroplating etc.
Integrated plants for heat treatment
Integrated plants for the manufacture of the following products:
  Automotive parts and accessories
  Tyres and rubber products
  Electrical components
  Instruments and gauges
  Hardware components and parts
  Spur and hypoid gears
Integrated plants for prototype manufacture and development

IV. AN APPROACH TO LOCAL MANUFACTURE

A. Role of small and medium industries in rural development and limitations in the development of rural industrialization

The handicrafts, small-scale and medium-scale industries manufacturing agricultural machinery and equipment play a dominant role in programmes for rural development. The promotion of these industries leads to an improvement in social and economic conditions; and an overall balance of rural and urban industrial activities which, in turn, retards migration of labour from rural to urban areas.

Social improvement can be achieved by the following means:

(*a*) Encouragement of indigenous entrepreneurship by way of a relatively large participation of individuals in the management and operation of small establishments, thereby improving productivity through personal efforts to raise operational funds and the effective use of such capital to provide marketable finished products;

(*b*) Improvement of the performance of traditional industry. In the majority of the developing countries, manufacturing establishments at craftsmanship level are of traditional types. The identification of these traditional skills and the timely injection of capital, modern machinery, equipment, and improved technical training and marketing activities can improve the overall performances of these units and thus pave the way for greater industrial development in the rural areas;

(*c*) Increase of employment. By creating more units in the handicrafts and small-scale sectors, many employment opportunities can be provided in the rural areas. Infrastructure facilities and capital outlay are relatively smaller in these sectors compared with large establishments.

Individual drive and entrepreneurship accelerate industrial activities.

Economic improvement can be achieved by the following means:

(*a*) Decentralization and dispersal of industry. In developing countries, the natural trend to establish industries in urban areas creates enormous problems by overstraining infrastructure facilities. A rational approach would be to encourage the growth of industries in rural areas with a planned dispersal and decentralization programme. The small units would supply parts and components to the large urban industries, as wages and overheads are relatively smaller in rural industrial operations. Dispersal would improve rural working conditions through the extension of roads, housing, electricity, water supply and other amenities of modern industrial life;

(*b*) Diversification of products and establishment of new product lines. As there is greater flexibility in the locational and operational requirements of handicrafts and small-scale industries, they are more suitable for diversification and the introduction of new product lines. Import substitution and an increase in subcontracting by such industries means that off-farm activities can be created with less investment and increased production. This type of ancillary development provides overall industrial stability;

(c) Greater utilization of rural resources and capital formation. In developing countries, greater utilization of resources is possible only by the creation of more rural handicrafts and small-scale industries. Owing to individual zeal, interest and saving, there is much potential here for capital formation of off-farm industrial activities. It is very common for the capital invested to come from family savings which would otherwise remain idle or be used to buy urban consumer luxury goods. Small industries make full use of all available resources with minimum wastage, resulting in greater saving and capital formation.

With regard to the overall balance of rural and urban industrial activities and the effort to retard migration from rural to urban areas, it should be noted that the migration of rural labour to urban areas creates an imbalance in the labour market, particularly in the rural areas. More rural industries are essential for rapid development. The overall development plan must contain a pattern of incentives and wage stabilization in the rural industrial sector, if the labour force there is to be maintained.

Yet, despite the need for rural industrial development, certain limitations on the expansion of handicrafts and small-scale industries in rural areas exist. They may be summed up as follows: lack of timely credit facilities; difficulty in acquiring machinery and raw materials; lack of appropriate product design; shortage of suitable factory premises; lack of technological and managerial know-how, trained manpower, marketing facilities and quality standards.

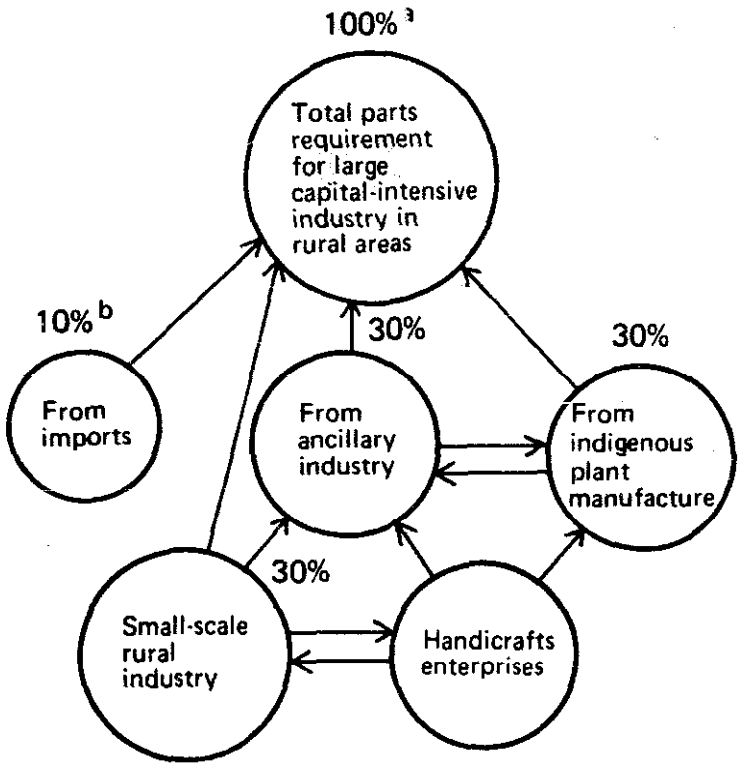
Each constraint creates special difficulties for small enterprises. An integrated development programme providing technological and institutional facilities is needed to form a system of links at the rural industrial level.

B. Capital-intensive large industries and ancillary industry development

Capital-intensive large industries need to consider the following aspects of rural operations: the many constraints on manufacturing operations in rural areas; the need to choose the right product line for which a limited number of components can be supplied by imports and a maximum number by local manufacturing units, to choose the most suitable machinery, equipment and material, and the need for capital to cover plant and ancillary units, the need for efficient production processes; for training facilities; for marketing networks and for repair and maintenance facilities.

It can be seen that capital-intensive large industry engaged in the manufacture of agricultural machinery and equipment in the rural areas needs a substantial number of ancillary industries to supply parts which cannot otherwise be made economically within the plant. On the other hand, the majority of small establishments depend on the larger industries and the ancillary industries for their survival. Handicrafts, small-scale, medium-scale, ancillary and large capital-intensive industries are all interdependent to a limited or greater extent. Closer co-operation between them will add a new dimension to overall development. See annex III, and figure VIII.

As indicated in figure VIII the involvement of large capital-intensive



Note: An arbitrary percentage breakdown of parts procurement is shown for the purposes of illustration

[a] Represents the total manufacturing cost.

[b] Imports can be in the form of raw materials or finished components.

Figure VIII. Chart showing policy for procurement of parts for agricultural machinery industry in rural areas

industry in agricultural machinery and equipment manufacturing operations in rural areas has the following effects:

(*a*) It introduces new product lines to the small-scale and ancillary industries;

(*b*) It encourages the creation of ancillary industries which have a greater share in subcontracting and spare parts manufacturing operations;

(*c*) It creates a resource of skilled personnel particularly in the small-scale sector. Some of these may start their own enterprises for the supply of parts and create a chain reaction of employment;

(*d*) It encourages small industries by supplying specific items of machinery, equipment and raw material in order to procure cheaper parts;

(*e*) It absorbs most of the rural labour force which would otherwise have migrated to the urban areas;

(*f*) It provides a greater opportunity for training to produce personnel for the higher and middle management posts;

(*g*) It extends marketing facilities;

(*h*) It improves rural living conditions.

C. An approach to technical and institutional interlinkage

Rural industries, unlike the industries located in urban areas, face many difficulties in management, technical and marketing operations.

In order to promote the activities of these handicrafts, small-scale and medium-size industries, including the ancillary industries, in rural areas, the creation of institutional and technological linkages will be of paramount importance to overall development, particularly at the village level. The primary requirements of investment and finance, appropriate machinery and technology and promotion of marketing can best be met by the creation of an institutional infrastructure within the rural area. Obviously, this requires both governmental and non-governmental participation.

A complete network of institutional infrastructure has to be designed and implemented in order to bring about more cohesive development in the rural areas by the diffusion of technological and institutional assistance. This, as illustrated in figure IX can be achieved in the following manner:

(*a*) Meeting the requirement of institutional infrastructure for the development of agricultural machinery and allied engineering industries in the rural areas;

(*b*) The creation and installation of an agricultural machinery and allied engineering industries development centre;

(*c*) Non-governmental institutional participation in the development centre through the establishment of:

(i) National and regional professional agricultural engineering institutions,

(ii) National and regional agricultural machinery, implements and allied equipment manufacturers associations,

(*d*) Government institutional participation in the development centre through the establishment of:

(i) Industrial extension services,

(ii) Project financing schemes,

(iii) Industrial estates,

(iv) Co-operative action,

(v) Regional and subregional departments for industrial promotion,

(vi) Standards institutes.

D. Proposed agricultural machinery and allied engineering industries development centre

The structure of the proposed centre is shown in figure IX.

The centre should be composed of the following three sections:

Institutional services

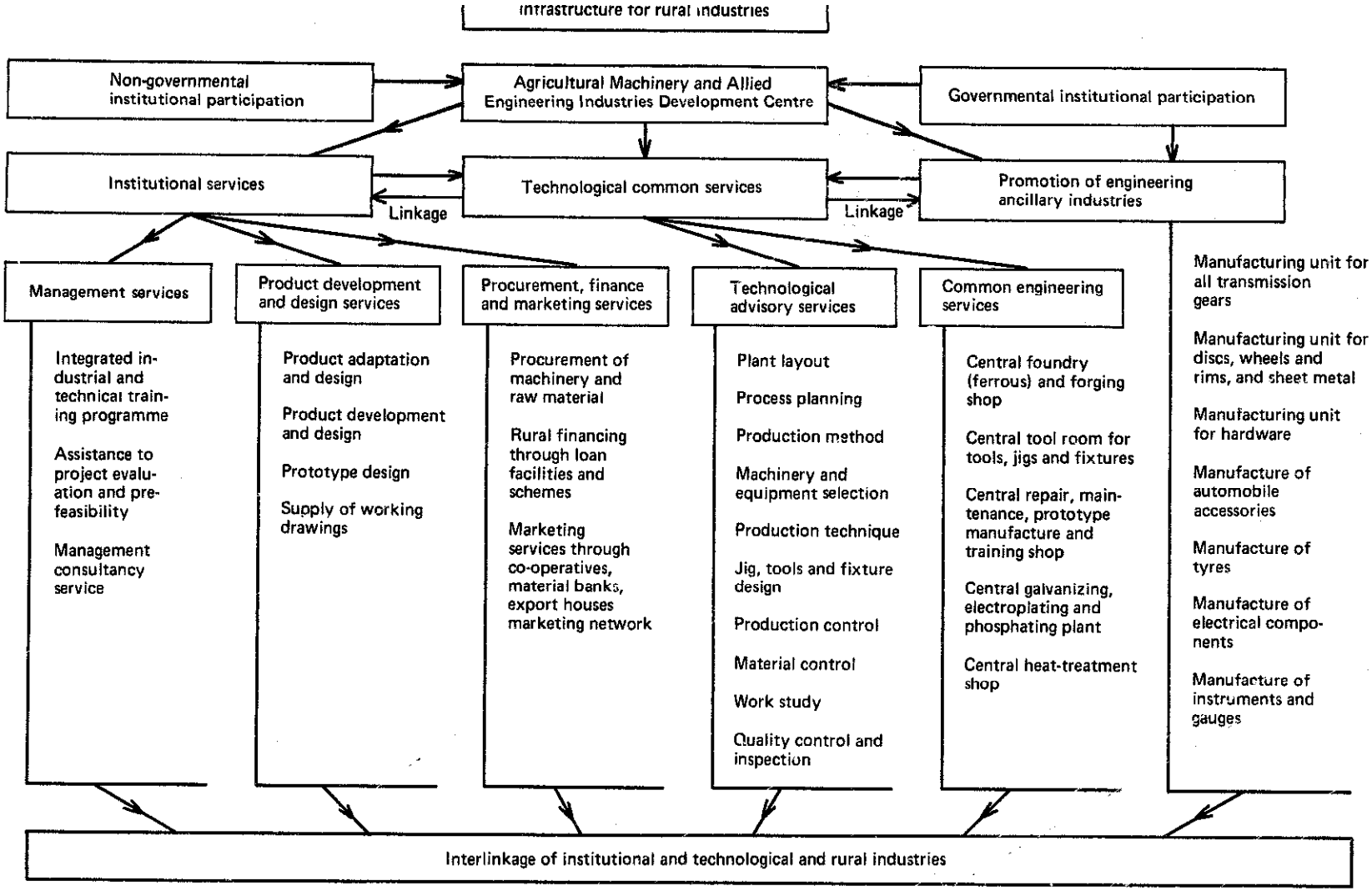


Figure IX. Flow chart of an agricultural machinery and allied engineering industries development centre

Technological common services

Promotion and establishment of ancillary industries services

The institutional services would include (details will be discussed in section V) the following:

Management services

Product development and design service

Procurement, finance and marketing service

The technological common services would include (details will be discussed in section VI) the following:

Technological advisory services

Common engineering services

Common engineering service facilities would include the following:

Central foundry (ferrous and non-ferrous) and forging shop

Central tool room for tools, jigs and fixtures

Central repair, maintenance, prototype manufacture and training shop

Central galvanizing, electroplating, and phosphating shop

Central heat treatment shop

The function of the ancillary industries promotional services will be to encourage the entrepreneurs to establish the factories for the manufacture of the following products in the rural areas: all transmission gears; sheet metal work, wheels, rims and discs; hardware; automobile accessories; tyres; electrical components; instruments and gauges; and many other items required for agricultural machinery industry.

The institutional and technological facilities extended through such a development centre could not only improve the stability and performance of the local industries engaged in the manufacture of agricultural machinery and equipment, but also promote sectional integration through the exchange of technological and commercial knowledge and experience for greater industrial development in the rural areas.

Industries in rural areas are at a disadvantage in technology use and are handicapped by the lack of managerial and skilled workers. The proposed agricultural machinery and equipment and allied engineering development centre would have a greater impact on the rural industrial development programme, through which the handicrafts, small-scale, and medium- and large-scale industries would receive comprehensive as well as *ad hoc* assistance in marketing, management and technology.

V. INTERLINKAGE IN INSTITUTIONAL INFRASTRUCTURE

It has been proposed to establish an agricultural machinery and allied engineering industries development centre involving the possible interlinkage of various institutional services. The institutional services of the development

centre would comprise a management service, a product development and design service, and a procurement, finance and marketing service.

The structure of the institutional services and the appropriate interlinkage between the various sections are shown in figure IX.

A. Management services

The management services of the centre will deal with the matters described below

Integrated industrial management and technical training programme for rural areas

Management appreciation courses will be concerned with the training of proprietors and managers of small- and medium-scale industries. The subjects will cover the principles and practice of management, production management, productivity, financial and cost accounting, cost analysis, budgetary and standard costing, purchasing, store keeping, inventory control, production control, advertising and publicity, industrial laws and labour welfare.

Specialized training courses will be given in production, financial and marketing management with special reference to cost accountancy, and bookkeeping.

Ad hoc intensive training courses on subjects such as work study, quality control inspection, product design, adaptation techniques, and selection transfer of appropriate technology, marketing, standardization etc.

The technical management training programme will be designed for skilled and semi-skilled artisans, small-scale supervisory personnel, and technical middle management of medium- and large-scale establishments, with a view to improving their abilities to produce and handle tools, equipment, jigs, fixtures etc. The programme will include the following:

(*a*) Comprehensive shop practice: foundry shop, carpentry and pattern-making shop, forging and blacksmithing shop, tool room, maintenance and preventive maintenance shop, electrical shop, welding, sheet metal and press shop;

(*b*) Trade-oriented special courses for tool makers, fitters, turners, welders, sheet metal manufacturers, pattern makers, electricians, plumbers etc.;

(*c*) Process-oriented courses for metallurgy and heat treatment, painting, shot-blasting, metal pre-treatment, for example, phosphating, galvanizing, electroplating etc.;

(*d*) Blueprint reading, drawing and design;

(*e*) Quality control, shop inspection and standardization.

Technical training through mobile workshops will also be provided. Mobile workshops attached to the development centre render comprehensive on-the-spot training to skilled and unskilled handicrafts workers in rural areas.

Assistance in project evaluation, pre-investment and feasibility studies for prospective entrepreneurs

The centre will render comprehensive assistance to the entrepreneurs who are interested in a specific agricultural machinery manufacturing project by the following means:

Project evaluation and market surveys

Pre-investment and feasibility studies

Choice of appropriate technology

Choice of machinery and equipment

Management consultancy service

The development centre will render management consultancy services to artisan and small-scale industries in rural areas. The service can be extended to a comprehensive plant study, covering aspects of finance, production and sales by qualified technical staff.

B. Product development and design service

The development centre for agricultural machinery and allied engineering industries will have a product development and design service for rural industries. The service will be responsible for the following matters:

(*a*) Accelerated adaptation and absorption of imported technology;

(*b*) Development of domestic technology;

(*c*) Assisting rural industries in the transfer of both imported and domestic technology through:

Development of product adaptation

Design of new products with high content of indigenous parts

Supply of product drawings, designs and specifications

Supply of working drawings considering the availability of machinery and equipment in the rural industries

Plan for prototype manufacture

For example, the centre may endeavour to develop the design of a suitable low-cost tractor based on the following factors:

Direct injection diesel engine up to 15 hp

Simple gear or belt-driven transmission system

Three-point linkage operated by either mechanical or hydraulic means

Tractor body of either cast housings or welded sections

One or two speeds

The manufacture of such a prototype can be organized in conjunction with the technological common services facilities of the development centre and local industries interested in the products. This will be the method of interlinkage between the institutional and the technological services within the development centre and the industries.

C. Procurement, finance and marketing services

These back up services will facilitate the effective operation and economic viability of the rural industries.

Procurement of machinery and raw materials

Due to the tight foreign exchange situation, most of the developing countries are facing a critical situation for obtaining machinery and raw materials for industries, particularly in the rural areas.

The development centre will be able to assist rural industries through selection and specification of materials and selection of appropriate machinery and equipment.

The development centre will be able to assist the rural industries by introducing a bulk purchase system in close co-operation with private importers, government institutional agencies and local industries. For small-scale industries, particularly in the rural areas, minimum stock control is essential. After ascertaining the demand, the centre will be able to assist by procurement through the bulk purchase scheme; and procurement through government agencies, importers or co-operative groups.

With regard to machinery and equipment, the centre's assistance could be through the following: hire-purchase schemes; government aid schemes to less developed areas; fund-raising; and allowing the use of common engineering service facilities at nominal cost.

This will create an internal linkage between institutional and technological services of the development centre and external linkage with the industries.

The development centre will make a machinery and equipment inventory diary for all the dispersed small industries in rural areas.

Finance and marketing services

The small rural industries need finance and marketing facilities, and the centre can organize the following schemes or services:

(*a*) Assistance to loan facilities from commercial, private or State-owned banks for the purchase of raw materials, machinery and equipment;

(*b*) A cash credit account, that is payment of advance against pledge goods under a scheme which can be designed by the centre and operated by the banks;

(*c*) Assistance in raising finance through financial institutions;

(*d*) Bringing the banks and the credit institutions closer to the industries;

(*e*) Recommending extension of government credit guarantee schemes and other financial schemes to promote rural activities;

(*f*) Recommending extension of government subsidies, particularly on the interest rates payable in less developed regions.

Marketing schemes and services

The development centre can extend rural institutional marketing facilities and services through:

(*a*) Co-operative marketing schemes;

(*b*) Intensification of subcontracting systems and facilities so that industries will depend more on each other for parts and accessories;

(*c*) Introduction of a materials bank for small-scale industries;

(*d*) Establishing sales centres;

(*e*) Establishing centres where products can be displayed;

(*f*) Creation of a marketing and export house to provide marketing and sales information and facilities;

(*g*) Preparation of a manufacturers and sellers directory;

(*h*) Promoting participation in exhibitions;

(*i*) Creation of a joint marketing advisory board.

VI. INTERLINKAGE IN TECHNOLOGICAL MATTERS

The technological common services of the development centre will ensure technological advisory services, common engineering services and promotion of ancillary industries.

A. Technological advisory services

The technological advisory services will deal with the matters described below.

Plant layout. The provision of plant layout for any individual enterprise is to include the flow diagram, the organization of sections within the plant, the arrangement of machinery, equipment and facilities.

Process planning. Assistance with process planning will include estimated production, man-hours available for each part to be manufactured, break-down of operations for each machine or process, estimated machine time, types of machine, jigs, tools and fixtures, pre-machined shape of material and specifications, and floor-to-floor estimated time.

Production methods. These include requirements of jigs, tools, fixtures and equipment to facilitate production; drawings for simple jigs, tools and fixtures; and, if necessary, the establishment of standard methods of production.

Machinery and equipment selection. The centre will be in a position to advise on the selection of machinery and equipment to suit the available facilities both in terms of finance and skills. The centre will be able to advise on speed, feed, depth of cut, and the power requirement for a component to be manufactured on a particular machine.

Production technique. The centre will be able to guide small industries on modern techniques; for example the application of pneumatic clamping heads in the use of carbide-formed tools, throw-away carbide-tip tools with speed, feed and depth cut requirements, metal processing techniques, heat treatment techniques etc.

Jigs, tools and fixture designs. The centre will assist in designing simple jigs, tools and fixtures and, if possible, their subsequent manufacture, using common engineering services within the centre.

Production control. For this purpose the centre will be able to assist in the preparation of:

Control or bar charts

Machine loading charts

Route cards with process sheets

Master scheduling and scheduling in various departments

Job cards and shop orders

Scientific follow-up incorporating a production recording sysstem

Material control. Material control assistance includes the following:

Ensuring economic batch production sizes

Ordering and receiving materials with a minimum stock level

Material requirement forecasts

Raw material inventory controls

Introduction of perpetual inventory through Kardex system stores organization

Material handling and facilities for storage during work in progress

Work study. For medium-size and small-scale industries, work study is an important aspect of increasing productivity. It involves work measurement and method study.

The centre will be able to assist in the technique of work measurement through time, production and systematic method studies of a particular operation, and to provide a visiting time-study and methods engineer. A definite scheme of incentives can be drawn up on the basis of speed and effort rating; measured daily work; group incentive based on group performance etc.; piece rate system.

Quality control and inspection. The development centre will be able to assist small firms to introduce a good quality control system. This requires:

Provision of calliper, micrometer, depth gauge, height gauge etc.

Design of special production inspection gauges, for example gap gauge, plug gauge, thread gauge etc.

Quality control charts with upper and lower limit for quality control

Statistical quality control for bar or chuck automatic machines

Inspection and control of tool geometry and its technology

Improvisation of special inspection tools

Training of inspectors and quality control engineers

B. Common engineering services

The common engineering services will form the real backbone of rural industrial development. Small, medium and even large factories cannot afford to

install all the machinery and equipment required. It is often economical to procure certain finished or semi-finished parts through subcontracting or direct purchase. Installation of common engineering services and facilities within the institutional set-up in rural areas can be achieved by incorporating them in the proposed agricultural machinery and allied engineering industries development centre. Thus the centre will render technological, manufacturing and commercial assistance.

The general requirements of various engineering establishments and industries can be met by the development centre by having the following central shops:

Foundry (ferrous and non-ferrous) and forging shop

Tool room for tools, jigs and fixtures

Repair, maintenance, prototype manufacture and training shop

Galvanizing, electroplating and phosphating shop

Heat-treatment shop

Central foundry and forging shop

The establishment of a central foundry and forging shop is a basic requirement for rural industries, providing common service facilities with a ferrous (cast iron, steel etc.) and non-ferrous (brass, aluminium etc.) foundry producing materials essential for any metalworking industry development.

Ferrous foundry

Products

The minimum grey cast iron and steel ingot production will be 20,000 t of liquid metal per annum, that is 80 t per day for 250 working days a year. Raw material will be scrap steel and pig iron. This entails a production of 5,000 t/a of high-duty grey iron for casting (grade 17 or mehanite specification), 9,000 t/a of S. G. iron and malleable iron, 1,000 t/a of steel castings, and 5,000 t/a of special steel ingots for forging.

Equipment

(a) Melting

Direct-arc melting furnace with a capacity of 8 t per batch, complete with electrical transformer of 3,000–4,000 kVA capacity, and 11 kV, 3 phase, 50 Hz supply. Furnace should be suitable for operation with basic and acid linings

Mains frequency induction melting furnace, capacity of 4–5 t per batch, with power input of 1,000–2,000 kVA for melting of iron and steel; high tension power required, 11 kV, 3 phase, 50 Hz; low tension power required, 415 V, 3 phase, 50 Hz

External overhead transport (EOT) crane, 20-m span, 10-t capacity

Electromagnetic discs, 1.25-m (approximately 4 ft) diameter, for lifting the iron for charging

Platform and weighing bridge, 10-t capacity

Immersion-type pyrometer for measuring liquid metal up to 2,000° C

Optical pyrometer, 1,200°–2,000° C

Combined bottom- and tip-pouring ladles, with capacities of 10 t, 5 t, 3 t and 1 t; hand shanks of 50 kg, 100 kg and 250 kg

Muffled furnace for preheating of ferro-alloys, oil-fired or electrically heated, temperature rise 800°–1,000° C

Induction melting furnace, approximately 10-t capacity, 500-kW power input for super-heating the metal

Continuous heat-treatment furnace for heat-treating the malleable cast iron, range up to 1,000° C

(b) Moulding

Continuous mixer, 10 t/h

Vibratory shaker, precrusher, vibratory conveyor, overband magnetic separator, surge hopper

Complete set of core makers' and moulders' tools, cope boxes etc.

Pneumatic moulding machines

Stationary sand slinger with ramming gap

Roller conveyors, jib cranes, standard steel bins, moulders hand tools etc.; rolled steel manufactured mould boxes

(c) Fettling

Fettling machines and equipment

(d) Pattern shop

Band saw machine, planing machine, crosscut circular saw, combined disc bobbin sander, wood-turning lathes, pillar drilling machines, hand tools

(e) Maintenance

Turning and screw-cutting lathe, chucking lathe, radial arm drilling machine, shaping machine, planing machine, boring machine and tools

(f) Common services

Electric substation

Air compressor set

Oil tanks, water reservoir, pipelines

Dust and fume disposal system

Forklift truck etc.

(g) Testing laboratory

Chemical section, sand-testing section, mechanical testing section, metallography section, heat-treatment section, and non-destructive section, to be equipped with all necessary machinery and equipment

Non-ferrous foundry

Products

The minimum factory production of non-ferrous castings will consist of various parts of pumps, crop protection equipment and tractors. The installed capacity will be 1,000 t/a for brass, and 300 t/a for aluminium.

The production of various brass and aluminium alloys will be:

60% Cu + 40% Zn (brass)–750 t/a

80% Cu + 20% Zn (bell metal)–250 t/a

Aluminium alloy–300 t/a

Equipment

The equipment not shared with the ferrous foundry will be as follows:

(a) Melting

Three oil-fired crucible furnaces (for gravity casting), fitted with air control automatic burner, etc., including chimney

Hot-chamber die-casting machine with high-pressure plunger goose-neck attachment:

Locking capacity 13 t

Plunger diameter 1½ in., area 1.76 in.^{2}

Pressure on metal 7½ t/in.^{2}

Volume per shot 13 in.^{3}

Weight per shot, aluminium 1.25 lb

Weight per shot, brass 3.9 lb

Automatic sand-core-making machine (duplex-type) for gravity casting

Automatic shell-moulding machine (duplex-type) for gravity casting

Beryllium-copper steel dies

Hand shanks, capacities of 1 kg, 2 kg and 5 kg. Core-keeping trolleys

(b) Fettling

Fettling machines (pneumatic type)

(c) Trimming

Trimming machines, belt sanders etc.

Forging shop

Products

The minimum factory production of the forging shop will be 5,000 t of finished forged parts per year, i.e. 20 t of forged parts per day for 250 working days per year.

Equipment

(a) Forging

Hammer forging machine, 80 t capacity (for hot forge)

Upset forging machine, 40-t capacity (for hot forge)

Drop forging machine, 40-t capacity (for hot forge)

(b) Heat treatment

Preheating furnace up to 1,600° C, oil-fired or electrical heating with thermostat control

Annealing furnace

(c) Billet cutting

Gas cutting machine, machine parts, shearing machine, abrasive cutter and pedestal grinder

(d) Inspection and metallurgical laboratory

This will be part of the central foundry

(e) Mechanical handling

Forklift truck, EOT crane, bins, weighing scale up to 5 t

Material specification for forging tools and dies

During forging operations there are three main causes for tool deterioration: pressure, abrasion and heat.

The problem is more serious for dies, since these are in more intimate contact with the hot material for a much longer period of time. Tungsten and chromium are the two alloying elements found to be the most effective for the selection of die material.

The composition of die steel for forging would be as follows:

Carbon 0.4 to 0.5 per cent
Tungsten 18 per cent
Chromium 3 to 4 per cent
Iron, remainder

Alternative composition of die steel for forging could be:

Carbon 0.8 to 0.9 per cent
Chromium 3 to 4 per cent
Manganese 0.5 to 0.6 per cent
Iron, remainder

Heat-treatment of the tools is done according to the manufacturers' recommendation.

Central tool room for manufacture of tools, jigs, fixtures and precision parts

The role of the central tool room will be to perform the following functions for rural industries:

Manufacture of jigs, tools, fixtures for production facilities
Training of highly skilled tool makers
Maintenance of all special-purpose tools
Manufacture of precision spare parts for the industry

The tool room will be geared for precision work up to 0.00001 in. and surface finish up to 0.2 microinch.

Production

The tool room will be capable of handling per annum the following:

Grinding of 10,000 units of small and simple tools

Grinding and lapping of 1,000 milling cutters, including high-speed steel (HSS) and carbide-tipped tools

500 jigs and fixtures weighing 100 t

1,000 simple jigs and fixtures weighing 100 t

Sharpening of 200 broaches

Grinding of 500 special gear cutters

Equipment

An essential equipment list is given below. Detailed specifications are reflected only for special machines in tool room work.

Tool room high-precision machines

Jig boring machine with all accessories

Boring and facing head, boring bars, collet chucks, internal micrometer, depth measuring attachment, auto-positioning jig boring machine capable of sensing position to an accuracy of 0.0002 in. In order to ensure the most sophisticated precision machining, the machine should be equipped with:

Two-dimensional tracer-controlled copy milling

Automatic profile generation

Auxiliary horizontal boring spindle

Automatic selection of co-ordinates

Automatic quill-retraction system

The specifications of the machine should be as follows:

Work table 60 in. × 30 in.

Work table longitudinal traverse 45 in.

Work table cross traverse 26 in.

Spindle speeds (stepless) 40–2,000 rpm

Spindle feeds (8 up and down) 0.0005 in. to 0.012 in. per spindle revolution

Precision universal grinding machine with accessories

Height of centres 6 in., distance between centres 24 in. to 60 in.

Wheel speeds (2), 1,561 to 1,910 rpm

Work speeds (4), 40 to 200 rpm

Table speeds 3 in. to 192 in. per minute

Wheel head infeed 0.003 in. to 0.0002 in.

Work head swivel 90° right, 45° left

Wheel head swivel 90° right, 90° left

Underslide swivel 90° right, 90° left

Tool room die-sinking machine (duplex-head-type) with electro-hydraulic tracer control

Table size 48 in. × 24 in.
Maximum depth of die 10 in.
Maximum length of die 20 in.
Maximum width of die 20 in.
Spindle speeds 30 to 1,800 rpm
Horizontal, vertical travel 0.25 in. to 20 in. per minute
Automatic horizontal and vertical step feed 0.010 in. to 3 in. per stroke

Precision cylindrical grinding machine with internal grinding attachment

Maximum wheel diameter 20 in.
Maximum wheel width 4 in.
Height of centres 6½ in.
Capacity between centres 24 in. to 72 in.
Wheel speeds (2), 955 to 1,205 rpm
Work speed (6), 16 to 235 rpm
Table speed 3 in. to 240 in. per minute

Optical dividing head

Calibration can be up to 2″ of arc. Maximum distance between centres 18 in.

High-precision gauge-grinding machine

(Specifications will be as above)

Precision internal-grinding machine

Precision surface-grinding machine

Longitudinal traverse 22 in.
Cross traverse 8 in.
Maximum height from table to centre spindle 16½ in.
Working table 20 in. × 8 in.

Universal milling machine with accessories (standard machine)

Universal horizontal boring machine (standard machine)

Precision lathe with all accessories (standard machine)

Precision universal broach-sharpening machine

Suitable for both internal and surface broaches, maximum length of 80 in., micro-feed attachment and built-in frequency changer

Precision twist-drill grinder with attachment

For grinding twist drills, both left-hand (LH) and right-hand (RH), high-speed steel (HSS) and carbide-tipped, diameter 1/32 in. to 3 in.

Precision automatic face-mill grinder

For grinding and lapping face-mill cutters (LH and RH) tips for HSS and

tungsten carbide, milling cutter diameter 6 in. to 12 in., maximum grinding-wheel size 10 in. × ½ in. × 1½ in. bore.

Double-ended grinding and lapping machine with angle plate and table (parallel face)
Maximum wheel size 8 in. × 3 in.
Wheel size for lapping 6 in. × ½ in.

Precision turning lathe with cross slide swivel for turret
Standard upright drilling machine
Standard radial arm drilling machine
Standard knee-type milling machine
Standard shaping machine
Double-ended grinding machine
Double-ended polishing machine
Band-saw with endless saw blade
Electric arc-welding machine, up to 800 A
} *Standard medium-size machines*

Electric spot-welding machine, up to ⅜ in. thickness to be welded
Precision surface table 36 in. × 36 in., weighing ½ t
Working surface table 24 in. × 24 in., weighing 200 kg
Heat-treatment furnace
30 in. × 20 in. × 20 in., temperature up to 1,600° C, electrically heated
Quenching tank 36 in. × 36 in. × 36 in.
Fitters' bench, vices, universal vices, hand tools, drill sets, expanding reamer set, reamers, taps, drills etc.

Measuring instruments

Horizontal high-precision optical comparator
Total range of scale ± 0.005 in.
Graduation of scale 0.00005 in.
Vertical movement of workpiece 3⅜ in.
External maximum diameter 4 in.
External maximum distance 6 in.
Minimum pitch diameter gauged 25/32 in.
Facilities for rapidly and accurately checking external and internal plain cylindrical gauges, screwing gauges

Tool-maker's microscope
With compound table, work centre cradle, vee-support, protractor ocular

Precision slip gauges (3 sets required)
1 set comprising 81 pieces in accordance with the specifications (BS888) given in table 10

TABLE 10. SPECIFICATIONS FOR PRECISION SLIP GAUGES

Range (in.)	*Steps (in.)*	*Pieces*	*Grade*
0.1001 – 0.1009	0.0001	9	
0.101 – 0.149	0.001	49	For workshop
0.05 – 0.95	0.05	19	For inspection
1, 2, 3 and 4	–	4	For calibration

Universal test indicator set

Dial indicator, back plunger with an anvil of 1/16 in.

Radius

Graduation 0.001 in.

Reading 0–100 or 0–50–0

Range 0 to 0.2 in.

Lever-type dial indicator

Standard reference vernier

Vernier depth gauge

Open vernier reading direct to 0.001 in.

Vernier height gauges

Capacity from 0 to 36 in.

Capacity from 0 to 18 in.

Base tangent calliper

Capacity up to 4 in.

Reading to 0.001 in.

Other

Vernier callipers, squares, engineers' squares, bevel protractor, combination set, small hole gauge, telescopic gauge, end-measuring micrometer set, depth gauge micrometer, internal micrometer, hand-grip deep-frame micrometer, thread-measuring tools and micrometer

Central repair, maintenance, prototype manufacture and training shop

Common engineering services will provide all-round maintenance facilities to the small and medium-size firms in rural areas. With the available machinery and equipment it will be possible for the development centre to manufacture prototype agricultural products designed by the product development and design service section. Moreover, extended training facilities can be provided in this section so that the workers will receive training in manufacture, repair and plant maintenance. In this way links can be established between the design and engineering sections of the centre and also with the industries.

Minimum machinery and equipment required

Lathe for turning and screw cutting

Maximum swing over bed 36 in.

Capacity between centres 72 in.
Maximum length of threads 6 in.
Maximum diameter of thread 6 in.
Maximum pitch 5 threads per inch

Capstan lathe with hex-turret and all accessories
Diameter of hole through spindle 2½ in.
Maximum swing under overhead support 13½ in.
Maximum distance of spindle flange to turret 33½ in.
Maximum length of bar stock 8 in.

Universal milling machine with compound dividing head and vertical milling attachment
Capacity 30 in. × 8 in. × 20 in.
Speeds 18, ranging from 26 to 1,250 rpm
Feeds 18, from ½ to 30 in./min, 9½ in. diameter, universal dividing head

Knee-type milling machine with dividing head
Capacity 30 in. × 18 in. × 20 in.
Speeds 18, ranging from 26 to 1,250 rpm
Feeds 18, from ½ to 30 in./min

Horizontal boring machine with sliding head and swivelling work table
Maximum diameter face and bore 60 in.
Spindle traverse, vertical 7½ in. to 65½ in.
Revolving table 48 in. × 48 in., maximum distance facing slide to boring stay 140 in.

Cylindrical grinding machine with internal grinding attachment
Grinding wheel size 20 in. × 2 in. diameter × 8 in.
Maximum diameter ground 10 in.
Maximum length between centres 72 in.
Roll face length 48 in., maximum weight of roll 350 lb

Surface grinding machine with magnetic table
Size of table 20 in. × 8 in.
Longitudinal travel 22 in.
Traverse travel 8 in.
Grinding wheel 8 in. diameter

Radial arm drilling machine with universal table
6 ft spindle radius, capacity 3 in. diameter in MS
Speeds 15 to 1,500 rpm, 17 steps
Feeds 0.004 to 0.030 in./rev, 6 steps

Upright drilling machine
Capacity 3 in. diameter in mild steel (MS)

Speeds 15 to 1,500 rpm, 17 steps
Feeds 0.004 to 0.030 in./rev, 6 steps

Gear-hobbing machine with accessories

Maximum distance from centre of work spindle to centre of hob arbour 5½ in.
Hob arbour diameter 1¼ in.
Maximum hob outside diameter 4 in.
Maximum diameter pitch (DP) module cast iron or steel 4 to 16

Gear-shaving machine with accessories

Capacity 18 in. diameter
Pitch diameter 1 to 18 in.
Outside diameter maximum 18.875 in.
DP or module 4 to 16, cutter diameter 9 in., maximum face width 10 in., maximum crown width 6 in.

Vertical lathe with turret slide arrangement and side tool attachment

Table diameter 36 in.
Maximum diameter of work 44 in.
Down feed of turret tool head 24 in.
Vertical traverse of side tool 30 in.

Heat treatment furnace

Oil-fired or electrically-heated heat-treatment furnace, maximum temperature up to 1,200° C with thermostat control

Quenching tank

Steel-made tank 36 in. × 36 in. × 36 in.

Press brake

Maximum bending pressure 50 t
Effective work length 100 in.
Width of table 8 in.
Stroke 0 to 4 in., number of strokes per minute 9

Eccentric press

Capacity 50 t
Blank thickness up to ⅛ in. mild steel (MS)

Tube-bending machine

Maximum tube diameter 2 in. in MS

Nibbling machine

Maximum tensile strength of plate 50 t/in.^{2}
Edge cutting, up to ⅛ in.
Number of strokes per minute 2,800 to 1,400
Maximum circular cutting 28 in. diameter

Shearing machine
Shear in mild steel plate up to 15/32 in.
Shearing length 100 in.
Strokes per minute 15

Hydraulic press
Table size 24 in × 24 in., capacity 5 t

Electric arc-welding set
Maximum current 500 A

Electric spot-welding set
Maximum thickness of material, MS 1/4 in.

Oxyacetylene welding set (standard)

Profile gas cutting machine
Maximum size to be cut, 48 in. diameter

Crankshaft turning machine
Crankshaft size: length 30 in., diameter 3 in.

Crankshaft grinding machine
Crankshaft size: length 30 in., diameter 3 in.

Portable tools and equipment
Drilling, grinding, trimming etc.

Electrical measuring equipment and maintenance equipment

Common services
Electric compressor set
Water tank, oil tank and pipeline
Electric substation
Fork-lift trucks, cranes etc.
Fitters' bench, cupboards etc.

Machinery for training (medium- and small-size)
Lathes, milling machines, drilling machines, welding machines, boring machines, and all the machinery in the maintenance shop for practical training

Central galvanizing, electroplating and phosphating plant

The processes of galvanizing, electroplating and phosphating are used to protect the surfaces of the components associated with the agricultural machinery and equipment. It is difficult for the small firms in rural areas to install in their own plant metal-surface treatment machinery, which is generally capital-intensive and beyond the means of small establishments. In order to provide this service for the industries in rural areas, the development centre can install such a plant for common engineering use.

The plant will be able to ensure the processing of chisels, tines, discs, gears, pinions etc., the phosphating of gear levers, bolts, nuts, rods, caps and many other parts, the bright-zinc plating of nickel and chrome plating of tractors and implements and other equipment.

Metal-surface treatment will involve various processes:

(a) *Bright-zinc plate, passivated and bleached.* Any conventional bright-zinc plating process to give a minimum thickness of 0.0003 in., involving passivation with a conventional chrome-type passivating solution and bleaching to give a zinc coating of good appearance which will withstand 48-hour acetic acid salt spray, conforming to ASTM B. 287;

(b) *Copper and nickel plate.* Any conventional copper plating process followed by a conventional nickel plating process to give a minimum thickness of 0.0006 in. and good appearance;

(c) *Copper, nickel and chrome plate.* Any conventional copper plating process followed by a conventional chrome plating process to give a resultant thickness of 0.0006 in. and a good appearance, conforming with BS 1224;

(d) *Phosphate, stain and oil process.* Any conventional phosphating process, providing it conforms with a particular weight, dyed by any approved water stain and sealed by any approved oil to give corrosion protection specified by manufacturer;

(e) *Parkolubrize process.* Phosphate with parkolubrize and seal with an approved lubrication oil to give a good corrosion protection surface.

Equipment

(a) *Parkolubrize, bonderize and copper plating*

Bonderizing vat, 4 ft × 3 ft × 3 ft deep
Hot swill vats
Trichloroethylene degreasers
Copper plate vats 6 ft × 3 ft × 3 ft deep
Hoists and runways
Parkolubrizing vats 3 ft × 3 ft × 3 ft
6 ft × 3 ft × 3 ft

Power requirement. The vat loads depend on the number of components per jig and the number of jigs loaded.

Total capacity 500 A
For copper plating, 25 to 30 A/ft² for the calculation of vat loading
Parkolubrizing, 15 to 25 min per vat
Copper plating for carburizing, 30 min per vat

(b) *Bright zinc, copper, nickel and chrome plating*

Equipment

Trichloroethylene degreaser
Zinc-plating vats 6 ft × 3 ft × 3 ft
Galvanized hot-swill vat 3 ft × 3 ft × 3 ft

Galvanized hot-swill vat 6 ft × 3 ft × 3 ft
Galvanized cold-swill vat 3 ft × 3 ft × 3 ft
Stainless-steel nitric-acid vat 3 ft × 2 ft × 3 ft
Stainless-steel nitric-acid vat 4 ft × 3 ft × 3 ft
Stainless-steel vat 3 ft × 3 ft × 3 ft
Copper-plating vat 6 ft × 3 ft × 3 ft
Zinc-plating barrel
Nickel-plating vats 6 ft × 3 ft × 3 ft
Chrome-plating vats 6 ft × 3 ft × 3 ft
Rinsing vats 3 ft × 3 ft × 3 ft
Various air taps, benches, vices, jigs, hoists etc.

Estimated process time. This is as follows: bright-zinc plating 15 min; barrel zinc plating 60 min; and copper, nickel, and chromium plating 60 min, to give a thickness 0.0006 in.

(c) *Other requirements*

The electroplating shops need a suitable chemical laboratory with equipment for the analysis of chemical and treated surface properties of parts.

Central heat-treatment shop

Heat treatment is essential to condition steel parts for greater load bearing and surface hardness. The equipment is also capital intensive and requires a high degree of chemical and metallurgical attention. The following heat-treatment processes should be provided for: normalizing and annealing; case-hardening; carburizing, hardening and tempering; induction hardening; cyanide and neutral-salt hardening and tempering.

(a) *Normalizing and annealing*

The equipment required is as follows:

Continuous normalizing furnace
Trolleys (overhead rails)
Hand trays and stillages for storing

The process time is 15 min.

(b) *Case-hardening*

This is the usual and most economical method for "deep" cases or for parts which require grinding after hardening. It is most suitable for the handicrafts and small-scale level.

The process requires the following equipment and supplies:

Charcoal grains 1/4 in. to 1/2 in.
Case-hardening boxes 12 in. × 18 in. × 12 in.
Oil-fired furnace 36 in. × 36 in. × 36 in., with temperatures up to 900° C.

Water or oil-quenching tank 48 in. × 48 in. × 48 in.

1/4-t hoist

Case depth is up to 0.040 in. at 900° C for 4 hours for small pieces up to 1 in. × 1 in. × 1 in., and up to 0.040 in. at 900° C for 8 to 12 hours for relatively large pieces to be carburized.

The following are the general case-hardening steels used in agricultural machinery industries:

Specification	*Refining*	*Quenching*	*Hardening*	*Quenching*
EN 32A	870°–900° C	Water or oil	760°–780° C	Water
EN 32C	870°–900° C	Water or oil	760°–780° C	Water
EN 32M	870°–900° C	Water or oil	760°–780° C	Water
EN 361	850°–880° C	Water or oil	780°–820° C	Oil
EN 362	850°–880° C	Water or oil	780°–820° C	

(c) *Carburizing hardening and tempering shop*

The following equipment is required:

Carburizing furnace with endothermic generator using propane and town gas (if available)

Hardening furnace, oil-fired or electrically heated

Oil-quenching vats

Water-quenching vats

Trychloroethylene degreasers vat

Mobile crane

Hoists for degreasers

Cooling conveyer

The case depth achieved is a function at time as follows:

Depth (in.)	*Time (h)*
0.010	1
0.025	2
0.035	3
0.035–0.070	6
0.070–0.085	10
0.085–0.100	14

Salt tempering requires a salt-type tempering furnace and a trichloroethylene degreasers vat. Tempering time is 60 minutes.

(d) *Induction hardening*

Equipment requirements are:

145-kW hardening furnace

75-kW tempering furnace

60-kW tempering furnace

Oil-quenching tank

Water-quenching tank

Washing plant

Electric grab-crane

An alternative to heating by induction is to use an open-hearth hand-controlled hardening furnace.

(e) *Cyanide and neutral-salt hardening and tempering*

Cyanide hardening is used for very small parts to be heat-treated in batches. The following equipment is needed:

Twin 24-in. cyanide pots
Trichloroethylene degreaser vat
Pre-heating pots
Oil-quenching vats
Water-quenching vats
Benches for wiring and degreasing

The case depth achieved is as follows:

Depth (in.)	*Time (min)*
0.005	30
0.010	60
0.015	90
0.020	120
0.025	150
0.030	180
0.035	210
0.040	240

For tempering after cyanide treatment, a 55-kW tempering furnace, a continuous salt-type tempering furnace and loading trolleys are required.

C. Promotion of ancillary industries

In order to promote industries supplying components to the manufacturing units in rural areas, assistance is required from government institutional facilities in the following fields: industrial extension services, financing of projects, industrial estates, co-operative action, and regional and subregional departments for industrial promotion.

In close co-operation with the centre and government institutional participation, investors (both in the private and public sectors) can install units to manufacture the following products: transmission gears including crown wheels and pinions for tractors; discs, wheel and rim and sheet-metal components; hardware, for example bolts, nuts, springs, hooks and chains; automobile accessories, for example air filters, oil filters, silencers, and gaskets; electrical components and accessories, horns, dynamos, starters etc.; instruments and gauges.

VII. NATIONAL POLICY AND PLANNING

In order to formulate a comprehensive plan for the systematic development of agricultural machinery and allied engineering industries in the rural areas of developing countries, there is a need for national planning. This can be

formulated through an agricultural machinery board, a high-powered body under the ministry of agriculture, planning and industries. The board will formulate the national policy on the basis of the following factors:

(*a*) The technological need for agricultural machinery industries in rural and urban areas;

(*b*) The development of an infrastructure for centralized or decentralized growth of technology coupled with a technological information system, services and know-how;

(*c*) An institutional system for accelerated absorption of appropriate imported technology, development of domestic technology, and transfer of both imported and domestic technology;

(*d*) An R and D plan for domestic technology.

Such planning and policies should provide guidelines in terms of fiscal and regulatory devices to encourage domestic technological development and allow sufficient import of foreign technology in the most critical sector of development.

A. National plan

To promote and implement the policies of the agricultural machinery board, a national infrastructural facility is required and can best be achieved through an agricultural machinery industries development corporation. This would be an autonomous and semi-official body. Its main functions would be as follows:

(*a*) To define technology requirements at various levels;

(*b*) To assist with meeting the requirements of industry for plant, infrastructure facilities (electricity, water, sanitation etc.), machine tools, equipment and metal-working processes, specification of material and products;

(*c*) To make a comprehensive survey of existing industry and the possible future demand for improved machine tools, equipment and manufacturing;

(*d*) To draw up a plan with a time target for product identification and development of agricultural machinery best suited to local conditions.

Such a plan should elaborate a manufacturing programme and the complete range of production on the basis of:

(*a*) Accelerated manufacture of indigenous parts and components;

(*b*) Promotion of co-operative manufacture of parts through the interlinkage of technological institutional service facilities and small, medium and large industries in the rural areas;

(*c*) Promotion of indigenous subcontracting through the interlinkage of manufacturing units;

(*d*) Reducing imports of raw materials, parts and components to complete the assembly of indigenous manufactured items;

(*e*) Importing complete units of agricultural machinery which cannot be produced within the development plant;

(*f*) Co-ordinating the comprehensive technology expansion plan with the overall development plan of the country in order to determine the overall requirements of agricultural machinery industries as compared with the rest of the engineering and allied industries sector;

(*g*) Establishing a national plan and target for managerial and skilled workers and developing a comprehensive training plan in order to supply labour, particularly in the rural areas;

(*h*) Planning an institutional and technological interlinkage among the rural industries through the agricultural machinery and allied engineering industries development centre.

The national technological plan for interlinked development should accordingly be carried out at an institutional level through organizations able to draw on support from both private and public sector industries. The proposed agricultural machinery industries development corporation will be the most suitable institution for executing such a development plan set out by the agricultural machinery board for greater rural industrialization.

B. Government policies to promote interlinkage

The overall government policies for interlinking development in the rural areas will be established through the agricultural machinery industries development corporation and the agricultural machinery and allied engineering industries development centre. The former will be responsible for promotional, fiscal, legislative and financial aspects of interlinking development, and the latter for institutional and technological aspects.

Government policy for manufacturing and technological linkage will be channelled through the development centre by the following means:

(*a*) Promotion of technological advisory services;

(*b*) Incorporation of common engineering service facilities through direct government investment where industries in rural areas will be able to obtain castings, forgings, precision tools and equipment, jigs and fixtures, proper heat treatment facilities and metal surface treatment facilities at a reasonable price;

(*c*) Creation of more ancillary small- and medium-scale industries under the agricultural machinery industries development corporation to produce parts and accessories by:

(i) Accommodating them on rural industrial estates with nominal rent,

(ii) Offering financial incentives and participation for investment in plant, machinery and equipment,

(iii) Liberalizing import facilities,

(iv) Providing training facilities through the development centre and training institutes;

(*d*) Establishing a co-operative manufacturing programme through the government policy for co-operative rural development; supplying prototypes developed and manufactured by the development centre to small industries;

(*e*) Establishment in rural areas of R and D centres responsible to the

agricultural machinery board and the development centre. This arrangement will provide feedback to the board for improved national development planning. Government policy will be to provide finance and know-how;

(*f*) Encouragement of subcontracting among local industries by:

(i) Regulating imported parts and components

(ii) Import substitution,

(iii) Providing raw materials for rural industries, through imports or local agents;

(*g*) Standardization of parts, components and products to create rural stability;

Interlinkage through the development centre will be achieved by the following means:

(*a*) Extending management services particularly at the handicrafts and small-scale level;

(*b*) Extending facilities for product development and design services linked up with government R and D centres for prototype design and manufacture;

(*c*) Creating procurement facilities for raw materials and marketing services by establishing raw material banks in rural areas, co-operative marketing institutions, marketing and export houses, and seminars and exhibitions;

(*d*) Creation of industrial estates in rural areas, which will be the most suitable means of bringing the ancillary and small-scale and medium-scale industries closer for effective interlinking development. This will create a greater subcontracting process and promote greater usage of machinery and equipment.

Government policy to promote administrative interlinkage will be through participation of the department of agriculture and industry and the agricultural machinery industries development corporation.

Government policy will involve the following:

(*a*) Registration of all industries and manufacturing establishments in rural areas;

(*b*) Establishment of an inventory of all machinery and equipment available in the rural industries, and supplying it to all the rural industries so that the availability of machinery can be ascertained easily among them as and when required;

(*c*) Publication of a free agricultural industries directory outlining all details including product specifications, facilities available and facilities required;

(*d*) Administrative import procedures, import substitutions and restriction on import of products manufactured locally;

(*e*) Providing factory inspectors;

(*f*) Introducing factory laws and safety measures;

(*g*) Co-ordinating with government departments to extend services, for example, electricity, water, sanitation, roads etc.;

(*h*) Introduction of a technical monthly bulletin to keep industries abreast with development;

(*i*) Introducing standards for weights and measures and products.

Government policy on taxes and legislative interlinked development will include the following:

(*a*) Common taxation system for all rural industries, including tax rebates for new industries and special reduced taxation for handicrafts and small-scale industries;

(*b*) Labour laws for rural industries;

(*c*) Safety regulations;

(*d*) Factory laws for rural industries;

(*e*) Welfare schemes for workers;

(*f*) Special tax exemptions in backward areas;

(*g*) Special reduced import duties and tariffs for industries in backward areas;

(*h*) Manufacturing and licensing procedures for foreign industries under co-operation agreements, and for indigenous industries;

(*i*) Regulating imports of raw materials and provision of special facilities for the least developed areas.

Government policy on financial interlinkage will be based on the following facilities extended to rural industries:

(*a*) Government loan scheme for industrial development;

(*b*) Financial assistance through state financial corporations and rural banks;

(*c*) Bringing the private and public banks closer;

(*d*) Credit guarantee schemes for local and export market opportunities;

(*e*) Supply of machinery and equipment on hire purchase;

(*f*) Outright grants for machinery and equipment in backward areas;

(*g*) Government financial subsidy;

(*h*) Government subsidy on transport especially where this is expensive;

(*i*) Liberal import policy and duty-free machinery, equipment and material for industries in backward areas;

(*j*) Liberal finance for working capital requirements for handicrafts and small-scale industries.

C. Administrative implementation mechanism

As shown in figure X the administrative mechanism would include:

(*a*) Policy and planning. The highest body will be composed of ministries of agriculture, industry, planning, finance, labour and employment, and the representatives of the agricultural machinery industries development corporation and the agricultural and allied engineering industries development centre.

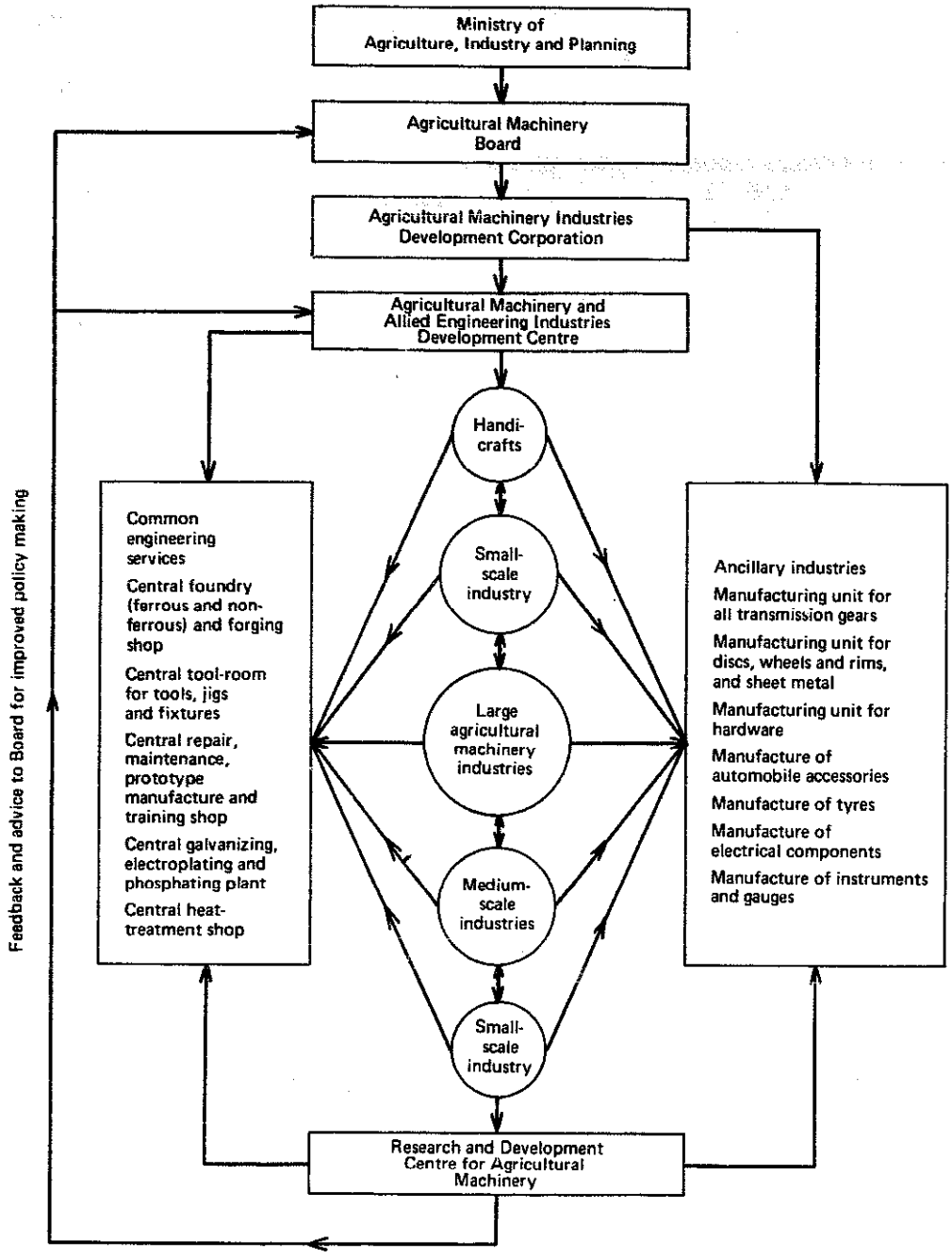


Figure X. Interlinked development of agricultural machinery industries in rural areas

(*b*) Development and promotion according to board directives. Facilities extended through the development corporation will include investment promotion, finance, factory allocation, facilities etc. The corporation will be composed of representatives from the ministries of agriculture, industries, planning, finance, labour and management, public works, private and public sector industrialists, government departments and agencies, non-governmental agencies and institutes and R and D centres, chamber of commerce and

industry, and the director of the proposed agriculture machinery and allied engineering industries development centre;

(*c*) Promotion and interlinking facilities. The development centre will be composed of a board of directors (from private and public sector industries), a managing director and administrative staffs;

(*d*) Development of agricultural machinery and equipment to meet local conditions;

(*e*) Strengthening of existing or establishment of a new R and D centre for agricultural machinery to co-operate closely with the development centre and local industries. The centre will report to the agricultural machinery board.

D. Entrepreneurship promotion

This is one of the most important aspects of interlinked development policy in rural areas and requires special government concessions, including the following:

(*a*) Credit facilities to acquire machinery, equipment, and factory premises, machinery and raw materials;

(*b*) Planned factory accommodation through industrial estates;

(*c*) Training schemes and programmes to attract the entrepreneur;

(*d*) Marketing facilities for entrepreneurship promotion, through a co-operative marketing operation, government centres and marketing and export houses.

Promotion of entrepreneurship needs an atmosphere of confidence for investment, a government policy, and realistic planning.

VIII. GUIDELINES FOR INTEGRATED PROGRAMMES

The guidelines for integrated development programmes envisage planned development of the following aspects: design and prototype manufacture; manufacture within available manufactuing resources; and maintenance services.

Consideration should be given to the identification and actual requirements of agricultural machinery and equipment based on the sophistication of the industry and the mechanization policy of the country as determined by local conditions. Product groupings should be established in accordance with the following conditions;

(*a*) Crop to be produced;

(*b*) Application of other input materials;

(*c*) Application of machinery and equipment according to the selected level of technology, for example:

(i) Agricultural hand tools and manually operated equipment,

(ii) Agricultural animal-drawn machinery and implements,

(iii) Agricultural power-operated machinery and equipment.

A systematic and integrated development programme should be drawn up on the basis of a selection of appropriate technology to suit:

(a) A local development programme of indigenous design;

(*b*) A local development programme based on partly indigenous and partly imported designs;

(*c*) A local development programme based on adaptation of foreign design under either licensing or co-operation agreements;

(*d*) An import programme.

A. Integrated programme at national level

Integrated programmes require development programmes for machinery and development programmes for manufacturing industries.

Both programmes need to be matched at national level. Programming should be based on:

(a) Creation of a programming group under the agricultural machinery industries development corporation;

(*b*) A statement of objectives, that is of the type, sophistication and quantity of machinery required over a given period, through imported design and an indigenous manufacturing programme, or through partly imported design and a partly indigenous manufacturing programme;

(*c*) Allocation of resources, for example factory site, materials, equipment and manpower;

(*d*) Estimation of time and costs for each activity;

(*e*) Revision of the programme until acceptable;

(*f*) Advice to the R and D centres for design and prototype manufacture;

(*g*) The institutional and technological framework with the co-operation of rural industries to implement, monitor and control the programmes.

B. Integrated programmes

Integrated programmes at the national level can be divided according to the level achieved in the least developed, intermediate developed and relatively advanced developed countries.

In the least developed countries the national programmes should be based on:

(*a*) Development and manufacture of hand tools, hand-operated machines, animal-drawn equipment, harvesting tools, storage bins etc. (see section II, technology levels I and II);

(*b*) Institutional and technological framework (sections IV, V and VI);

(*c*) National repair and maintenance activities and comprehensive training.

In the intermediate developed countries the national development programmes should be based on:

(*a*) Improvement of existing hand tools and hand-operated machines and animal-drawn implements (as described in section II, technology level I);

(*b*) Development of pumps, threshers, crop protection equipment and selected tractor-drawn equipment and implements (described in section II, technology level II);

(*c*) Reinforcing existing facilities by adaptation, prototype manufacture, testing, repair and maintenance of existing machinery;

(*d*) Institutional infrastructure (as outlined in sections IV, V and VI).

In relatively advanced developed countries the national development programme should be based on:

(*a*) Development of hand tools, pumps, engines, implements, crop protection equipment, trailers, storage, silos, power-operated threshers, cleaners etc. (described in section II, technology levels I, II and III);

(*b*) Licensing or foreign co-operation for the development of local manufacture of tractors, power tillers, engines, combine harvesters, dryers, crop-handling equipment, special implements etc. (described in section II, technology levels III and IV);

(*c*) Design and development of low-cost small tractors and power tillers;

(*d*) Establishment of ancillary industries for the manufacture of discs, wheels and rims, tyres, transmission gears etc. (described in section IV);

(*e*) Institutional and technological assistance in design, development and prototype manufacture, repair and maintenance, (described in sections V, VI and VII);

(*f*) R and D centres (described in section VII).

C. Integration at regional level

Consideration has been given, especially in Africa, Latin America, the Middle East and South Asia, to the formation of regional and subregional centres for the development of agricultural machinery and equipment. At regional and subregional levels, the integrated programme can best be carried out by: regional development and design centres, regional pilot plants and regional co-operation in the exchange of information.

D. Integrated programme and co-operation among developing countries

Close co-operation among developing countries can best be established through:

(*a*) Transfer of designs from one country to the other where environmental and working conditions are alike and the equipment is well suited to local farming conditions;

(*b*) Joint development programmes for manufacturing;

(*c*) Information exchange in R and D;

(*d*) Licensing and financial participation on a joint venture basis;

(*e*) Import and export of ancillary parts, particularly in the soft currency areas;

(*f*) Extension of institutional and R and D linkage.

Annex I

PROFILE OF AGRICULTURAL HAND TOOLS MANUFACTURE AT HANDICRAFTS LEVEL

This profile covers selected hand tools, e. g. spade, hoe, fork and sickle. These simple tools for agricultural operation are most used by small farmers in developing countries. In urban areas where they are used for gardening work it is rather difficult for small-scale producers to export their goods; their prospects depend on potential demand within local or regional areas. Local market possibilities should be carefully surveyed.

Overall evaluation

Users: small farmers holding less than 2 ha or gardeners

Method of sales: can be sold directly to farmers or through wholesale distributors

Market potential: for domestic markets or very limited exports

Requirement of feasibility study: may not be necessary

Expert assistance: may be required if modern machinery is used. Expert advice on heat treatment can improve on product quality

Joint venture: not recommended

Linkage with other industries: woodworking industries or local carpenters

Detailed information

Tables 11-23 and figures XI and XII contain basic information on the manufacture of agricultural hand tools at handicrafts level for a shop without electricity and a shop with a 30 kW, 50 Hz, single phase, 220/240 V current supply.

TABLE 11. PRODUCT SPECIFICATIONS (FOUR SELECTED PRODUCTS)

Product	*Specifications*
Spade	Blade and shank size, overall length 20 in.; blade size 8 in. × 6 in.; weight 1.5 kg
Hoe (tined)	Maximum length of tine 10 in.; width 6 in.; tine diameter ½ in.; weight 1 kg
Fork	Weeding fork, 3 prongs, length 14 in.; width 7 in.; diameter of prong ⅝ in.; tang bore diameter 1¼ in. (minimum) to 2½ in. (maximum); weight 2 kg
Sickle	Length 9 in., maximum width 1 in.; handle 5 in.; weight ½ kg

Material specifications

Material specifications for hand tools are SAE 1078, carbon 0.72%–0.85%, manganese 0.30%–0.60%. The material is suitable for forge and heat treatment.

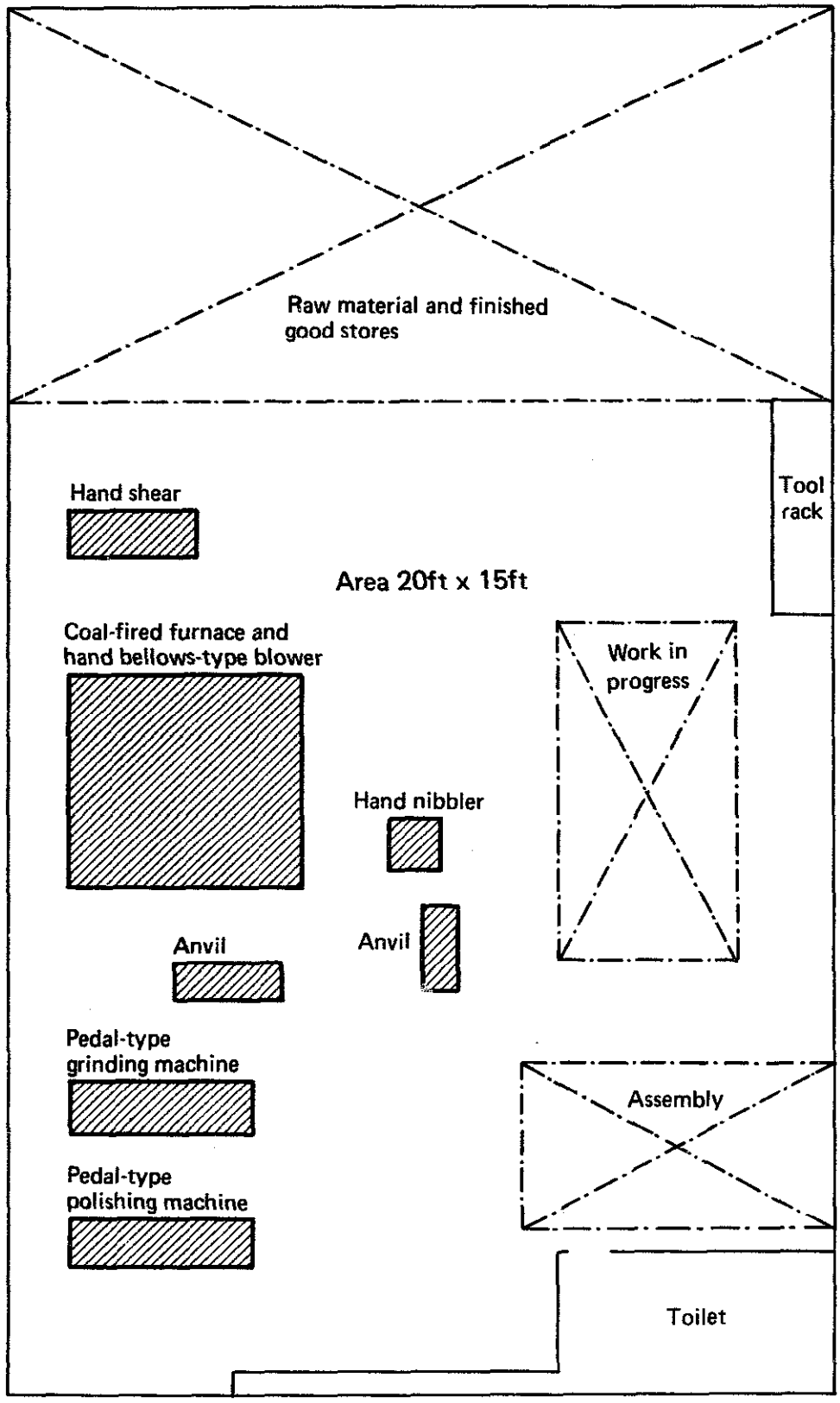


Figure XI. Layout of village blacksmith shop for production of agricultural hand tools (without electricity supply)

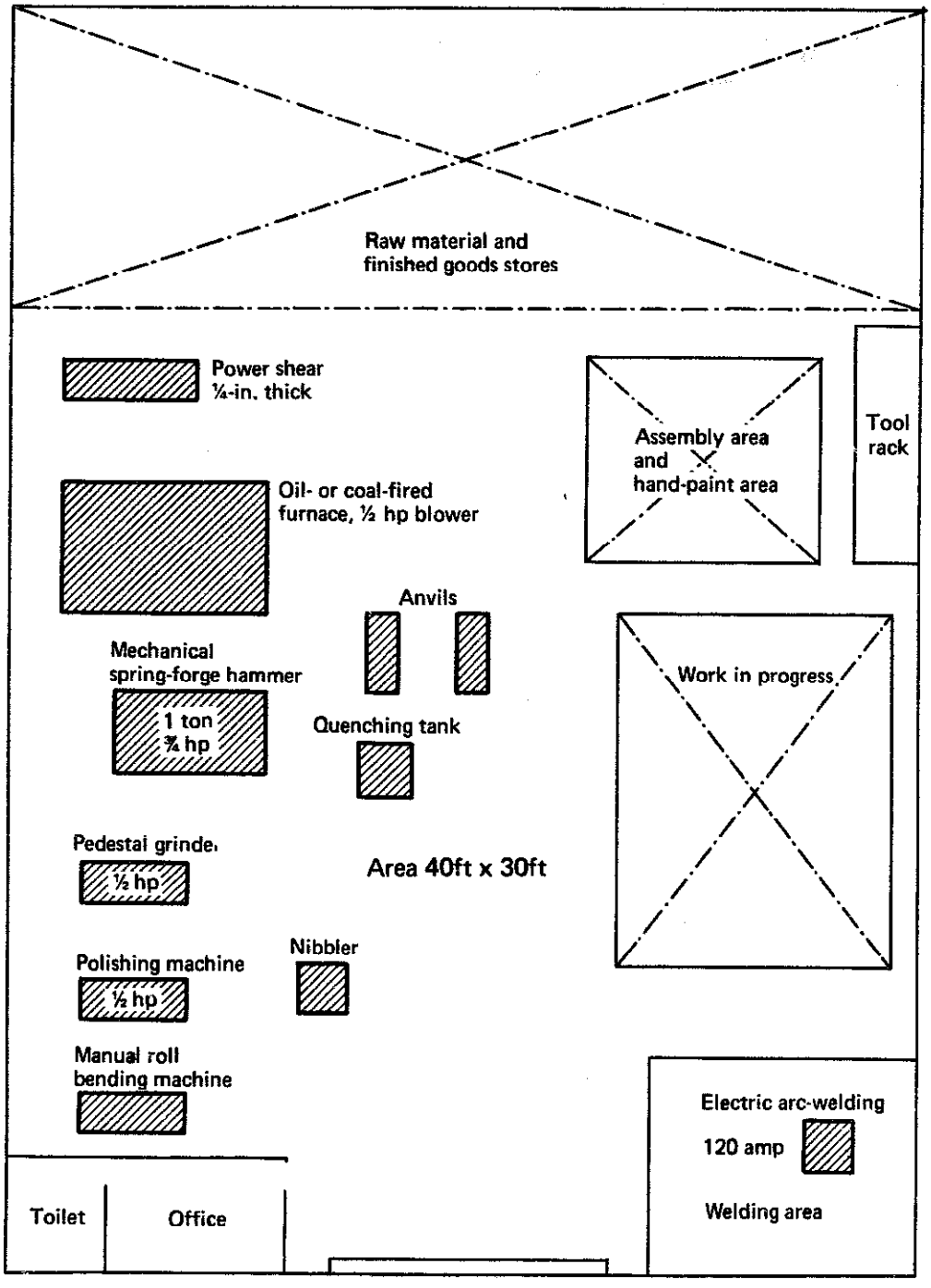


Figure XII. Layout of blacksmith shop for production of agricultural hand tools at handicrafts level (with electricity supply)

TABLE 12. PRODUCTION VOLUME

Product	Shop without electricity		Shop with electricity	
	Daily production	Annual production[a]	Daily production	Annual production
Spade	4	1 000	12	3 000
Hoe	4	1 000	12	3 000
Fork	4	1 000	12	3 000
Sickle	4	1 000	12	3 000
Total	16	4 000	48	12 000

[a] Based on 250 working days and an 8-h shift.

TABLE 13. MANPOWER REQUIREMENTS

Category	Shop without electricity	Shop with electricity
Direct labour		
Skilled	3 (including owner)	5 (including owner)
Semi-skilled	–	2
Unskilled	1	1
Indirect labour		
Skilled	–	1 (accounts clerk)
Semi-skilled	–	–
Unskilled	–	–
Total	4	9

Floor area

The required floor area is 300 ft² (20 ft × 15 ft) for a shop without electricity, 1,200 ft² (40 ft × 30 ft) for a shop with electricity. See figures XI and XII for layout plan.

TABLE 14. ESTIMATED COST OF MACHINERY AND EQUIPMENT

Hand-operated machine tools			Electrically operated machine tools		
Description	Quantity	Estimated cost (dollars)	Description	Quantity	Estimated cost (dollars)
Hand shear, 12 in.	1	200	Power shear, 1/4 in	1	500
Coal-fired furnace with hand-bellow-type blower, 24 in. × 24 in. × 18 in.	1	2 200	Oil-fired or coal-fired furnace, 1/2 hp, 24 in. × 24 in. × 18 in.	1	5 000
Anvil with pedestal, 200 kg	2	200	Mechanical spring forge hammer, 1 t, 3/4 hp	1	4 000
Quenching tank, 24 in. × 24 in. × 24 in.	1	300	Quenching tank, 36 in. × 36 in. × 36 in.	1	500

TABLE 14 *(continued)*

Hand-operated machine tools			*Electrically operated machine tools*		
Description	*Quantity*	*Estimated cost (dollars)*	*Description*	*Quantity*	*Estimated cost (dollars)*
Pedal-type grinding machine, 12-in. wheel	1	100	Anvils with pedestal, 200 kg	2	200
Pedal-type polishing machine	1	100	Double-ended pedestal grinder, 1/2 hp, 12-in. wheel	1	400
Hand nibbler, 1/4 in.	1	200	Double-ended polishing machine, 1/2 hp	1	400
Blacksmith's tools and conventional tools	1 set	600	Manual roll bending machine	1	200
Miscellaneous		300	Electric arc welding machine, 120 A	1	200
			Blacksmith's tool set, 1/4 in. portable drill, paint can and brushes	1 set	600
			Miscellaneous		500
Total		4 200			12 500

TABLE 15. INVESTMENT REQUIREMENT

(Dollars)

Basic investment	*Shop without electricity*	*Shop with electricity*
Fixed capital		
Land	–	–
Building	–	–
300 ft² at $5	1 500	–
200 ft² at $5	–	6 000
Furniture, fittings, racks etc.	300	600
Machinery and equipment	4 000	12 500
Electrical installation		1 000
Building	50	300
Transport (cart or trolley)	100	500
Contingencies	150	300
Total fixed capital	6 100	21 200
Working capital		
Direct material (3 months)	815	2 370
Labour (3 months)	950	[illegible]
Indirect costs	300	[illegible]

Basic investment	*Shop without electricity*	*Shop with electricity*
Training costs	–	500
Contingencies	35	155
Total working capital	2 100	6 500
Total investment [a]	8 200	27 700

[a] Excluding cost of land.

TABLE 16. ANNUAL DIRECT MATERIAL COST

			Shop without electricity			*Shop with electricity*		
Item	*Weight of blade (kg)*	*Price of raw material or unit*	*Annual production (units)*	*Total raw material (kg)*	*Cost (units)*	*Annual production (kg)*	*Total raw material ($)*	*Cost ($)*
Spade[a]	1.5	0.30	1 000	1 500	450	3 000	4 500	1 350
Hoe[a]	1.0	0.30	1 000	1 000	330	3 000	3 000	900
Fork[a]	2.0	0.30	1 000	2 000	600	3 000	6 000	1 800
Sickle[a]	0.5	0.30	1 000	500	150	3 000	1 500	450
Subtotal			4 000	5 000	1 530	12 000	15 000	4 500
		($/unit)						
Wooden handle[b]		0.40	3 000		1 200	9 000		3 600
Handle (sickle)[b]		0.10	1 000		100	3 000		300
Nails and ferrules[b]					200			400
15% scrap for steel					230			675
Total					3 260			9 475

[a] Manufactured in own shop.

[b] Bought finished.

TABLE 17. ANNUAL INDIRECT MATERIAL COST
(Dollars)

Item	*For 4 000 units*	*For 12 000 units*
Lubricants, coolants etc.	30	50
Maintenance and spare parts	200	1 000
Paints, office supplies	200	500
Total	430	1 550

TABLE 18. ANNUAL COST OF ELECTRICITY, FUEL AND WATER
(Dollars)

Item	*Shop without electricity*	*Shop with electricity*
Electricity, 60,000 kWh		2 500
Fuel, coal and oil	550	1 000
Water	50	100
Total	600	3 600

TABLE 19. ANNUAL LABOUR COST

Category	Shop without electricity			Shop with electricity		
	Number of persons	Annual wage rate ($)	Total ($)	Number of persons	Annual wage rate ($)	Total ($)
Direct labour						
Skilled	3	1 000	3 000	5	1 500	7 500
Semi-skilled				2	1 000	2 000
Unskilled	1	800	800	1	800	800
Subtotal	4		3 800	8		10 300
Indirect labour				1	1 200	1 200
Total	4		3 800	9		11 500

TABLE 20. SUMMARY OF ANNUAL MANUFACTURING COST

(Dollars)

Item	Shop without electricity	Shop with electricity
Direct material	3 260	9 475
Indirect material	430	1 550
Power, fuel, water	600	3 600
Transport	200	500
Labour	3 800	11 500
Total	8 290	26 625

TABLE 21. ANNUAL SALES

Product	Unit selling price ($)	Shop without electricity		Shop with electricity	
		Annual production (units)	Annual sales ($)	Annual production (units)	Annual sales ($)
Spade	2.50	1 000	2 500	3 000	7 500
Hoe	3.00	1 000	3 000	3 000	9 000
Fork	3.00	1 000	3 000	3 000	9 000
Sickle	1.50	1 000	1 500	3 000	4 500
Total		4 000	10 000	12 000	30 000

TABLE 22. TOTAL ANNUAL COST

(Dollars)

Item	*Shop without electricity*	*Shop with electricity*
Manufacturing cost	8 290	26 625
Sales cost	200	1 000
Depreciation of fixed capital (10 per cent)	400	1 250
Total	8 890	28 875

TABLE 23. PROFIT

(Dollars)

Item	*Shop without electricity*	*Shop with electricity*
Annual sales	10 000	30 000
Total annual cost	8 890	28 875
Profit (before tax)	1 110	1 125

Annex II

PROFILE OF ANIMAL-DRAWN AGRICULTURAL IMPLEMENT MANUFACTURE AT RURAL SMALL-SCALE INDUSTRY LEVEL

This profile covers the following implements: single-hand wheel hoe, animal-drawn disc harrow, animal-drawn mould-board plough. These products are mostly used by farmers in the developing and least developed countries. With the necessary technical know-how, it is possible for the plants producing tools of this size to export their products. The viability of these industries in rural areas depends on the evaluation of demand by the farmers at local and national level backed by a proper feasibility study and market survey study.

Overall evaluation

Users: farmers with 2–5 ha of land

Method of sales: preferably by appointing agents to sell at both village and national levels; attention will have to be given to spare parts supply; agents or distributors can stock parts; thereby the annual turnover can be increased

Market potential: good possibilities on both the domestic and export markets; products can be offered to exporting houses in the country

Requirement of feasibility study: necessary before investment

Expert assistance: required in the following areas:

Feasibility study

Training

Product design and product development

Marketing

Heat treatment

Joint venture: recommended

Linkage with other industries: foundry, forge, stockist, hardware industry

Detailed information

Tables 24–37 and figure XIII contain basic information on the manufacture of implements for agricultural crop production at rural small-scale levels.

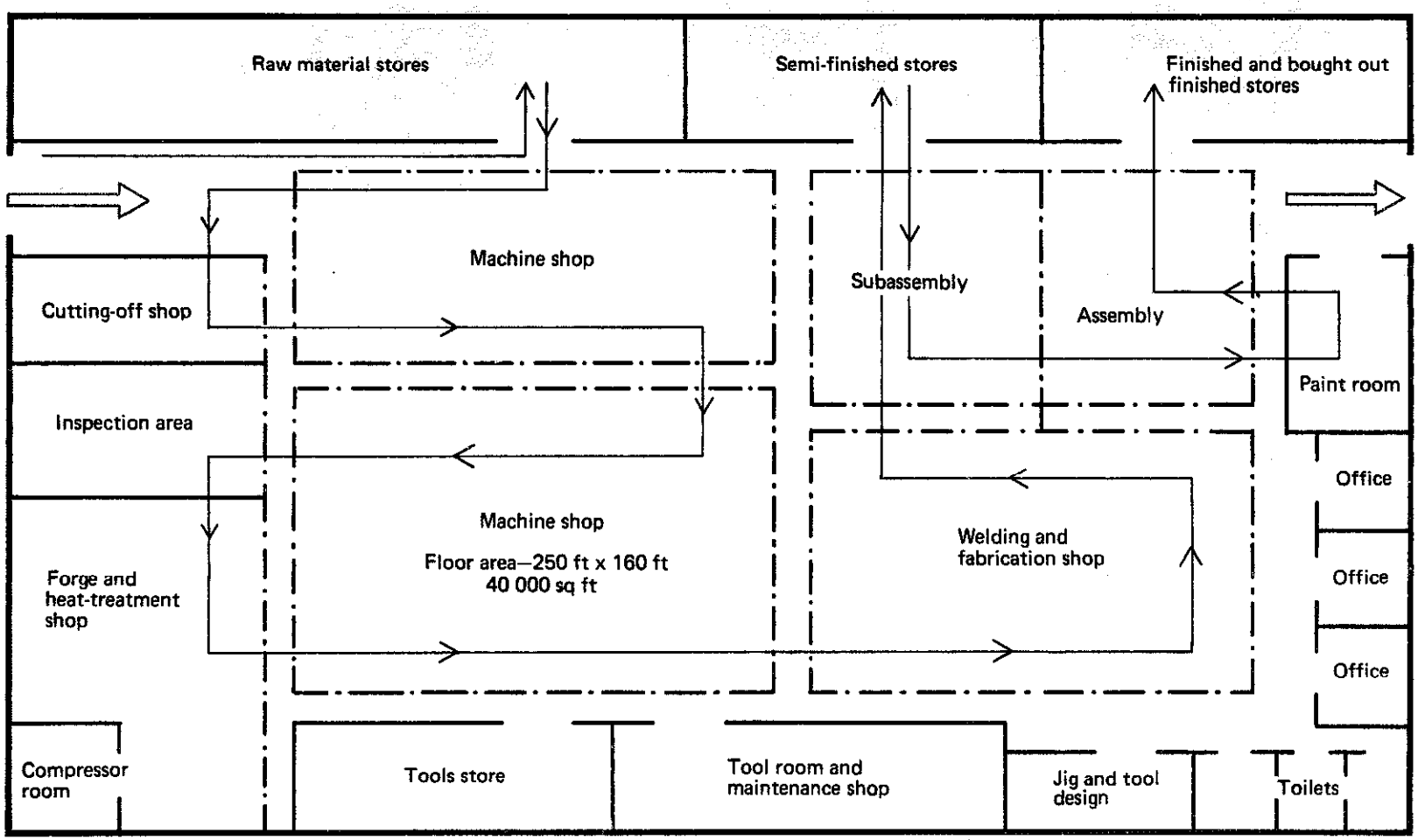


Figure XIII. Layout of small-scale agricultural implement manufacturing plant. The area devoted to administration is 2,000 ft²

TABLE 24. PRODUCT SPECIFICATIONS (THREE SELECTED PRODUCTS)

Product	*Specification*
Single-hand wheel hoe	Weight 12 kg (optional: 3 hoe blades, or 3 cultivator tines, or 3 ploughs)
Animal-drawn disc harrow	Weight 50 kg; discs 6–12; working width 36 in.; working depth 2½–5 in.; output 0.25 ha/h
Animal-drawn mould-board plough	Weight 35 kg; furrow width 5–8 in.; furrow depth 2½–7 in.

TABLE 25. MATERIAL SPECIFICATIONS

Agricultural component	*SAE number*	*Carbon (%)*	*Manganese (%)*
Implement frame (MS)	1006–1008–1010–1015	0.08–0.18	0.25–0.60
Springs	1065	0.60–0.70	0.60–0.90
Plough beam or tool bar	1070	0.65–0.75	0.60–0.90
Plough shares, sheet metal	1074	0.70–0.80	0.50–0.80
Rake teeth	1078	0.72–0.85	0.30–0.60
Scraper, blades, discs, spring tooth harrow	1085	0.80–0.93	0.70–1.00
Mower and binder section twine holders, knotter discs	1086 1090	0.82–0.95 0.85–0.98	0.30–0.50 0.60–0.90

TABLE 26. PRODUCTION VOLUME

Product description	*Daily production*	*Annual production*[a]
Single-hand wheel hoe	24	6 000
Animal-drawn disc harrow	8	2 000
Animal-drawn plough	8	2 000

[a] Based on 250 working days and an 8-h shift.

TABLE 27. MANPOWER REQUIREMENTS

Area	*Skilled*	*Semi-skilled*	*Unskilled*	*Total*
Direct labour				
Cutting off	–	1	–	1
Inspection	2	–	–	2
Forging and heat treatment	2	–	–	2
Toolroom and maintenance	3	1	–	4
Machine shop	9	2	1	12
Welding and manufacture	6	4	2	12
Subassembly	2	4	1	7
Assembly	4	2	1	7
Paint shop	1	–	–	1
Total direct labour	29	14	5	48
Indirect labour				
Manager	1	–	–	1

Area	*Skilled*	*Semi-skilled*	*Unskilled*	*Total*
Accountant	1	–	–	1
Sales executive	1	–	–	1
Development engineer/ designer	1	–	–	1
Superintendent	1	–	–	1
Jig and tool designer	1	–	–	1
Foremen	3	–	–	3
Secretary	1	–	–	1
Charge hand	1	–	–	1
Stores and tool keeper	3	–	–	3
Security	1	–	–	1
Clerk	1	2	–	3
Total indirect labour	16	2		18
Total manpower				66

TABLE 28. ESTIMATED COST OF MACHINERY AND EQUIPMENT

Area	*Description*	*Number*	*Estimated cost*
Cutting shop	Power hack saw, round bar, up to maximum diameter of 3 in.	1	1 000
	Abrasive cutter/grinder 1/2 hp, 8-in. wheel	1	800
	Hand shear 12-in. diameter	1	200
Forge and heat treatment shop	Mechanical hammer forge 50 t (for hot forge)	1	14 000
	Oil-fired furnace with blower 30 in. × 30 in. × 15 in.	1	5 000
	Water-quenching tank 3 ft × 3 ft × 3 ft	1	500
	Oil-quenching tank 3 ft × 3 ft × 3 ft	1	300
	Anvils	2	200
	Blacksmith's tools	Set	400
Machine shop	Pedestal grinder 12-in. wheel, double-ended	2	800
	Upright drilling machine, MS 1-in. diameter	1	5 000
	Radial drilling machine 3-ft arm steel 1 1/2-in. diameter	1	8 000
	Lathe, maximum bore 3 in.; swing 18 in. maximum; length 36 in.		6 000
	Capstan lathe with hex turret and attachment, swing 6 in.; gap 24 in.	1	9 000
	Jigs and fixtures for parts		6 000
Tool room and maintenance	Universal milling machine, arbour 1-in. diameter; table 3 ft × 1 ft	1	8 000
	Universal cutter grinder, up to 12 in.	1	9 000
	Surface table	1	800
	Gauges and tools	Set	1 500
	Maintenance equipment	Set	1 500

TABLE 28 *(continued)*

Area	*Description*	*Number*	*Estimate cost*
Inspection	Inspection tools, table etc.	Set	2 000
Welding and manufacturing shop	Arc welding 250 A	2	1 000
	Press brake, 10-ft long, 5 t	1	6 000
	Eccentric press, 35 t, 4-in. gap	1	8 000
	Welding fixture and jigs	Set	2 000
	Manual roll bending machine, up to 1-in. diameter rod	1	150
Subassembly	Drilling machine upright, MS, up to 1-in diameter	1	2 500
	Portable grinder 6-in. diameter wheel	2	300
	Portable drill gun ½ hp	2	600
	Subassembly fixtures	Set	500
Paint room	Pneumatic spray, paint equipment etc.	Set	300
Compressor	Complete motor compressor set 300 ft³/min: line pressure 80 psi	Set	10 000
Stores	Racks, stillage, pallets	Set	8 000
Mechanical handling equipment	Fork-lift truck 1 t;	1	8 000
	½-t hoists	6	6 000
	Hydraulic pallet truck	2	800
Total			134 150

TABLE 29. INVESTMENT REQUIREMENT
(Dollars)

Item	*Cost*
Fixed capital	
Land	–
Building cost: (i) Administrative block, 2 000 ft² at $5	10 000
(ii) Factory building, 40 000 ft² at $5	200 000
Furniture and fittings, including drawings and office equipment	20 000
Machinery and equipment	134 150
Electrical installations	10 000
Building	5 000
Transport car and van (1 t)	8 000
Contingencies	1 050
Total fixed capital	388 200
Working capital	
Direct material (3 months)	97 500
Direct labour (3 months)	20 275
Indirect cost (3 months)	3 500
Training cost	5 000
Contingencies	1 225
Total working capital	127 500
Total investment[a]	515 700

[a]Excluding cost of land.

TABLE 30. ANNUAL DIRECT MATERIAL COST

Description	*Parts group*	*MOW*[a]	*BOF*[a]	*IMP*[a]	*Cost of group ($)*	*Total unit cost ($)*	*Annual production (units)*	*Total material cost ($)*
Single wheel hand hoe	MS handles	×			2.00			
	MS fork	×			1.00			
	Hoe frame	×			1.50			
	Shovel	×			2.50			
	Toeing hook	×			0.50			
	Y-bracket	×			0.50			
	Axle shaft	×			2.00			
	CI wheel	×	×		5.00			
	Wooden grip		×		0.50			
	Bolts, nuts		×	×	0.50	16	6 000	96 000
Animal-drawn disc harrow	Beam frame	×			8.00			
	Disc axle shaft	×			8.00			
	Middle tin shovel	×			9.00			
	Gang angle mechanism	×			10.00			
	Seat arrangement	×			5.00			
	Disc hub	×	×		5.00			
	Hub bracket	×	×		5.00			
	CI wheel and back rest				3.00			
	Disc 3/16 in × 18 in., or 1/4 in. × 18 in.; or inside bevel 7/32 in. × 18 in.		×		20.00			
	Bearings			×	20.00			
	Bolts/nuts/washer			×	5.00	98	2 000	196 000
Animal-drawn mould-board plough	MS handle	×			3.00			
	Steel beam	×			3.00			
	Steel mould-board and share	×			10.00			
	Bracket	×			2.00			
	Landside	×			1.00			
	Chain ring and shackle	×	×		1.00			
	Ridging body	×			4.00			
	CI gauge wheel	×	×		5.00			
	Bearing			×	4.00			
	Bolts/nuts/washers			×	2.00	35	2000	70 000
	Total							362 000
	Scrap allowance							18 000
	Total direct material cost							380 000

[a]MOW, manufactured in own shop; BOF, bought finished; IMP, imported.
[b]Assuming a steel price of $500 per tonne.

TABLE 31. ANNUAL INDIRECT MATERIAL COST

(Dollars)

Item	*Cost*
Lubricants, coolant	400
Maintenance, spare parts	2 000
Paints	8 000
Office supplies, telephone etc.	3 000
Sundries	600
Total	14 000

TABLE 32. ANNUAL COST OF ELECTRICITY, FUEL AND WATER

(Dollars)

Item	*Cost*
Electricity, 3 000 kWh	5 000
Fuel oil	2 000
Water	500
Total	7 500

TABLE 33. ANNUAL LABOUR COST

Category	*Number of persons*	*Annual wage rate ($)*	*Total cost ($)*
Direct labour			
Skilled	29	1 000	29 000
Semi-skilled	14	800	11 200
Unskilled	5	500	2 500
Indirect labour			
Manager	1	5 000	5 000
Accountant	1	4 000	4 000
Sales executive	1	4 000	4 000
Development engineer designer	1	4 000	4 000
Superintendant	1	3 000	3 000
Jig and tool designer	1	3 000	3 000
Foreman	3	2 000	6 000
Secretary	1	1 000	1 000
Charge hand	2	1 500	3 000
Clerk	2	1 000	2 000
Store and tools	3	800	2 400
Security	1	1 000	1 000
Total			81 100

TABLE 34. SUMMARY OF ANNUAL MANUFACTURING COST
(Dollars)

Item	*Cost*
Direct material cost	390 000
Indirect material cost	14 000
Power, fuel, water	7 500
Transport cost	2 000[a]
Labour cost	81 000
Total	494 500

[a]For a car and a 1-t van.

TABLE 35. ANNUAL SALES

Product	*Unit selling price ($)*	*Annual production (units)*	*Total sales ($)*
Single-hand wheel hoe	30	6 000	180 000
Animal-drawn disc harrow	150	2 000	300 000
Animal-drawn mould board plough	80	2 000	160 000
Total			640 000

TABLE 36. TOTAL ANNUAL COST
(Dollars)

Item	*Cost*
Manufacturing cost	494 500
Sales cost	20 000
Depreciation of fixed capital	39 000
Total	553 500

TABLE 37. PROFIT
(Dollars)

Item	*Amount*
Annual sales	640 000
Total annual cost	553 500
Profit (before tax)	86 500

Annex III

PROFILE FOR AGRICULTURAL POWER MACHINERY MANUFACTURE AT RURAL, MEDIUM- AND LARGE-SCALE INDUSTRY LEVEL IN DEVELOPING COUNTRIES

The product is a medium-size four-wheel tractor powered by a direct-injection diesel engine with a power of 40 hp (30 kW) at 2,500 rpm. This product is used by farmers having 5 ha of land or more, for all types of agricultural operations in developing countries. It may be exported, and the successful operation of the plant requires:

(a) Support of ancillary industries, e.g. foundry, forging, sheet metal manufacturing industry and many others;

(b) Comprehensive training of management and workers (skilled) at various levels;

(c) Systematic marketing and distribution network.

The viability prospects of this product depends on potential demand within the country or neighbouring countries; country-wide marketing possibilities should be carefully examined and surveyed.

Overall evaluation

Users: farmers, for agricultural operations; industries, for transport with trailers; in forestry, and many other fields

Method of sales: sales and marketing should be carried out through authorized distributors or dealers with sales and after-sales facilities, such as stocking of spare parts, servicing, training etc.

Market potential: domestic markets and good export possibilities within neighbouring developing countries

Requirement for feasibility studies: thorough pre-feasibility studies are necessary before investment decisions are made

Expert assistance: required in the preparation of marketing and feasibility study, product design and development, training of technical manpower, training in heat treatment and metallurgy, operation and installation of machinery and process sheet preparation marketing

Joint venture: highly recommended

Linkage with other industries: in order to procure semi-finished and bought-out components, the following supporting industries are needed:

(*a*) Foundry for grey, malleable and spheroidal cast iron;

(*b*) Forging and die-casting;

(*c*) Tyres, wheels and rims manufacturing unit;

(*d*) Sheet metal and presswork industries;

(*e*) Gear cutting and transmission equipment manufacturing industries;

(*f*) Electrical and instrument manufacturing industries;

(*g*) Steering wheel and automotive parts manufacturing industries;
(*h*) Brake shoe and clutch manufacturing industries;
(*i*) Spring and hardware manufacturing industries;
(*j*) Paint manufacturing industries;
(*k*) Rubber manufacturing industries.

Detailed information

Product specifications

The specification is only indicative and does not conform to any specific model.

Make: joint collaboration with a tractor company
Number of cylinders: 3
Engine: direct injection diesel engine
Maximum power of engine: 40 hp (30 kW) at 2,500 rpm
Compression ratio: 17.5:1
Road speed: 1–17 mile/h (2–27 km/h)
Power take-off: 6 spline shaft, $1^3/_8$ in. diameter
Hydraulic system: with pressure control from 155 to 2,400 psi
Working load: 3,000 lb (maximum)
Dimension: overall width 64 in., overall length 110 in., overall height 75 in.
Weight: 2,800 lb (without fuel and water)
Fuel tank: 8 gal (36 litres)

Material specification

There is wide application of various types of material in the manufacture of tractors. The important materials used (in terms of weight) are as follows:

Castings: malleable or grade 17 castings with mehanite specification
Steel: EN1(a), EN8, EN16, EN24T, EN32(c), EN-42-46, round and in various sections; castings according to BS specification; sheet metal: 18–20 SWG

Most of these types of steel require hardening, case hardening and tempering. Hardness varies from 50 to 64 Rockwell C.

Sources of parts

Table 38 indicates which parts of the tractor should be made in the factory and which should be purchased

TABLE 38. BREAKDOWN OF TRACTOR BASED ON GROUPING OF MAJOR PARTS

Main group of parts	*Description*	*MOW*[a]	*BOSF*[a]	*BOF*[a]	*IMP*[a]
Engine	Main engine, radiator fuel, lube oil, air intake system, starter, dynamo/alternator, including electrical parts			×	×
Lift cover and controls	Hydraulic lift cover housing, control shafts pins etc.	Lift cover castings, control shaft pins	Lift cover castings		

TABLE 38 *(continued)*

Main group of parts	*Description*	*MOW*[a]	*BOSF*[a]	*BOF*[a]	*IMP*[a]
Gearbox housing	Housing, gears, splined shafts, bearings, seals, rings, yokes, clutch and clutch control, gear change lever and mechanism	Gearbox housing shafts, yokes, control levers, gear change lever	Gearbox casting, forged shafts	×	×
Centre housing	Housing, differential, crown wheel and pinion, bearing, splined shafts, PTO gears, seals etc.	Centre housing and shafts	Centre housing castings, forged shafts	×	×
Rear axle housing (LH + RH)	Housing, axles, shafts, rear brake drums, brakes, brake controls, bearings, seals, dead weights	Rear axle housing (LH and RH) brake drums, axle shafts (LH and RH)	Rear axle housing castings, forged axle shafts, brake drums castings	×	×
Front suspension and front suppport	Front axles, stub shafts, front hubs, bearings, seals, dead weights	Front axles, stub shafts, hubs, dead weights	Forged axles, die-cast hubs	×	×
Hydraulic pump and three-point linkage	Hydraulic pump, hydraulic cylinder and piston, draft and position control equipment, shafts, pins etc., linkage, bars, chain	Hydraulic cylinder, piston, draft and position control equipment	Forged body of cylinder		×
Steering box and linkages	Steering box, steering wheel and linkages	Linkages	Forged linkages	×	×
Hand brake linkage and attachments	Hand brake, linkage etc.	Hand brake linkage		×	×
Pedals and footsteps	Brake, throttle and clutch, pedal controls and footsteps	Brake, throttle, clutch pedal and footstep			
Sheet metal and press work	Fuel tank, front bonnet, front grill, fenders, instrument panel, exhaust pipe, tool box with lid			×	
Wheel and tyres	Front and rear wheel rims, tyres			×	×
Electrical equipment	Front lights, rear lights, instruments, fuel, water, hydraulic wiring cutouts, battery, fuses etc.			×	×
Hardware	Bolts, nuts, studs, washers, circlips, screws, sockets, chains etc.	Special bolts, nuts and studs		×	×
Tool kit	Spanners etc.			×	×

[a]MOW, factory manufactured parts; BOSF, bought semi-finished; BOF, bought finished; IMP, imported.

Operations to be used in making the factory-made parts are as follows:

PARTS OR GROUP DESCRIPTION	TYPE OF OPERATION
Lift cover housing	Casting and machining
Gearbox housing	Casting and machining
Centre housing	Casting and machining
Rear axle housing (LH and RH)	Casting and machining
All transmission shafts (simple or splined)	Machinery and heat treatment (the latter where recommended)
Yokes, shift lever, gear change lever and mechanism	Die casting and machining
Rear axle shafts (LH and RH)	Forging, machining and heat treatment
Brake drums	Casting and machining
Front stub axles (LH and RH)	Forging, machining and heat treatment
Front hubs	Casting and machining
Axle beams (front suspension)	Forging and machining
Link rods	Forging and machining
Link bars	Forging and machining
Hydraulic cylinder	Forging and machining
Hydraulic cylinder piston	Forging and machining
Draft and position control equipment	Pressing, metal-forming, machining
Steering connection rods and links	Forging and machining
Clutch pedal, brake pedal and accelerator pedal, foot step	Forging and machining
Hand brake system	Machining
Special bolts, nuts, studs, pins and levers	Machining, electroplating or galvanizing

The manufacturing programme should be based on a phase-out system:

Phase I

Lift cover housing

Gearbox housing, centre housing, rear axle housing

Brake drums, special bolts, nuts, studs, pins, levers and rods

All other parts to be procured either bought out finished locally or by import

Phase II

All transmission shafts (simple and splined)

Yokes, shift lever, gear change levers and mechanisms

Rear axle shafts

Front axle stub, front hub, link rods and all other parts to be procured either bought out finished or by import

Phase III

Axle (front) beam, linkage bar

Hydraulic cylinder, hydraulic cylinder piston

Draft and position control equipment

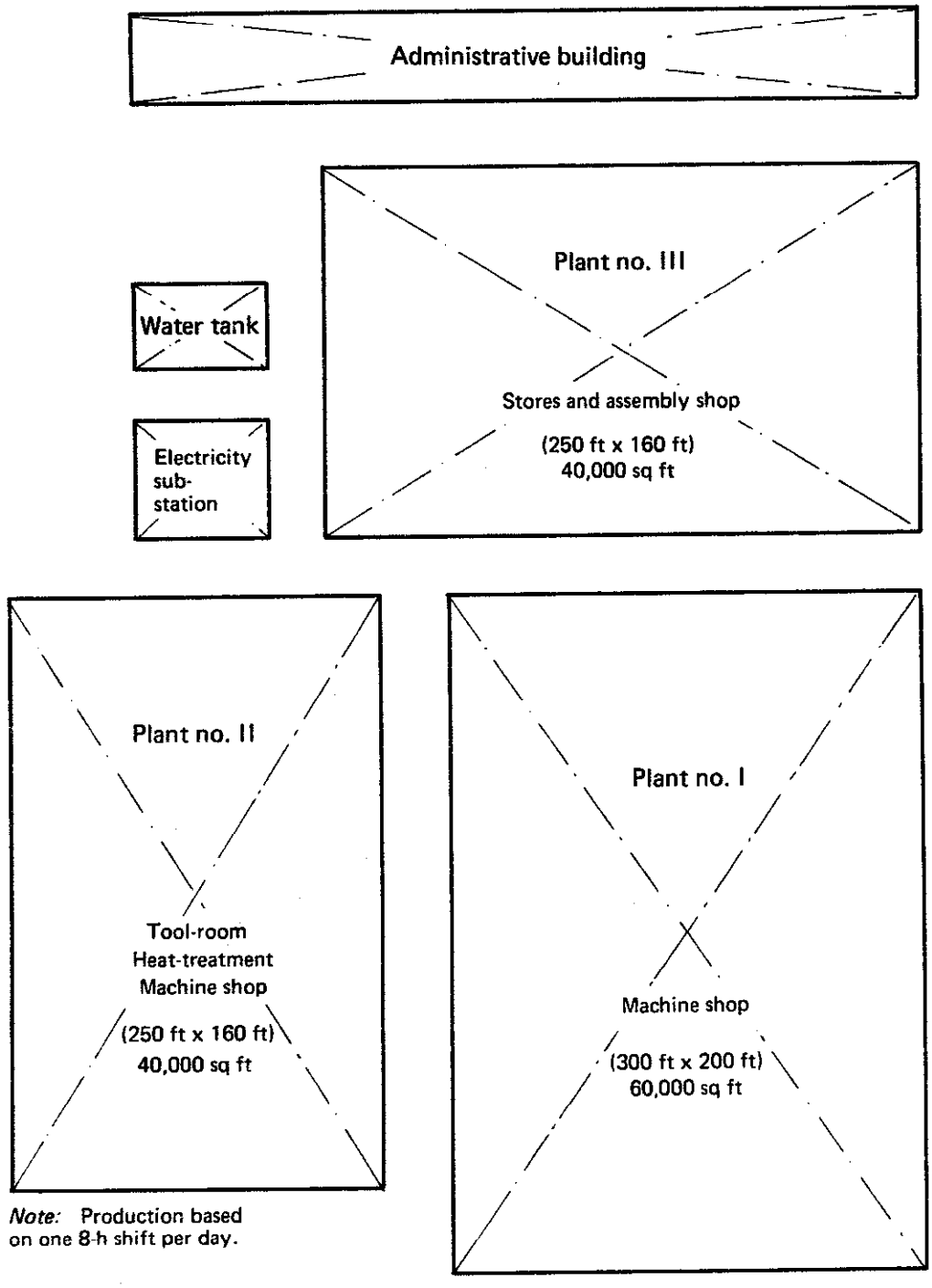
Steering connection rods

Clutch pedal, brake pedal, accelerator pedal

Hand-brake system and all other parts to be procured either bought out finished or by import

Requirements

Tables 39–47 and figures XIV–XVII contain the requirements for the manufacture of medium-size 4-wheel tractors at rural, medium- and large scale industry level in developing countries. A production volume of 14 tractors daily (3,500 annually) is assumed.



Note: Production based on one 8-h shift per day.

Figure XIV. Factory layout for production of 3,500 medium-size tractors per annum

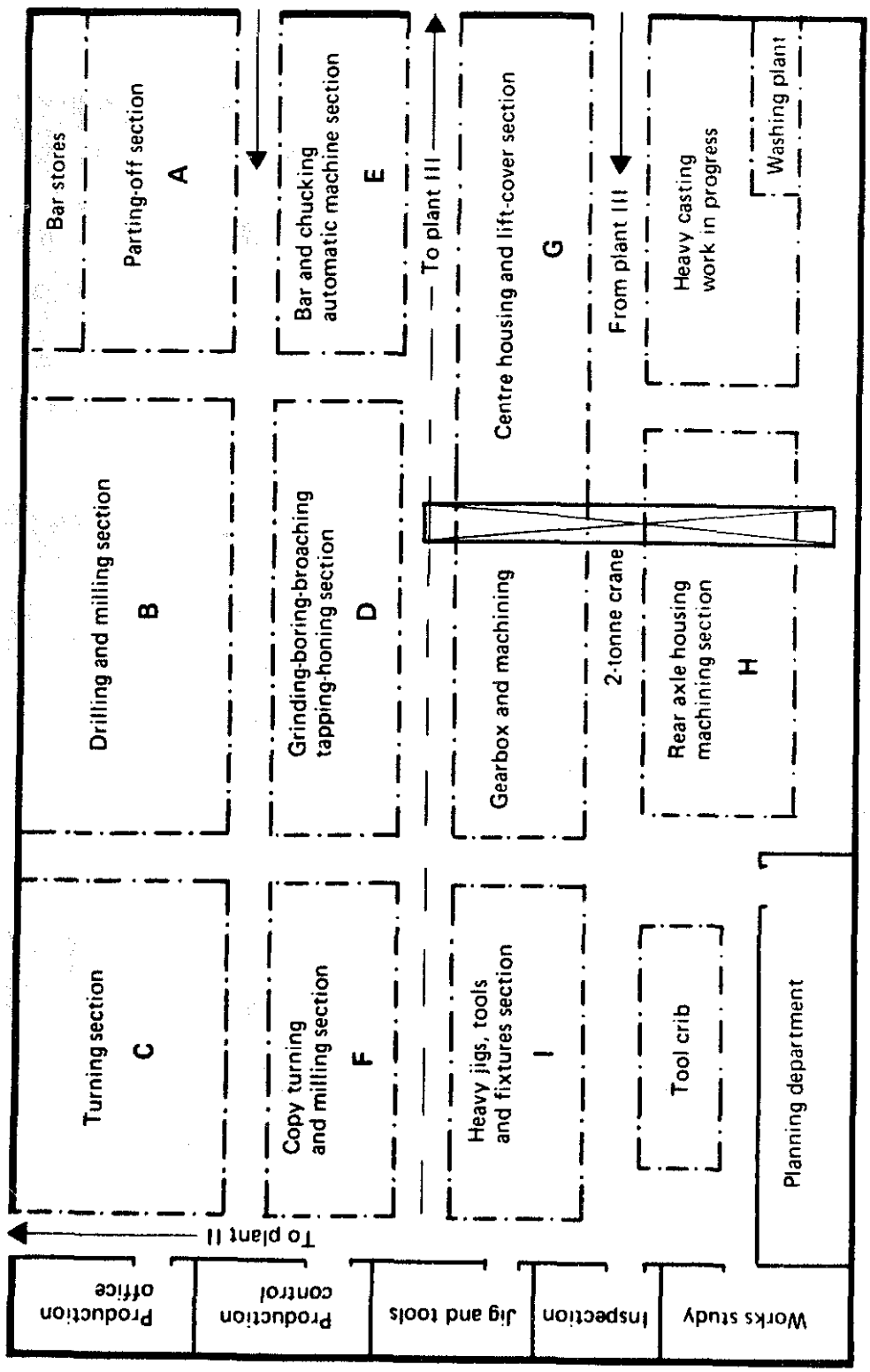


Figure XV. Layout of tractor manufacturing plant I (machine shop)

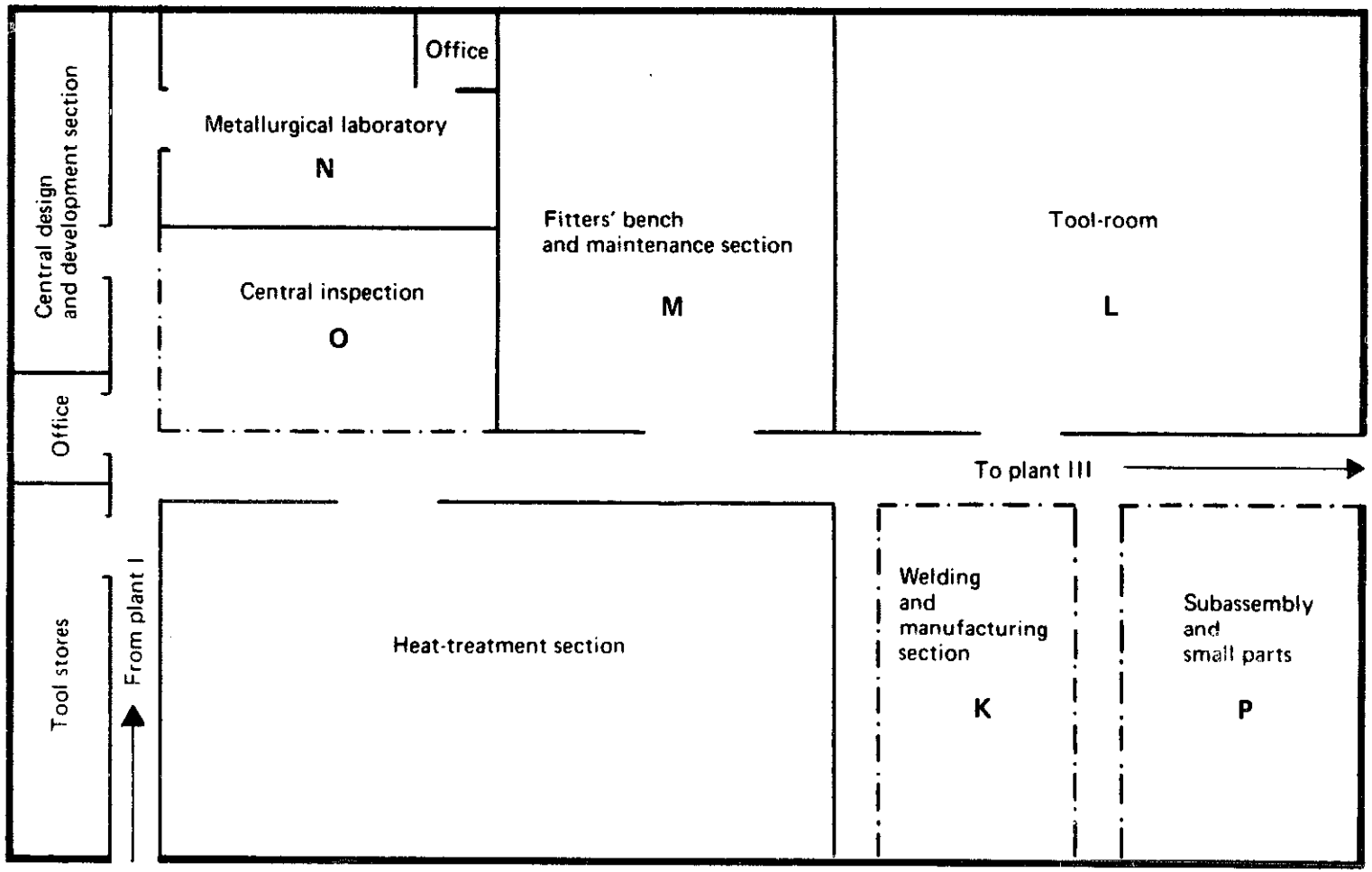


Figure XVI. Layout of tractor manufacturing plant II (heat treatment/tool-room shop)

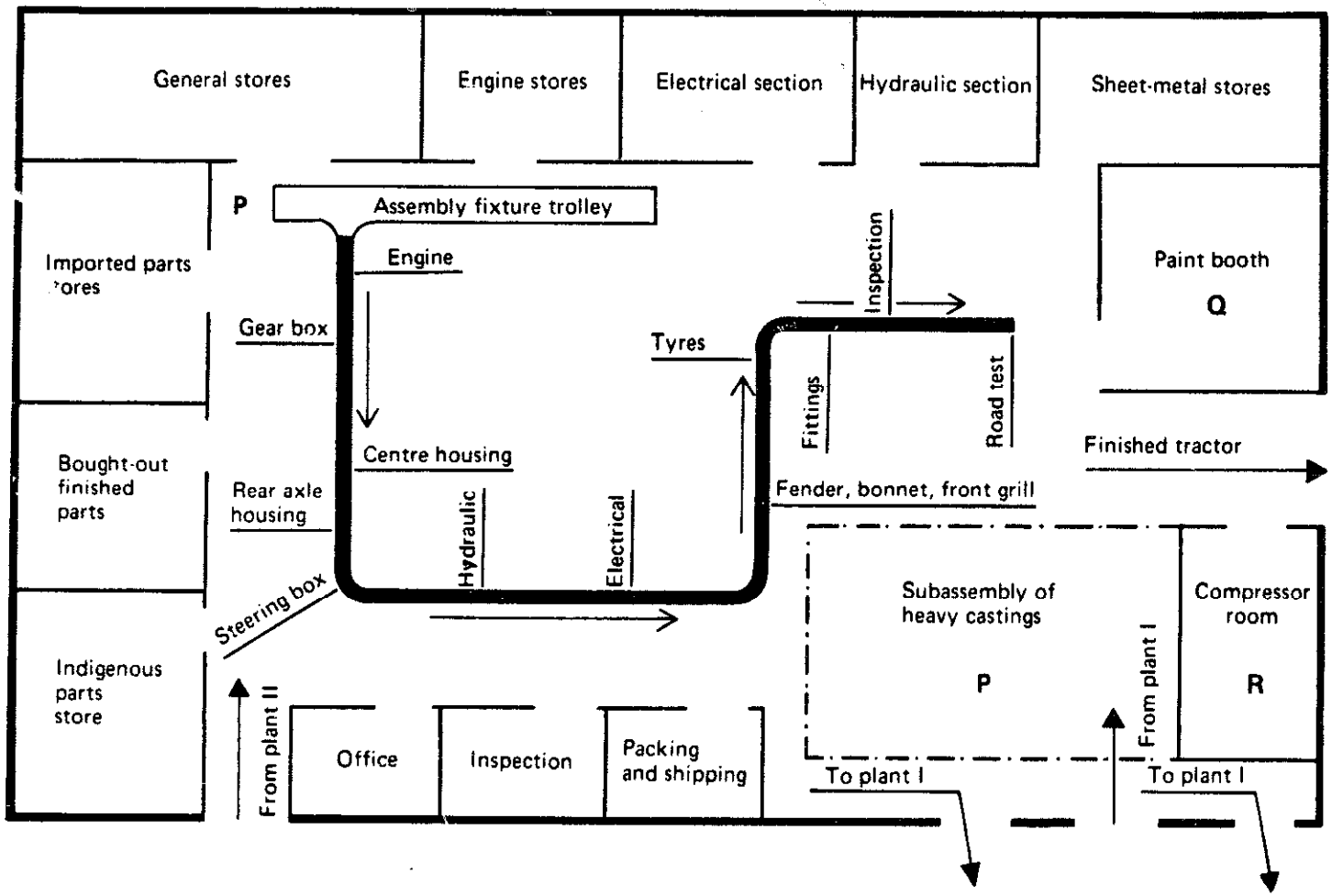


Figure XVII. Layout of tractor manufacturing plant III (stores and assembly shop)

TABLE 39. MANAGEMENT REQUIREMENT (HEAD OFFICE)

Management staff	*Number of persons*	*Total*
Managing director + staff	1 + 3	4
Sales and marketing manager + staff	1 + 15	16
Chief accountant + staff	1 + 9	10
Internal auditor	1	1
Manufacturing manager (to be included in indirect factory management)	(1)	(1)
Chief product development engineer + designer + assistant engineer and staff	1 + 2 + 3	6
Chief product training officer + staff	1 + 3	4
Total		41

TABLE 40. MANPOWER REQUIREMENT (FACTORY)

Personnel	*Number of persons*	*Total*
Indirect labour		
Manufacturing manager + staff	1+3	4
Chief personnel officer + staff	1+4	5
Factory accountant + staff	1 + 6	7
Chief purchase officer + buyers + clerks	1+6+2	9
Security officer + guards	1+5	6
Chief metallurgist + staff	1+2	3
Chief quality controller + inspectors + clerk	1+12+1	14
Chief industrial engineer + methods engineers + time study engineers + jig and tool designers + estimators + clerks	1+4+6+6+2+2	21
Chief planning engineer + assistant engineers/process planners and estimators + clerk	1+8+1	10
Chief production controller + production supervisors + chasers + clerks + recorders	1+6+10+2+6	25
Chief maintenance engineer + assistant engineers + mechanical and electrical skilled, semi-skilled and unskilled labour + clerk	1+3+6+1	11
Chief training officer + staff	1+3	4
Superintendent of machine shop plant I (see figures XIV and XV) + clerks	1+2	3
Assistant engineer + foreman + charge-hand for sections A and B	1+1+1	3
Assistant engineer + foreman + charge-hand for sections C and D	1+1+1	3
Assistant engineer + foreman + charge-hand for sections E and F	1+1+1	3
Assistant engineer + foreman + charge-hand for sections G and H	1+1+1+1	3
Charge-hand tool crib	1	1
Superintendent of machine shop plant II (see figure XVI) + clerks	1+2	3
Assistant engineer + foreman + charge-hand for sections J and K	1+1+1	3
Assistant engineer + foreman + charge-hands for section L	1+1+2	4
Superintendent of assembly + stores plant III (see figure XVII) + clerks	1+3	4

Personnel	*Number of persons*	*Total*
Assistant engineers + foremen + charge-hands subassembly and assembly	2 + 2 + 2	6
Charge hand, paint booth	1	1
Assistant engineer + foremen + charge-hands + recorder of stores	1 + 3 + 7 + 4	15
Supervisor (packing and shipping) + clerk	1 + 1	2
Cleaners, cook, canteen staff, welfare staff, drivers, mechanic	10	10
Total indirect manpower		183
Direct labour		
Machine shop plant I, operating 66 machines		
Skilled	66	
Semi-skilled	40	
Unskilled	20	
Subtotal	126	
Machine shop plant II		
Skilled	40	
Semi-skilled	40	
Unskilled	20	
Subtotal	100	
Assembly shop plant III		
Skilled	25	
Semi-skilled	20	
Unskilled	20	
Subtotal	65	
Total direct labour	291	
Total manpower	514	

TABLE 41. FLOOR AREA[a]

Item	*Area (ft²)*
Administration	4 000
Manufacturing	
Machine shop plant I	60 000
Machine shop plant II	40 000
Assembly shop plant III	40 000
Substation	500
Total	144 500
For raw material castings and finished tractor stores, additional open area	100 000
Total	244 500

[a]See figure XIII.

TABLE 42. ESTIMATED COST (C.I.F.) OF MACHINERY AND EQUIPMENT[a]

Description	*Quantity*	*Estimated total cost ($)*
A. Parting-off section		
Automatic hacksawing-machine, MS, up to 6-in. diameter	1	1 000
Circular cutter saw, up to 5-in. diameter	2	2 000
Abrasive cutter, 12-in. diameter wheel	1	800
Belt abrasive grinder, 8-in. wide belt	1	300
Pedestal grinder (double-ended), 12-in. diameter wheel	2	800
Polishing machine (double-ended)	2	200
B. Drilling and milling section		
Upright drilling machine, up to 2 in. MS	2	10 000
Gang drilling machine with table, 60 in. × 15 in., 6-spindle head, 1-in. diameter, MS	1	15 000
Automatic drill with tapping machine, 1-in. diameter, MS	1	10 000
Radial arm drill, 36-in. head traverse, 3-in. diameter, MS	3	20 000
Turret-head-type drill with 5-turret position, 1½ in, MS	1	15 000
Universal milling machine with attachments, 12-in. diameter cutter table size 36 in. × 18 in.	1	25 000
Knee-type milling machine with attachments, 8-in. diameter cutter, table size 30 in. × 12 in.	3	20 000
Keyway slot milling machine, width of spline, ⅝ in.; surface table, 40 in. × 10 in.	1	25 000
Spline shaft milling machine, programming arrangements for odd and even spline and both internal and external splines, table size, 24 in. × 6 in.	1	33 000
C. Turning section		
Lathe, spindle diameter 3 in.; swing, 24 in.; centre gap, 30 in.	1	15 000
Lathe, spindle diameter 1 in.; swing, 15 in.; centre gap, 18 in.	1	12 000
Capstan lathe with attachments, spindle hole, 2-in. diameter; capstan slide, 9 in.	3	30 000
Chucking capstan with all attachments, maximum workpiece diameter 12 in.; turret slide, 9 in.	3	35 000
Double-ended parting and centring machine, spindle gap, 40 in.	1	8 000
D. Grinding, boring, broaching, lapping and honing section		
Vertical surface grinding machine with rotary magnetic table, maximum grinding area, 6 in.; grinding height, 20 in.; diameter of wheel, 30 in.	1	35 000
Surface grinding machine, diameter of wheel, 24 in.; table size, 30 in. × 24 in.		25 000
Centreless grinding machine, wheel diameter, 24 in.; maximum diameter of work 2 in.	1	25 000
Cylindrical grinding machine, maximum workpiece, 6-in. diameter, 18 in. long	1	30 000
Internal cylindrical grinding machine with face grinding attachment, maximum bore, 13 in.; maximum length, 12 in.	1	40 000
Spline shaft grinding machine, grinding length, 30 in.; grinding diameter, 6 in.	2	50 000
Special-purpose automatic fine-boring machine (duplex), maximum bore diameter, 4 in.; bore depth, 20 in.	2	120 000
Horizontal boring machine, maximum bore, 18-in. diameter, length, 30 in.	1	60 000
Broaching machine, push-type, maximum diameter, 6 in.; length 12 in.	1	30000

Description	Quantity	Estimated total cost ($)
Horizontal lapping machine, table size, 18 in. × 12 in.; accuracy, 0.00004 in.	1	60 000
Vertical honing machine, maximum diameter, 6 in.; hone depth, 12 in.	1	35 000
E. Automatic turning machines		
Single-spindle, bar automatic with automatic indexing, workpiece diameter, 2 in.; length, 4 in.	2	60 000
Single-spindle, bar automatic with automatic indexing workpiece, diameter, 1 in.; length, 5 in.	8	320 000
Single-spindle, bar automatic with automatic indexing workpiece, diameter, 1 in.; length, 6 in.	2	90 000
Single-spindle, bar automatic with automatic indexing workpiece, ½ in.; length, 8 in.	2	55 000
Single-spindle, chuck automatic with automatic indexing, maximum workpiece diameter, 6 in.	–	40 000
Single-spindle, chuck automatic with automatic index, maximum workpiece diameter 3 in.	1	40 000
F. Automatic profile-turning machines		
Automatic copying lathes with three-cut recycling system, maximum diameter, 6 in.; length, 30 in.	2	70 000
Automatic copy-milling machine, maximum table size, 30 in. × 18 in.	1	60 000
G. Machines for gearbox housing, centre housing and lift cover housing		
Horizontal duplex milling machine, adjustable milling heads, with automatic quill retraction system for rough, semi-finished and finished cut surface, work table, 100 in. × 20 in.; longitudinal table travel, 80 in.	2	300 000
Portal-frame milling machine, with 3 adjustable milling heads, with automatic quill retraction system and adjustable heads, table size, 100 in. × 80 in.; longitudinal travel, 80 in.	1	200 000
Multispindle drilling machine with bolster plate, 24-spindle table, size 100 in × 80 in.; each spindle 1-in. diameter; MS	1	50 000
Automatic multispindle tapping machine, 12 spindles up to 1¼-in. tap size		50 000
Horizontal deep-hole drilling machine, up to 1½-in. diameter; length of hole, 20 in.; MS	1	35 000
Tunnel-type washing machine for centre housing, gear box axle housing	1	20 000
H. Machines for rear axle housing (LH and RH)		
Duplex multi-spindle drilling, facing machine with rotary indexing table, 24 spindles in each head, table diameter, 75 in.	1	120 000
Duplex boring and facing machine, table size, 72 in. × 36 in.	1	100 000
Jigs, tools, fixtures for heavy castings	Set	150 000
Jigs, tools, fixtures for light parts	Set	80 000
I. Heat treatment; galvanizing, electroplating		
Induction-hardening machine 25 kW	1	30 000
Induction-hardening machine 150 kW	1	45 000
Heat treatment furnace, oil-fired with automatic control, thermostat	1	60 000
Cyanide bath	1	1 000
Degreasing plant	1	
Quenching tanks	2	1 000

TABLE 42 *(continued)*

Description	*Quantity*	*Estimated total cost ($)*
Galvanizing plant/electroplating	Optional	May be obtained from subcontracting
Phosphating plant	1	10 000
J. Welding and manufacturing section		
Butt-welding machine, 500 A	1	5 000
Spot-welding machine, 800 A	1	5 000
Arc-welding machine, 500 A	2	4 000
Roll-bending machine	1	1 000
Press, 2.5 t	1	10 000
Press, 10 t	1	20 000
Welding fixtures	Set	5 000
K. Tool room		
High-precision jig-boring machine, working table, 40 in. × 30 in.; drilling, 1⅝ in.; boring, 3¼ in. in steel; accuracy, 0.00005 in.; accuracy of setting, 0.00002 in.	1	120 000
Universal cutter grinder, cutter diameter, 9 in.; work table, 12 in. × 12 in.	2	50 000
Precision internal grinder, bore up to 4-in. diameter; maximum chucking diameter, 13 in	1	40 000
Twist drill grinder, both LH and RH, steel and carbide tip, up to 2½-in. diameter	2	5 000
Ram-type hydraulic press, 1 t	1	5 000
Tap grinding machine, up to 1-in. tap	1	15 000
Universal broach-sharpening machine (internal and surface broach), up to 80 in. in length	1	35 000
Precision bench lathe, up to 2-in. diameter; workpiece centre gap, 15 in.	1	15 000
Universal milling machine with all indexing attachments and accessories, maximum cutter diameter 8 in.; table size, 36 in. × 24 in.	1	35 000
Circular band saw (steel band), width of steel blade band, ¾ in.; work table, 24 in. × 24 in.	1	5 000
Surface table, 36 in. × 36 in., 1-t weight	1	2 000
Slip gauge set	2	4 000
Wide range of measuring tools	Set	5 000
Air-conditioner, 5 t	1	4 000
Universal vice etc.	3	1 000
Special tools and cutters	Set	5 000
Precision surface-grinding machine, diameter of wheel, 8 in.; work table 18 in. × 12 in.	1	20 000
Precision cylindrical grinding machine, maximum workpieces, 2-in. diameter, 24 in. long	1	45 000
L. Fitters bench and maintenance section		
Maintenance equipment	Set	8 000
Portable welding set, 250 A	1	2 000
Oxyacetylene welding set	3	2 000
Soldering and brazing equipment	6	500
Fitters benches with vice	6	1 000
Tools and equipment, including carpentry	Set	4 000
Oil-fired furnace	1	3 000
Electrical and water (pumping) maintenance equipment	Set	1 500

Description	*Quantity*	*Estimated total cost ($)*
M. Metallurgical laboratory		
Spectrophotometer, wavelength 8.80 to 36 gi mi tungsten and deuterium lamp, fused quartz absorption cell, sensitivity better than ± 0.0002 at 0.0004 absorbance	1	6 000
Microscope for metallographical examination, magnification, 20–1 000 times	1	5 000
Brinell hardness-testing machine with fine measuring microscope, magnifying up to 25 times, load, 500–750–3 000 kg; tolerance, 1%	1	15 000
Vickers hardness tester for loads of 0.10–10 kg, fine measuring microscope with magnification up to 200 times	1	3 000
Metallurgical equipment	Set	4 000
Magnetic-particle testing apparatus	2	8 000
N. Central inspection section		
Gear involute and lead-testing, tooth-pitch module 1–17, diameter of base circle, 1–2.35 in.	1	15 000
Double-flank rolling tester, diameter of gear, 12 in.; distance between axes, 2.8-16 in.; precision, 0.0004 in., enlargement, 200 × 300 × 400	1	6 000
Dynamic-angle flank testing machine, modules 1–6	1	10 000
Electrical tester for dynamo and starter		5 000
Universal measuring machine, 16 in. × 4 in. × 6 in.		
Telesurf (CIA–0.000004 in. to 0.002 in.) horizontal enlargement, 100:1; vertical enlargement, 1 000 000:1	1	4 000
Apparatus for sorting parts	1	1 000
Inspection gauges and equipment	Set	5 000
Inspection tables, 24 in. × 24 in., 800 kg	8	5 000
Complete set of dial indicators etc.	24 sets	3 000
Height gauge, vernier calliper, depth gauges etc.	24 sets	3 000
O. Subassembly and assembly fixtures		
For all parts where necessary	Set	5 000
Assembly trolley	8	4 000
P. Paint booth		
Compressor and spray paint equipment	2 sets	10 000
Water screen and heating system for drying	1 set	5 000
Electrostatic paint equipment	1 set	10 000
Q. Compressor set		
Complete air compressor set with water cooling and pipelines, valves etc., line pressure, 80 psi, delivery, 600 ft^3/min		30 000
R. Mechanical handling equipment		
Overhead crane for heavy casting area with gantry and installation, 2 t	1	30 000
Fork-lift truck, 2 t	2	45 000
Stacker truck, 1 t	2	25 000
Pallet trucks, ½ t	6	10 000
Stillage pallets, bins, racks	Set	10 000
Hand pallet trucks	6	20 000
Self-supporting hoists for machine, ½ t capacity	30	55 000

TABLE 42 *(continued)*

Description	*Quantity*	*Estimated total cost ($)*
S Stores equipment		
Bins, racks, cupboards, etc.	Set	40 000
Kardex cabinets and system	Set	5 000
Hydraulic testing equipment	Set	5 000
Production tools	Set	60 000
Spare parts (total) based on all machinery	Set	250 000
Total		3 975 100

[a]For layout plan see figures XIV, XV and XVI.

TABLE 43. INVESTMENT REQUIREMENT

(Dollars)

Basic investment	*Cost*
Fixed capital	
Land	–
Building cost	
Administrative area, electricity sub-station and road	80 000
Factory building, 140 000 ft² at $6/ft²	840 000
Furniture, fittings and office equipment	60 000
Machinery and equipment	3 981 100
Electrical installation, 3 000 kVA	60 000
Building	50 000
Transport (2 trucks, 12 cars, 2 vans and 1 crane)	170 000
Contingencies (10%)	558 000
Total fixed capital	5 800 000
Working capital	
Direct material (3 months)	2 100 000
Direct and indirect labour (3 months)	525 000
Training cost	25 000
Contingencies	100 000
Total working capital	2 750 000
Total investment[a]	8 550 000

[a]Excluding cost of land.

TABLE 44. ESTIMATED ANNUAL MANUFACTURING COST[a] FOR PRODUCTION OF 3,500 TRACTORS

(Dollars)

Item	*Cost*
Imported parts (c.i.f. to factory door)	5 600 000
Indigenous parts with local or imported raw material	2 800 000
Total raw material cost	8 400 000
Labour costs	2 100 000
Overhead costs (including indirect material, power, fuel, water, lubricants, spare parts)	2 100 000
Total manufacturing cost	12 600 000

[a]Based on 250 working days and an 8-h shift.

TABLE 45. ESTIMATED ANNUAL SALES

Product	*Unit selling price ($)*	*Annual production (units)*	*Total sales ($)*
40-hp tractor	4 000	3 500	14 000 000

TABLE 46. TOTAL ANNUAL COST[a] FOR PRODUCTION OF 3,500 TRACTORS

(Dollars)

Item	*Cost*
Estimated manufacturing cost	12 600 000
Sales cost	200 000
Depreciation of fixed capital (10 per cent)	580 000
Total	13 380 000

[a]Based on 250 working days and an 8-h shift.

TABLE 47. PROFIT

(Dollars)

Item	*Amount*
Annual sales	14 000 000
Total annual cost	13 380 000
Profit (before tax)	620 000

Annex IV

ESTIMATED DEMAND FOR AGRICULTURAL MACHINERY

Global demand is difficult to forecast. Estimates, national or international, are approximately the projections of the existing level of demand. Moreover, the physical demand for agricultural machinery in each country depends mainly upon: actual expansion of farmland for agricultural production; intensification of agricultural production through a planned national agricultural policy; and replacement of existing agricultural machinery due to machinery obsolescence or technological change.

Other economic factors are lack of credit, low solvency of farmers, non-availability or high price of agricultural inputs.

Intensification of production creates a demand for mechanical energy. The total energy demand for crop production is not spread out uniformly over the year, but is however concentrated in short periods during cultivating, sowing and harvesting time.

The figure of 0.5 hp/ha is widely used for power required for agricultural mechanization. Its magnitude varies. In the United States of America and Western Europe, it is 1.0 hp/ha, and in Japan 3.0 hp/ha. In India, where multiple cropping is established, the specific mechanized power can be considered as 0.8 to 1.0 hp/ha.

Selection of power package or range

The simplest case is where it is possible to meet the demand for mechanical power in the field one size of power package rated at Y_1 (hp). The cultivation equipment has the highest power demand, which may be calculated from the draft requirements and working speed of the following common implements:

Mould-board ploughs	14 lb/in.^{2} of furrow slice
Rotary tiller	20 lb/in. of working width
Spring time cultivator	55 lb per tine
Row planter	45 lb per row

The acceptable minimum speed of travel is approximately 2 mph, which leads to the following ratings:

$$\text{Engine power (hp)} = \frac{\text{pull (lb)} \times \text{speed (mph)}}{375n}$$

Where n is the overall efficiency of power utilization between engine and implement. For n = 50 per cent engine power should be (hp):

Implement	*Horsepower*
Single furrow ploughs, 8 in. wide × 8 in. deep	9.6
Rotary tillers working 40 in. wide	8.6
Spring tine cultivators working 40 in. wide	4.1
Three-row planters	1.5

These calculations indicate that for cultivators with a single furrow mould-board plough an acceptable engine rating should be 10 hp. In actual fact, with definite farm size and uniform operating conditions, the majority of the implements can be manoeuvred by a major single power package.

Where animal-drawn equipment is used the problem is rather different. The

size of the power package is fixed by a pair of bullocks (0.8 hp), so that with a given rating of implements the total number of animals required can be calculated. In this case, the full capacity of the implement is severely constrained by the lower power available in the draft form and only at one speed.

Estimated demand for agricultural machinery

In order to determine the annual rate of demand, the actual increases in farm land, rate of intensified agricultural production and replacement of machinery are of prime importance.

The provisional study of the FAO Indicative World Plan (IWP) covers demand for inputs for 1975 and 1985 for the major developing areas, including estimated investments and proposals for animal-drawn and mechanized equipment (table 48), estimated tractor requirements (tables 49 and 50) and the estimated value of agricultural inputs.

The investment estimates point to the following conclusions:

(*a*) There will be a great demand for power-mechanized equipment in Asia, Latin America and the Middle East;

(*b*) In Africa investment in animal-drawn equipment will be more predominant and will be raised from $75 million to $90 million, nearly 55 per cent of total investment;

(*c*) In Latin America the trend is more towards investment in mechanized equipment (95 per cent of total investment in 1985);

(*d*) In developing countries, in both Asia and the Middle East, the investment outlook is for more mechanized equipment.

Estimated demand for tractors

IWP figures for 1975-1985 show the following pattern of development:

(*a*) An increase in demand for four-wheel tractors in Asia from 200,000 units to 970,000 in 1985. An interesting feature is a 20 per cent growth rate in two-wheel tractors, probably for the incorporation of more mechanized systems where animal-drawn farming exists;

(*b*) In Latin America the demand for tractors will be somewhat less during 1975–1985 because the present tractor population is higher in this area;

(*c*) In the Middle East the estimated growth rate of tractor requirements will be in the region of 5.1 per cent during 1975–1985;

(*d*) In Africa (south and north of the Sahara) the growth rate of mechanized input will be 2.9 per cent and 4.8 per cent during 1975 to 1985.

There will also be a greater demand for fertilizer and crop protection inputs.

All the above estimates of demand for agricultural inputs show clearly that the requirements of mechanized farming will be more predominant in Africa (north of the Sahara), Asia and the Middle East during the next decade.

The input demand for machinery and equipment in Latin America will be less because of the existing build-up of machinery and equipment, which has reduced demand to a great extent. In Africa (south of the Sahara) greater emphasis should be placed on the improvement in farm mechanization, as the demand rate for mechanized input is not very encouraging for the next decade.

To intensify crop production, a comprehensive and cohesive national mechanization policy is needed particularly in the least developed countries, where greater effort is required for the utilization of manpower through mechanization and off-farm industrial activities in all agricultural and industrial sectors.

TABLE 48. ESTIMATED INVESTMENTS IN 1962 AND PROPOSALS FOR 1975 AND 1985

Region and type of equipment	1962 Value (million dollars)	1962 Percentage of total investment	1975 Value (million dollars)	1975 Percentage of total investment	1985 Value (million dollars)	1985 Percentage of total investment
Africa (south of the Sahara)						
Animal-drawn[a]	60	70	75	60	90	55
Mechanized[b]	25	30	50	40	75	45
Total	85		125		165	
Asia						
Animal-drawn[a]	425	86	483	59	545	28
Mechanized[b]	70	14	340	41	1 415	72
Total	495		823		1 960	
Latin America	115	20	80	10	50	5
Animal-drawn[a]	435	80	720	90	1 050	95
Mechanized[b]	550		800		1 100	
Total						
Middle East	25	36	30	26	35	21
Animal-drawn[a]	45	64	85	74	135	79
Mechanized[b]	70		115		170	

Source: Provisional study of IWP.
[a]Including hand tools but not including the cost of draught animals.
[b]Tractors, equipment for tractors, combine harvesters etc.

TABLE 49. ESTIMATED TRACTOR REQUIREMENTS

Region	1965	1975	1985	Growth rate (per cent) 1965–1975	Growth rate (per cent) 1975–1985
Africa south of the Sahara	22 000	35 000	56 000	4.8	4.8
Asia					
Two-wheeled tractors[a]	19 000	109 000	700 000	19.1	20.0
Four-wheeled tractors	85 000	200 000	970 000	12.5	13.2
Latin America	376 000	570 000	810 000	4.3	3.6
Middle East	35 000	71 000	117 000	7.3	5.1
North-West Africa	36 000	49 000	65 000	3.1	2.9

Source: Provisional study of IWP.
[a]Two-wheeled tractor figures are indicated only for Asia, since they are of little importance elsewhere.

TABLE 50. PROPOSED ANNUAL RATE OF TRACTOR SUPPLY

Region	1965	1975			1985		
	Estimated Total	*As replace-ments*	*Proposed increase*	*Total*	*As replace-ments*	*Proposed increase*	*Total*
Africa south of the Sahara	4 000	6 000	2 000	8 000	9 000	3 000	12 000
Asia							
Two-wheeled tractors[a]	3 500	6 000	26 000	32 000	43 000	167 000	210 000
Four-wheeled tractors	16 000	17 000	36 000	53 000	55 000	130 000	185 000
Latin America	43 000	43 000	23 000	66 000	66 000	27 000	93 000
Middle East	5 000	6 000	5 000	11 000	11 000	6 000	17 000
North-West Africa	3 000	3 000	4 000	7 000	7 000	1 000	8 000
Total							
Two-wheeled tractors	3 500	6 000	26 000	32 000	43 000	167 000	210 000
Four-wheeled tractors	71 000	75 000	70 000	145 000	148 000	167 000	315 000

Source: Provisonal study of IWP.

[a]Two-wheeled tractor figures are indicated only for Asia, since they are of little importance elsewhere.

Agricultural machinery and implements

*A. M. Michael and B. S. Sirohi**

There is a feeling in developing countries that because of scarcity of capital and know-how on the one hand, and abundance of low-cost labour on the other, farm mechanization can only rarely be justified.

Farm mechanization uses physical and biological sciences to find and apply better ways for the production, handling, processing and storing of food, fibre and fodder to improve rural life and living conditions. It also refers to the design, development, testing, manufacturing, marketing, operation and maintenance and repair of all agricultural implements, machinery and equipment. Mechanization has to be developed with respect to the prevailing economic, human and social constraints.

ANIMAL-DRAWN IMPLEMENTS

Productivity on small- and medium-size farms (less than 5 ha) is increased by using animal power, and the Government of India has been supporting country-wide research and development (R and D) programmes. In the early 1940s Professor Mason Vaugh, Head of the Agricultural Engineering Department of Allahabad Agricultural Institute, developed and introduced a number of animal-drawn implements. The Division of Agricultural Engineering, Indian Agricultural Research Institute, New Delhi, other research institutes and agricultural universities have been playing a notable role in improving the designs of animal-drawn equipment. The Indian Council of Agricultural Research (ICAR) has a major co-ordinated research project on the development and testing of improved implements and machinery, with 17 research centres handling research, development and testing. ICAR has also set up prototype production centres in Delhi and Coimbatore to manufacture prototypes for evaluation, trial and demonstration. State Governments have also been supporting development programmes. The Indian Standards Institution (ISI) has set requirements for animal-drawn tillage and cultivation equipment.

Growth in manufacture has been considerable, from the village level to the organized sector. Village artisans have benefited from training programmes in

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states which provide design and manufacturing concepts. As Government policy, manufacture of most simple implements is encouraged in the small-scale sector.

Some of the most commonly manufactured animal-drawn implements are mould-board ploughs of different sizes, reversible ploughs, disc harrows, spike-tooth harrows, blade harrows, 3- or 5-tined cultivators, wetland puddlers, seed and seed-cum-fertilizer drills for cereal crops, planters for sugar-cane, potatoes, maize, cotton etc., fixed and adjustable cultivators, ridgers, furrowers, weeders, scrapers, levellers, V-framed ridger, bund former, wooden floats, Persian wheels, chain washer pumps, bullock-drawn reciprocating low lift pumps, potato and ground-nut diggers, lawn mowers, threshers, wheel-mounted sprayers and dusters, pneumatic wheeled carts and wagons, sugar-cane crushers, chaff cutters and oil *ghanies*.

VARIED POWER SOURCES

One of the major limitations in the widespread application of windmills in India, is the lack of suitable machines in the market. Only a limited number of indigenously manufactured machines has been installed.

The application of solar energy is mainly in the areas of eating and drying of agricultural produce and water pumping for irrigation. Efforts are being made to develop a suitable solar engine which could be used for stationary applications such as water pumping, threshing etc. The limitation is the high cost of the prime mover for converting solar energy to other forms of energy.

The hydraulic ram is a contrivance to raise part of a large amount of water available at some height to a greater height. The main advantage is that once installed there is hardly any running cost. The machine can work continuously for 24 hours and thus gives a regular water supply. Wherever suitable locations exist, hydraulic rams offer an economical means of lifting water.

Diesel and petrol engines are important prime movers. Diesel engines have become popular due to their low operational and maintenance cost and high efficiency. Production of diesel engines in the organized sector was established for the first time in India in 1932. After independence, the launching of agricultural development programmes under the "Grow More Food Campaign" gave a boost to the industry. In agriculture, diesel engines are used mostly with pumping sets, power tillers, wheeled tractors, motorized scrapers, motor graders etc. and other agricultural machinery such as threshers, sugar-cane crushers etc. While engines used with pumping sets have a power range of 5–15 hp (4–11 kW), those on wheeled and crawler tractors range from 18–275 hp (14–200 kW). Production has increased substantially during the past two decades. The number of manufacturing units, hardly 6 in 1951, rose to 32 in 1975, whilst production which was about 20,000 in 1951, rose to 141,000 in 1975. There is also a large production in the small-scale sector. Production of medium- and large-scale units since 1972, given belows, is based on details from the Agricultural Machinery Directory, Indian Society of Agricultural Engineers:

Year	Up to 20 hp (15 kW)	20–100 hp (15–75 kW)	Above 100 hp (75 kW)
1972	60 847	11 072	1 649
1973	123 047	11 817	2 327
1974	93 500	21 734	2 850
1975	116 000	22 347	2 950

Electric motors

Electric motors are more economical than diesels in initial cost, operation and maintenance, especially in agricultural applications. A wide variety is manufatured in India, ranging from fractional horsepower to large sizes. The major application is in irrigation pumping, but production should be diversified to meet requirements of pumping and other stationary applications. There is also a need for better quality control.

Tractor industry

Tractor manufacture has developed into a major farm industry. Production under licence rose from 1,414 in 1962/63 to 33,252 in 1975/76. At present, twelve manufacturers are making tractors from 25–75 hp (19–56 kW) most of them completely indigenous. All must have their tractors tested at the Government Tractor Training and Testing Station (GTT and TS), Budni (Bhopal), India, which follows the Test Code IS:5994-1970 of the ISI. A fully indigenous tractor was designed and developed at the Central Mechanical Research Institute (CMERI) and is in regular production. A few other models of tractors have also been designed and developed.

The GTT and TS at Budni assists in special investigations and tests. Other government institutions, such as CMERI, Durgapur; National Test House, Alipore, Calcutta; India Institute of Sciences (IIS), Bangalore; Petroleum Research Institute, Dehradun etc., provide testing and advisory facilities. Agricultural universities and the institutions of ICAR also undertake work. Training in selection of tractors and matching implements, maintenance, upkeep and servicing, and procedures for particular crops and conditions are vital for efficient utilization. The Government of India has set up two training centres at Budni and Hissar. Both offer regular courses for progressive farmers and owner operators, nominees of government departments, farming institutions, university students in agricultural engineering and agriculture and engineering entrepreneurs.

Power tillers

The power tiller is a multipurpose hand tractor fitted with a rotavator or with rotary tilling blades fitted to the wheel or drive shaft. Power tillers manufactured in India have versatile features in that the same machine when fitted with a rotavator can be used for rotary tilling of dry and wet paddy lands.

Other implements can be fitted and the machine works like a conventional four-wheeled tractor except that the operator has to walk behind it. In the case of trailers, disc harrows etc., an operator's seat permits faster operations.

The single-cylinder light diesel engines of 5–12 hp (4–9 kW) are relatively economical for operations in small and medium farms. To adapt the tillers for boggy and wet paddy lands, special cage wheels and steel wheels for heavy traction jobs such as ploughing are offered. Nevertheless, their wide acceptance has been slow. Not only is the technology relatively new, but prices are too high for an average farmer with three to five hectares. All power tillers licensed for manufacture were initially tested at the GTT and TS at Budni, Bhopal, India.

Earth-moving

There is an increasing need for heavy earth-moving equipment for land reclamation, construction of dams, irrigation and drainage canals, roads, and other jobs. Indigenously manufactured machinery is now being extensively used in agricultural, irrigation and other projects.

Irrigation pumps and water lifts

In a country with vast resources of underground water and a network of rivers and canals, lift irrigation assumes considerable importance. Centrifugal pumps are widely used for irrigation, though not efficient for low-head, high-discharge operations. Another limitation is that the suction lift is limited to about 6.5 m. A development to overcome this problem is a medium-lift, submersible centrifugal pump with hydraulic drive manufactured in Sweden.

Vertical turbine pumps and submersible pumps are used to lift water from deep wells.

Since the manufacture of the simplest centrifugal pump in the early 1930s, the Indian pump industry has grown steadily. Large-scale manufacturers have a total installed capacity of 508,000 units per annum, of which 95 per cent comprises those required for irrigation. The small-scale sector is also engaged in production for agricultural and domestic use. Growth is almost 400 per cent a year. Most manufacturers maintain their own testing facilities and several organizations are engaged in testing to meet requirements of the ISI. The National Test House in Calcutta, India, and other Governmental or semi-governmental stations, the GTT and TS at Budni, India, the Water Technology Centre of the Indian Agricultural Research Institute, New Delhi, the Agricultural Engineering College of Punjab Agricultural University etc., test pumps and provide facilities to manufacturers.

The development of plant protection equipment in India has made rapid progress over two decades. More than 40 manufacturers cater to the need of a wide range of farming and crop conditions. Aerial application is also being practised, for which Hindustan Aeronautics Limited, at Bangalore, have organized the production of aircraft.

The smaller the size of droplets, the better and more effective the coverage

of insecticide or pesticide. This necessitated changes in the spraying technique from high volume to low volume, as the latter needs less water for application of chemicals. Another development in spraying technology is ultra-low-volume spraying. The chemical is usually either undiluted or formulated in oil. This technique, so far used mainly in aircraft spraying, has also been introduced in knapsack sprayers. ISI has formulated control requirements for materials, interchangeable parts and testing procedures. The Central Plant Protection Training Institute, Hyderabad, India, provides training on selection and use of equipment. Leading manufacturers have training facilities for maintenance and repair.

DAIRIES AND POULTRY

The dairy industry in India is almost as old as civilization. After independence, it derived impetus from the establishment of organized milk collection, processing and distribution to cater for urban areas. Companies manufacturing equipment also supply designs, and commission plants, including those for milk powder, baby food and specialized products. Turnover of the large-scale equipment is Rs 75 million per annum and of small units Rs 25 million per annum. The National Dairy Development Board, established in 1965, offers technical and consultancy services. The Indian Dairy Corporation promotes milk marketing and dairy equipment. Training and research facilities are available at the Indian Institute of Technology, Kharagpur, the National Dairy Research Institute, Karnal, and a number of agricultural universities.

Remarkable progress has been made in producing basic equipment for the poultry business, such as incubators, feed mills, brooders, feeders, grading and processing equipment, and ancillary equipment and instruments. More than 70 manufacturers are involved and products are exported. ISI standards cover equipment, feedstuffs and their ingredients, housing, storage, handling and transportation. The Central Food Technological Research Institute (CFTRI) at Mysore conducts training courses and disseminates know-how for processing. The Central Training Institute for Poultry Production and Management at Bangalore offers three-month courses in poultry science. Poultry equipment is also a subject at the Indian Veterinary Research Institute, Izealnager, and the agricultural universities.

AGRICULTURAL PROCESSING

Processing of rice and other food, animal feed, and seed are important for agriculture. Modern rice processing uses paddy cleaners, rubber roller shellers, paddy separators, polishers, rice-grading, hot-soaking and parboiling equipment and mechanized paddy dryers. Modern technology obtains a higher milling recovery, superior quality, by-products of greater value, reduction of wastage and storage losses, and better economic returns. In 1964, the Government of India set up a pilot project of seven modern rice mills. These have brought

increased outputs, superior quality and by-products of better value. Financial benefits have more than compensated for the cost of modernization.

Equipment under production includes scalpers, cleaners, boilers (for rice mills), dryers (husk-fired and oil-fired), storage tanks (steam heat exchanger), heat exchangers, paddy cleaners, dehuskers, rubber rolls, paddy separators, polishers, rice graders, weighing machines, solvent extraction plants, bagging and stitching machines, and modern parboiling equipment. Fruit and vegetables processing extends their use during off-seasons.

Use of modern techniques in canning and bottling began in the late 1920s and developed further after independence. By 1975, the number of units in the country was about 1,200, and it was estimated that the value of output would reach Rs 400 million during 1977–1978.

The CFTRI, Mysore, is working on processes and preservation. The Food and Nutrition Board is responsbile for development and quality. Seven Food Craft Institutes offer courses, and a central consultancy unit has been set up for entrepreneurs. Equipment such as washing tanks, cutting machines, pulpers, filler presses, juice extractors, filling machines etc., is manufactured in the country. Integrated programmes of animal husbandry and poultry has brought the introduction of special techniques for cattle and poultry feed. Roughage mills, crushers, size reducers (burr mills, hammer mills, roller mills etc.), elevators, storage tanks and bagging units are among the equipment used to form a complete plant.

High-yielding varieties of maize, sorghum, and bajra, high-fertilizer-responsive varieties of wheat and rice have created a demand for seed-processing equipment, and the National Seeds Corporation has provided leadership. Seed-processing operations include cleaning, separating, grading, drying and treating. Equipment used to form a unit comprises cleaners and graders, elevators, seed treaters, dryers, conveyors, holding bins, bagging and stitching machines. About 10 large-scale manufacturers in India produce most of the items, more than 20 manufacturers or suppliers deal with specialized equipment, and a large number make ancillary items such as platform weighing machines, air-conditioners, dehumidifiers etc.

STANDARDIZATION AND QUALITY CONTROL OF MACHINERY

Faster introduction and use of appropriate intermediate technology is essential. Codes of practice or recommended practices in the form of standards are relatively new, and emphasis is on the requirements of producers, consumers and technologists. In order to maintain quality and to reap the benefits of standardization, a need was felt for formulating standards for agricultural machinery. ISI set up a Fair Implements and Machinery (now renamed Agricultural Machinery and Tractors) Sectional Committee in 1959. Standardization of component dimensions permits interchangeability within and between similar machines. It also helps to streamline production, and contributes to the development of ancillary units required by equipment manufacturers. For the formulation of technically sound standards, extensive research, testing and follow-up surveys are necessary. With an increase in the

use of power machinery, it may be desirable that prescribed safety requirements be made compulsory. Financing institutions could take advantage of the system, to ensure not only that quality products are made eligible for credit financing, but also that it is properly maintained and operated. A code of practice for installation, after-sales services, norms of spare parts, stocking etc. is therefore important.

Mexican agricultural tractors industry

*R. Carvajal Márquez**

Background

Agricultural mechanization in Mexico was met in part first by imports mainly from the United Kingdom and the United States and later by promoting assembly and manufacture. National manufacture started in 1966, when 647 tractors were produced, a figure which by 1977 had reached 11,574–still inadequate for a country with an area of 2 million square kilometres (see table 1).

Mexico is, in general, very arid. Only 23 per cent of the area, or 45 million hectares, could be considered humid. In addition, only 36 per cent, or 71 million hectares are flat; and 15 per cent or 30 million hectares suitable for cultivation. Of this area 60 per cent depends on rain for moisture. The area available to cultivation is not fully exploited, and in 1973, one of the better years, only 53 per cent was under-used, the average being just over half.

Thus, the area good enough for cultivation is very small, and held by very few people. Most farmers lack the economic capacity to acquire mechanical aid for their parcels of land, so that the demand for tractors is accordingly diminished. Government technical and financial support is therefore required to encourage agricultural mechanization. This aid should aim at national sufficiency in food production and a just economic system. National deliveries of tractors grew at a rate of 4.6 per cent between 1960 and 1977, but with an irregular pattern. From 1960 to 1963 there was a decrease of 18 per cent; from 1964 to 1965 a growth of 48 per cent; from 1966 to 1967 a diminution of 17 per cent; from 1967 to 1968 there was a rise of 54 per cent; from 1969 to 1971 a decrease of 36 per cent; from 1972 to 1975 a growth of 119 per cent; and from 1976 to 1977 a reduction of 13 per cent.

Projections of demand up to 1982 in four different power ranges of tractors are given in table. 2. These forecasts of future demand ignore price variations since prices are officially controlled. Increases in the area under cultivation are also not considered since they are unrelated to the statistics of purchases.

The national manufacturing total of 11,574 units in 1977, about half of them in the 60–79 hp (45–59 kW) range, represents 75 per cent utilization of installed capacity, which is 15,500 units per annum.

A comparison between capacity of production and future demand shows a

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TABLE 1. NATIONAL APPARENT CONSUMPTION OF TRACTORS,[a] 1960–1977

Year	*Production*[b]	*Imports*
1960	–	7 056
1961	–	5 094
1962	–	5 143
1963	–	6 156
1964	–	9 088
1965	–	7 776
1966	467	6 018
1967	2 798	5 010
1968	5 367	6 624
1969	5 059	6 458
1970	3 954	4 978
1971	5 076	2 277
1972	6 677	2 885
1973	6 646	4 080
1974	7 951	7 411
1975	10 507	10 525
1976	9 664	7 863
1977	11 574	3 600

[a]In the power range 25–125 hp (19–94 kW).
[b]Figures for the T-25 are not included since this tractor is currently only assembled from parts. Local manufacture is planned for a later date.

TABLE 2. PROJECTIONS OF TRACTOR DEMAND TO 1982

Year	*Total*	*<40 hp (30 kW)*	*41–59 hp (31–44 kW)*	*60–79 hp (45–59 kW)*	*>80 hp (60 kW)*
1978	28 711	1 389	2 534	11 145	13 643
1979	29 397	1 498	2 314	11 822	13 763
1980	30 083	1 607	2 263	12 429	13 784
1981	30 769	1 716	2 057	13 021	13 975
1982	31 455	1 824	2 876	13 594	14 161

deficit, even considering future extensions. One of the principal problems facing the automotive industry is the supply of foundry parts. Mexican state investors are studying possible solutions for the time, price and quality questions.

Tractor prices to farmers were almost constant from 1968 to 1973, but the increase from 1975 to July 1978 was more than 100 per cent. Even so, prices in the international market are generally higher than in Mexico.

Tractor manufacturing technology used in Mexico comes from the United Kingdom and from the United States, except for that required to assemble the T-25. This comes from the Union of Soviet Socialist Republics, to which a small once-only payment was made for total transfer, allowing the user freedom of manufacture and international trade. The others are more in the nature of a rent than a transfer of technology, in that the cost is a percentage per unit sold and restrictions exist on international trade.

Conclusions

The Government has to make special efforts to solve simultaneously problems of attaining self-sufficiency in food production, the acquisition of adequate and appropriate technology, and the promotion requirements to manufacture enough cheap tractors to satisfy the increasing demand. These three aspects are interlinked and must be dealt with bearing in mind the importance of retaining independence and freedom to choose types of tractors which could satisfy the needs of mechanization at the lowest costs possible in relation to investments, technology, trade and component prices.

Agricultural mechanization and farm machinery production in Pakistan

*A. U. Khan**

Pakistan has a population of approximately 75 million, and a quarter of its land area of about 37,000 square miles (9.6 million hectares) is in the fertile plains of the Indus valley. The balance is the desert in the south-east and a mountainous region in the north and west. In general, the climate is semi-arid and subtropical. While 38 per cent of the land is considered suitable for cultivation, only 24 per cent is cultivated.[1] Of approximately 19 million hectares cultivated, about 13 million hectares,[2] or 66 per cent, is irrigated. Some of the irrigated area is double-cropped, and the major crops are wheat, rice, cotton, sugar-cane and corn (maize). The agricultural sector constitutes 36.4 per cent of the total GNP,[3] and nearly 72 per cent of the population depends on agriculture for a living.

Nearly 90 per cent of the farms are less than 10 ha in size, run monthly by family labour.

Pakistan has been following an import-based agricultural mechanization strategy with a major emphasis on introducing large tractors of 45 hp (34 kW) and above from industrialized Western countries. Consequently, a severe foreign exchange drain is being incurred.

Potential for local production of tractors, implements and farm machinery is great. Past efforts have been limited mostly to introducing certain imported machines, but with the exception of conventional 35–60 hp (26–45 kW) tractors, such an approach has not proved too successful. If agriculture is to be properly mechanized, due attention should be given to all elements of the system, e.g., research, design and development, testing, extension, manufacturing, sales and service. Of particular significance would be the development and introduction of technologies appropriate for farms of less than 10 ha.

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[1]*Rural Development Year-book of Agricultural Statistics, 1973–1974* (Islamabad, Pakistan, Ministry of Food and Agriculture, 1975), p. 26.

[2]*Agricultural Statistics of Pakistan, 1976* (Islamabad, Pakistan, Ministry of Food and Agriculture, 1976), pp. 150–153.

[3]*Pakistan Economic Survey* (Islamabad, Pakistan, Finance Division, 1975).

MAJOR FARM EQUIPMENT

Most animal-drawn implements are based on traditional designs evolved over centuries, produced by village blacksmiths or a few small firms. Efforts are needed to import, evaluate and introduce a variety of those proved successful in countries with similar agro-climatic conditions.

The Pakistan Census of Agriculture, 1975, showed 35,714 tractors, nearly all privately owned by farmers with more than 10 ha. About 58,000 were operating at the end of 1977. From 1964/65 to 1976/77, a total of 78,091 tractors in the 40–60 hp (30–45 kW) size were imported. From 1974/75 onwards, the numbers increased substantially.

Power input, except for well boring, has been estimated at 0.120 hp per acre (0.22 kW/ha) animal, human and mechanical. It has been generally accepted that a minimum of 0.2 hp per acre (0.4 kW/ha) is essential in most developing countries for obtaining reasonable crop yields. Using this as a target, projections of demand for tractors of 45 hp (34 kW) or more by 1988, show a steady increase from 15,000 in 1978 to 24,450 in 1988. (The table gives demand projections for tractors, implements and farm machinery up to 1982.)

Plans for producing tractors in the public sector have now been announced by the Government. Steps are now needed to encourage production also in the private sector. Projections also indicate a sufficiently large tractor market to justify indigenous production of more than one make of 40–60 hp (30–45 kW) tractors. Development of an ancillary industry for components production is essential. Five different makes of imported 25–35 hp (19–26 kW) tractors are being tested by the provincial agricultural engineering organizations. Limited numbers of selected makes will be imported for sale to farmers to evaluate suitability and commercial viability under actual farm conditions.

TRACTOR, IMPLEMENT AND FARM MACHINERY DEMAND PROJECTIONS FOR THE PERIOD 1978–1982

Description	*Estimated population plus shortages in 1977 (units)*	*Demand projections (units)*				
		1978	*1979*	*1980*	*1981*	*1982*
Tractors	58 000	15 000	15 750	16 540	17 370	18 240
Cultivator	52 400	13 550	14 230	14 940	15 690	16 480
Mould-board plough	5 500	1 420	1 490	1 570	1 650	1 730
Disc plough	6 400	1 660	1 740	1 830	1 920	2 020
Disc harrow	5 100	1 320	1 380	1 450	1 530	1 600
Levelling blade	22 100	5 720	6 000	6 300	6 620	6 950
Rotavator	1 900	490	520	540	570	600
Grain drill	3 700	960	1 000	1 060	1 110	1 160
Fertilizer drill	550	140	150	160	160	170
Power sprayer	1 000	260	270	280	300	320
Trailer wagon	30 650	7 930	8 320	8 740	9 180	9 640
Cane crusher	1 250	320	340	360	370	390
Wheat thresher						
(a) Tractor-powered	11 050	3 300	3 750	4 130	5 030	6 000
(b) Electric motor-powered		1 050	1 500	1 650	1 990	2 400

INDIGENOUS PRODUCTION

South-East Asian experience indicates that rapid progress can be achieved through local production of simple, indigenously designed, 4-wheel tractors. Two such tractors, one designed at the International Rice Research Institute (IRRI) in the Philippines and the other commercially produced in Thailand, have been imported for testing and evaluation. They are being adapted for local upland farming conditions and, if successful, will be introduced to local manufacturers.

The most popular tractor tillage implement indigenously produced is the cultivator, made by numerous small firms. Tractor cultivators are also widely used, but the range of other tractor implements is limited and should be broadened by production and imports. Mould-board ploughs, disc harrows, disc ploughs and chisel ploughs require special attention. More liberalized imports of components such as springs, points, sweeps etc. will help to improve the quality of locally produced cultivators.

Levelling blades and trailers are two other tractor attachments produced in substantial numbers. Limited production of seed drills, disc ploughs and disc harrows is also being undertaken. While capacity exists to meet local demand, there is a shortage of discs and other cutting tools. Encouragement is needed for making discs and soil cutting tools such as shovels, cultivator sweeps and ploughshares.

Pakistan has recently imported 2,000 Chinese 12 hp (9 kW) diesel power tillers, which are being marketed all over the country. In the dryland farming areas they are being sold with a 50 per cent subsidy. There is a widespread belief that power tillers are not suitable for local conditions and evaluation is needed especially in the rice growing areas. The Chinese and Japanese types are fairly complex and difficult to produce in low volumes. In Thailand and the Philippines, simple, locally designed power tillers have been successful. Some of the IRRI models have been imported for test and evaluation, and a local firm has manufactured a prototype. Experience with the Chinese power tillers will to a large extent dictate the future of power tillers in Pakistan.

Diesel engines are used for tube-wells and crop processing and there is an established industry producing slow-speed stationary diesels of 10–30 hp (8–22 kW). Lack of production of lightweight high-speed diesels in the 6–12 hp (4.5–9 kW) size however has been a serious problem. They are needed for a wide range of farm and other equipment.

A nationalized company makes a small number of medium-speed, 4.5–8 hp (3.4–6 kW) vertical air-cooled diesel engines. The price is higher than comparable imported engines and it has not found a large market. To encourage production, imports of small-size diesels has been banned, and consequently, 6–12 hp (4.5–9 kW) engines are not easily available at economical prices. Limited imports coupled with progressive local production of one or two selected makes could be helpful.

The Plant Protection Directorate used to provide aerial spraying for most major crops, a practice now being phased out. Local manufacturers producing manual and power-operated equipment have to compete with imported mass-produced machines offered at subsidized rates. A degree of market

protection, even at some sacrifice of quality and price, may be necessary in the early stages of indigenous manufacture.

Shortage of labour during the peak demand period is creating pressure to mechanize paddy transplanting operations. The Government has recently imported 100 power-operated 12-row transplanters from China. Two hundred and fifty power-operated 6-row transplanters have also been imported from the Democratic People's Republic of Korea. These machines are now being evaluated and marketed in the rice-producing areas of Punjab and Sind. A number of local firms have produced prototypes.

Animal- and tractor-drawn seed drills are used on a limited scale, and seed-cum-fertilizer drills have not yet been introduced, though increases in yields reported due to their use makes it important for them to be introduced soon.

Almost all crops are manually harvested but labour shortages during peak periods present serious problems. Harvesting combines are highly capital-intensive machines which displace labour and their use is not recommended for a country like Pakistan. A few reapers and reaper binders have been imported from Italy and Japan, a self-propelled reaper binder is being developed at the Agricultural University, Faisalabad, and a local firm's front-mounted tractor reaper is now being tested.

The wheat-threshing machines were first introduced in 1958–1959. Acceptance was slow at first but increased after 1970. The threshers currently popular usually take power from tractors. They can also be powered by 25-hp (19 kW) electric motors or 35-hp (26 kW) stationary diesel engines. A serious limitation is that output is low for the power consumed. The threshers also damage grain, affecting germination and increasing spoilage during storage. Threshing technology has been relatively static for over a decade, but the introduction of two new multicrop IRRI designs has generated considerable interest. The IRRI machines can thresh wheat, paddy, sorghum, soyabean and many other small grain crops, and are powered by 6–12 hp (4.5–9 kW) diesel engines. Demand is expected to increase rapidly.

Pakistan's young wheat thresher manufacturing industry is progressing rapidly. At mid-1977 about 70 firms were producing approximately 5,000 units annually. Nearly three quarters of the firms are small with an annual production of less than 50 threshers. Almost all have some excess production capacity. Eight firms have produced prototype units of the IRRI multicrop threshers and some have started commercial production. Under the Government's Salinity Control and Reclamation Project (SCARP) tube-wells are being installed in Punjab and Sind. They are fairly large and generally powered by electric motors. Approximately 50,000 have been installed so far. Water from them is mixed with river water for irrigation. About 150,000 private wells, usually smaller in size, are powered by 15–20 hp (11–15 kW) diesel engines. Pumps and diesel engines are produced locally. The Government provides a subsidy of $750 to $1,500 on new wells driven by diesel engine. Heavy slow-speed diesels widely produced for rice and wheat milling have been adapted for use. Electric power is made avilable for agricultural well operation at 30 to 40 per cent subsidized rates. The cost of wiring and installation of electric tube-wells is also subsidized.

MECHANIZATION LINKAGES

Research and development (R and D) facilities in agricultural machinery are limited. Except for the Agricultural Engineering Department, University of Agriculture, Faisalabad, hardly any machinery R and D work is undertaken at educational institutes and the industry has virtually no organized R and D activity.

The Government is, however, taking steps to establish adequate facilities, and a National Institute of Agricultural Mechanization (NIAM) is under active consideration. The Agricultural Research Council's co-operative machinery R and D programme with IRRI is being expanded and will form a part of the National Institute. The National Institute will devote special attention to the testing and introduction of new technologies. NIAM will be closely linked with provincial organizations engaged in machinery R and D through its own co-operative machinery testing and adaptation sub-stations in each province. There is a serious shortage of designs to meet the special needs of farms with less than 10 ha, and NIAM will focus its development efforts on these needs.

Most manufacturers in Pakistan produce almost all their machinery components themselves. Manufacture of farm implements and machines is well suited for small-scale batch production in rural areas. There are, however, some machinery components which can only be produced with relatively more complex production equipment. An inter-linkage between rural and urban industries will thus be necessary for large-scale production of most farm machines. The important high-technology components which may have to be produced are ball-bearings, roller chains, bearings, seals, belts, springs, discs, cultivator sweeps and points, mould-board ploughshares etc. If these are made available to the rural and small industries, manufacture of farm implements and machinery can progress smoothly. Manufacture of suitable engines must be undertaken at centrally located plants in the metropolitan areas. Availability of 6–12 hp (4.5–9 kW) lightweight medium- and high-speed diesel engines is essential for the production of a wide range of machines for small- and medium-sized farms.

The Pakistan Tractor Corporation (PTC), through which all tractors and farm machinery imports are channelled, operates marketing offices in the major cities for distributing foreign tractors. Two private firms which import through PTC also operate a marketing and service network. Many firms import parts and distribute through dealers. Tractor implements are mostly produced by small firms and sold locally. National level marketing might help to improve the implement manufacturing industry's organization and perhaps the quality of products. The Ministry of Rural Development has launched the Integrated Rural Development Programme (IRDP) under which 625 service centres (Markaz) have been set up in the rural areas of the country. These will provide comprehensive farm services such as banking, seed and fertilizer supply, machinery repair and service facilities to local farms. The objectives include assistance to village blacksmiths for rural machinery repair, maintenance and manufacturing facilities and hiring pools. PTC has organized a scheme to help private repair shops with training and other assistance. Six training schools for operators are provided by the Agricultural Engineering Organization. The

Pak-German Institute of Co-operative Agriculture has one for operators and another for mechanics. Dealers, operators and servicemen are trained by a tractor firm in Lahore on two types of tractors.

In addition to the Agricultural Development Bank, most commercial banks have recently started offering credit to farmers for purchase of machinery. In a recent survey of thresher manufacturers in Pakistan, however, lack of credit was pointed out as a major constraint. Small manufacturers do not have access to adequate credit for producing machines. The National Bank of Pakistan has recently started a supervised credit scheme for agriculture and technology which provides loans to enterpreneurs. Some of the priority clients are agricultural machinery manufacturers, self-employed engineers and technical workers.

PUBLIC POLICIES

Currently, government policies are undergoing changes to encourage local manufacture of agricultural machines. The Government has recently allowed manufacturers to import production equipment under gift schemes. Financing policies for tractor ownership are being liberalized. The Government has also introduced schèmes to popularize certain machines through price subsidies. For the last four years, all tractors and agricultural machinery have been imported in the public sector through PTC, the idea being to make equipment available at cheaper prices, to provide effective after-sales service and to do away with some malpractices of the private sector. In practice, however, this monopolistic practice has created a number of problems. The Government has recognized this and has recently permitted imports of tractors by private firms.

Restriction of imports of 45–60 hp (34–45 kW) tractors to five makes has had only a healthy effect on mechanization since supply of parts and servicing is developing in rural areas. Continued restriction may be necessary, however, to avoid proliferation of makes followed by deterioration of service and spares facilities.

Issues related to agricultural mechanization and machinery production are dealt with by many different ministries and it is difficult to obtain clear-cut decisions to facilitate indigenous production. As a result, no comprehensive plan has yet emerged for co-ordinated development. A single organization should be charged with responsibility for developing the industry.

In some cases, present regulations in effect discourage local production. For example, many farm machines which are locally produced can be imported free of customs duties, whereas imports of steel, copper, brass and other raw materials needed for local production have high customs duties. The Government's recent scheme for rebate of duties to agricultural machinery manufacturers may help to eliminate this anomaly. Another interesting example is that ground-operated plant protection equipment is imported and sold to farmers at a 50 per cent subsidized price. Local manufacturers of similar equipment consequently find it almost impossible to compete in the open market.

A widespread belief that locally produced equipment must initially match the quality and price of comparable imported equipment has to some extent

hampered the development of an indigenous agricultural machinery industry. Imported agricultural machines are often permitted to compete openly with locally produced equipment. The question of market protection for indigenous manufacture needs careful consideration. Manufacturing under licence with established manufacturers can produce excellent quality control. Government import policies should provide incentives as well as regulatory policies, to encourage planned and co-ordinated production.

Most provincial governments operate bulldozer, tractor and farm machinery hire stations, which have an important role, especially during the early stages of mechanization, for introducing new models, testing new implements and providing mechanization training. In the long run, however, the services could be more effectively offered through small localized private hiring services.

Government puchases can play a significant role in improving production quality and in test-marketing limited numbers of the new indigenously produced machines. Provision for import of equipment by actual users helps to introduce new technologies and provides opportunities for evaluation under farm conditions without cost to the Government.

Industrial co-operatives seem to offer some possibilities for improved production of even fairly complex machines in rural areas. In many rural towns where a sizeable farm implement production is being carried out by blacksmiths, industrial co-operatives would help in marketing production on a wider scale and in improving quality by providing technical and other assistance.

Conclusion

Indigenous production of farm machinery has had mixed development. While production of threshers has increased steadily, only a few tractor implements have been locally produced. Production of tractors has not yet started but plans have been made. Steps are being taken to rectify nationalization problems so that this important sector can be rapidly developed. Increasing shortage of rural labour is creating pressure for mechanization and Government R and D organizations will play an important role in developing appropriate technologies. The future of agricultural mechanization and local production in Pakistan of agricultural machinery is promising.

Agricultural machinery industry and rural industrialization in the Sudan

*M. A. Bedri**

INTRODUCTION

The paper reviews the present status of agricultural machinery and rural industrialization in the Sudan and considers plans for the future, including a major project evaluated by the World Bank/UNIDO Co-operative Programme. The Government's policy of developing co-operation with other African countries is also considered.

The Sudan is the largest country in Africa, with an area of approximately 1 million sq m (2.5 million km^2) equivalent to about 600 million feddans (one feddan = 4,200 m^2 = 0.42 ha). About 200 million feddans (84 million ha) are suitable for habitation; at present only 17 million feddans (7.1 million ha), are cultivated, 4 million (1.7 million ha) by irrigation from the Nile and its tributaries, and 13 million (5.5 million ha) by rain.

The cultivated area will increase to about 21 million feddans (8.8 million ha) by the end of the present six-year plan in 1982–1983. One third of the country north of latitude 19° N, is an arid desert where agriculture is possible only on a narrow strip along the banks of the Nile. The more humid climate of the southern region with heavy rainfall is suitable for tropical crops. The central plain has been the main area for traditional farming and is now the most suitable for modern development. Cotton, sorghum, wheat, millet, ground-nuts, sugar-cane and sesame are the most important crops. The population of the Sudan is about 17 million and very sparse.

The United Nations includes the Sudan among the least developed of the developing countries. It is poor, with low rates of capital formation, a low level of savings and high indebtedness. About 80 to 90 per cent of the population depends on agriculture for a living, earning between 96 and 98 per cent of all export earnings. In contrast, 6–7 per cent of imports have a direct bearing on basic agricultural productivity, comprising items such as fertilizers, insecticides, herbicides and agricultural tractors and machinery. Between 1962 and 1976, the Sudan imported 13,773 tractors of 20 types; 1,715 combine harvesters (17 types), and 13,020 varied implements.

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Agricultural production

Agricultural production comes from irrigated and rain-land farming. Crops from the irrigated area were mainly dependent on hand labour up to 1960. Today seed-bed preparation and insecticide, herbicide and fertilizer applications are fully mechanized. Wheat is combine-harvested, sorghum is partly threshed. Sugar-cane cultivation is mechanized, but harvesting is by hand. Cotton is mostly planted, weeded and picked by hand, but mechanical planting and weeding is being applied when conditions are favourable. Mechanical cotton picking is under trial and evaluation. The introduction of machinery for these crops was dictated *inter alia* by shortage of labour caused by migration to the cities and new industrial projects, higher wages, and the fact that mechanization improves the timing of operations and decreases losses.

The rain-land area is divided into two sub-sectors according to methods of traditional and mechanized farming.

Traditional farming covers an area of about 4 million feddans (1.7 million ha) and all operations are by hand or with primitive hand tools. This is subsistence-level agriculture, and holdings are mostly very small. All the millet, most of the ground-nuts and sesame, and some of the sorghum produced in the Sudan come from this area.

In an area of 9 million feddans (3.8 million ha), crop production is completely mechanized. Holdings range from 1,000 feddans (420 ha) to 500,000 feddans (210,000 ha) or more. Mechanization is the only way to develop these millions of hectares which have enough rainfall, but which are far from cities and towns and lack transport, food and water for domestic use.

Manufacture of agricultural machinery

By 1976/77 the contribution of the industrial sector to GDP had reached 14 per cent, and the manufacturing industries recorded a growth rate of more than 5 per cent. The main sectors are food, textiles, chemicals, leather and engineering. The engineering sector is the least developed. Tractors and agricultural machinery are locally assembled in workshops belonging to the equipment distributors.

The first phase of the Government's economic and social development plan from 1977/78 to 1982/83, includes the following objectives:

(a) Development of agro-industries based on local agricultural production to achieve self-sufficiency and a surplus for export;

(b) Production of agricultural inputs such as cement, insecticides, fertilizers, agricultural machinery and spare parts;

(c) Development of small-scale industries based on local material and rural industries to check the drift to urban areas;

(d) Achievement of a balanced distribution of industries;

(e) Development of basic infrastructure, especially hydroelectric power and construction industries;

(f) Encouragement of participation of both foreign and national private sectors.

The contribution of the industrial sector to GDP is expected to increase from 14 to 16 per cent, and that of the manufacturing sector should reach 10 per cent in 1982/83. There is a pressing need for agricultural machinery of different types. The six-year plan for economic and social development has stressed the increased use and manufacture of agricultural machinery. At present there is no agricultural machinery industry in the country. The table shows the imports of agricultural machinery and equipment by type from 1962–1976. There are, however, many repair workshops for tractors and machinery in all production areas. There is a limited manufacture of irrigation pipes, fuel and water tanks, small canal ditchers and agricultural trailers of different sizes and for different purposes. Axles, wheels, tyres and sheet metal are imported. Welding electrodes, liquefied gas and paint are produced in factories in Khartoum. In rural areas small hand tools are made in blacksmith's shops using scrap iron. These include hand hoes, weeding hoes, planting sticks (selluka) and animal-drawn wooden ploughs with metal tips (Beladi plough).

IMPORTS OF TRACTORS, COMBINES AND AGRICULTURAL IMPLEMENTS, 1962–1976

(Number of units)

Type of equipment	*1962–1969*	*1970–1972*	*1973*	*1974*	*1975*	*1976*	*Total*
Tractors	4 427	2 987	1 416	2 151	852	1 940	13 773
Combines	574	293	220	254	121	253	1 715
Agricultural implements							
Disc plough	481	325	55	145	179	255	1 440
Toolbar and ridger	2 586	761	47	309	260	523	4 486
Offset disc harrow	144	33	45	48	236	4	510
Wide level disc with seeder box	1 846	1 475	40	–	1 065	110	4 536
Planter	100	120	–	68	141	210	639
Multipurpose blade	254	52	16	3	74	30	429
Ditcher	143	100	2	100	163	–	508
Border disc	14	17	–	–	18	–	39
Land plane	40	6	4	130	8	6	194
Chisel plough	10	20	–	6	–	30	66
Cultivator	12	–	–	2	49	110	173

Technical institutions

Technical institutions which could play an important role are described below.

The Department of Agricultural Engineering of the Sudan Gezira Board is engaged in R and D and in modification of agricultural machinery to suit crops grown in the Gezira province; works in close co-operation with the National Institute of Agricultural Engineering, United Kingdom; has developed

a tractor-mounted cotton-stalk puller, fertilizer and herbicide spreader and ground-nut washer; has modified a ground-nut digger and a combination of disc, rotavator and ridger; and organizes mechanization trials, tests equipment and provides technical advice and assistance.

The Agricultural Engineering Administration of the Ministry of Agriculture is the offical government body for testing imported tractors and machinery; is responsible for training and technical advice to all agricultural corporations and production units and for modernizing the traditional sector; and operates centres for training agricultural mechanics, tractor drivers and machine operators.

The Agricultural Engineering Department of the Faculty of Agriculture, University of Khartoum, arranges some field tests and limited mechanization trials. Agricultural students have the opportunity to major in agricultural machinery and mechanization. In co-operation with the faculty of engineering, it has offered a degree in agricultural engineering. The first graduates will complete the course in 1979/80.

The Mechanized Farming Corporation of the Ministry of Agriculture is responsible for development of mechanized rain-fed agricultural projects. Besides reclaiming land, developing infrastructure and advising farmers, it organizes trials and development of new practices to increase yields and reduce costs, and runs workshops available to farmers. It receives assistance from the World Bank and has negotiated a third loan for $17 million.

Problems and future needs

The problems facing the Sudan are those of most developing countries. The most important are shortages of engineers, operations, maintenance and repair facilities, repair mechanics, tractors, spare parts and facilities for developing special purpose machinery. Infrastructure is also generally poor. Many of the difficulties are caused by shortages of foreign exchange. The extended (18 year) development plan to 1994/95, gives top priority to the agricultural sector, which accounts for more than 90 per cent of foreign exchange earnings. The economic activities of other sectors, especially transport and industry, are critically linked with those of the agricultural sector.

Assuming an average of 70 hp per tractor, the level of mechanization today for the Sudan is 0.17 hp/ha, compared with 0.20 hp/ha for Asia and 0.27 hp/ha for Latin America. To fulfil the potential for high yields on a large scale, 0.5 hp/ha is generally required. Taking an intermediate figure, lower than for Asia and Latin America, the number of tractors required for mechanizing the present area of 12 million acres is about 24,000 to 30,000 tractors of 65–67 hp. In addition, new areas are planned for cultivation. By 1983, the total should be about 8.8 million hectares. It is expected that the Arab Funds will allocate more than $2 million for the next 25 years for agricultural development in the Sudan. The last market survey towards the end of 1976 showed:

	Annual requirements 1982–1983	*Total in use 1983*
Tractors, 70–77 hp	4 000	25 000
Combine harvesters, 14–16 ft, self-propelled	700	4 200
Chisel ploughs, mounted or trailed, 10 tyres, 2.44 m or more	200	2 200
Wide level disc + seeder + drawn, 15 ft 18 in. discs	1 600	11 500
Toolbar with ridger, 2–2.44 m, 4–6 bottoms of 22 in. mounted	1 000	7 000
Planters, 4–6 rows, and fertilizer attachment	200	800
Heavy disc plough, 4–5 discs	200	1 800
Seed drill 3 m wide, mounted, and fertilizer box	50	260
Offset disc harrow, 9 ft, trailed	40	300

$90 million manufacturing project

The six-year long-term plan up to 1995 provides for the establishment of industries manufacturing inputs such as agricultural machinery, fertilizers and insecticides under a joint committee from all relevant ministries. A mission from the World Bank/UNIDO Co-operative Programme helped in evaluation and negotiations. A tractor and machinery project is to be established, with the Massey Ferguson Company (MF) holding 25 per cent of the shares, the Sudanese Development Corporation holding 24 per cent and the Government of Sudan 51 per cent in a complex including manufacturing and assembly facilities, a training centre etc., at a cost of nearly $90 million. Maximum production operating on one shift for 250 working days per year will be reached in four years.

The planned annual output for the project is:

Tractor MF285, 25–40 per cent local content	3 000/4 000
Self-propelled combine harvester MF520B, bagger type, 14–16 ft, 110 hp diesel engine, 15–20 per cent local content	400
Disc harrow with seed + fertilizer, MF360, 15 ft, trailed, disc 18 in	1 400
Toolbar carrier MF80, 2.44 m, with 4–6 ridger bodies, 22 in, mounted	1 200
Heavy-duty disc plough MF90	300
Cotton/ground-nut planter, fertilizar attachment, MF37, 2.44 ft, 4–6 rows	200
Chisel plough MF129, trailed	350

Local content for implements will be from 50 to 80 per cent.

Linkages

The probable location of the project in the Gezira province would give closer contact with important agricultural institutions such as the Gezira University at Wad Medani, the Sudan Agricultural Research Corporation at Wad Medani, the Sudan Gezira Board and its Agricultural Engineering Research Unit at Barakat, the Rahad Project, in the Gezira province, and the Agriculture Machinery Training Centre (project of the Food and Agriculture Organization of the United Nations (FAO), at Wad Medani and other secondary technical schools. The Khartoum Centre Foundry (KCF) is to be strengthened and will supply castings. Further links are expected with battery and paint manufacturers. Assembly and part manufacture of diesel engines may also be undertaken.

Transfer of technology and development of engineering skills is considered vital for the future of heavy industry in the country and the project is the first step in this direction. As it develops, ancillary industries must come into existence to supply some requirements. Subcontracting for metal manufactured parts and simple machinery will help develop local workshops and small foundries.

Economic effects anticipated at full capacity production are as follows:

(a) Foreign exchange saving of $7.4 million per year;

(b) Internal return of 28 per cent and probably 38 per cent when two-shift operation is introduced;

(c) Employment for more than 500 people, rising potentially to 800 on two shifts;

(d) Incidental benefits for existing industries: workshops, machine shops and foundries.

The yearly production of the complex in its first stage operating on a one-shift basis will be three times the Sudan's present annual imports. Good workshops and repair and spares centres will be needed together with skilled engineers and mechanics. This would apply equally to the distributor, at present a state corporation. If not enough efficient distributors are available, the company would consider establishing its own distribution and servicing organization. It is estimated that establishment of the complex will take two years from the date of securing all finances.

Training and research

Demands for agricultural engineers, skilled mechanics and machine operators will automatically increase considerably, and the Government is taking measures to alleviate the shortage. The Tozi Training Centre in the Blue Nile province (AID project 1973) for tractor drivers and machine operators has already expanded to take 120 drivers per year, and will be further expanded to take 240. The Wad Medani Agricultural Machinery Centre for training mechanics will also be expanded. Two new training centres for tractor drivers, operators and mechanics will be established and others are planned.

The Government is negotiating with French authorities to establish a modern agricultural engineering centre. Negotiations are in progress with FAO to establish a mobile station for machine evaluation, testing and training. A joint UNIDO/Industrial Development Centre for Arab States (IDCAS) mission on the establishment of a Regional Pilot Project for Development of Agricultural Machinery and Implements to suit the particular conditions of the Arab countries was undertaken in 1976 and gave a comprehensive account of the situation of agricultural mechanization in the Sudan. It recommended that a regional organization be set up in the Sudan, alongside the future tractor and machinery complex to help develop engineering designs, capabilities and technical manpower.

Credit for farmers

Agricultural corporations and co-operatives buy on credit extended to them by local banks and the central co-operatives association at low interest rates. The Government has approved the establishment of the first co-operative bank to advance loans to the co-operatives also at low interest. The Agricultural Bank of Sudan, the main importer of tractors and machinery, extends loans to farmers to purchase equipment, fertilizers, spares, jute bags and other inputs. The new plan is for the Bank to assume its conventional role after the joint venture company starts production. In the six-year plan the farmer will be able to borrow from the Bank on easier terms than before. The farmer gets the tractor and equipment on a hire-purchase basis without putting up collateral and at an interest rate of 6 per cent a year rather than the 9 per cent which was the going rate.

Sudanese-Egyptian co-operation

The Sudan has always recognized the importance of regional co-operation between African countries. Because of this and the need of both countries for one another, the Sudan and Egypt have entered into an economic and technical programme to serve their mutual agricultural and industrial interests. The Sudan will receive technical and managerial know-how and Egypt will obtain food from Sudanese resources. Integration will increase markets for different products; develop industrial and agricultural projects; and create new economic activity and advanced industries.

The first step was to make available as much information as possible in agriculture and industry. The collection of data overlapped with an intensive exchange of visits by experts. After this came the formation of joint technical and economic committees covering all specialized activities in agriculture and industry. The committees held meetings in both countries to evaluate existing projects and made feasibility studies. First proposals to help the Sudan were based on Egyptian experience and technical knowledge giving priority to agro-industries, such as sugar, food, textiles and hides. Joint agricultural projects for production of oil-seeds and animal food have been proposed, to be based in the Sudan. Several projects are now under execution, and joint venture companies in mining and agricultural activities have been formed.

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The experience of the United Republic of Tanzania

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The United Republic of Tanzania encourages small industries in urban and rural areas. In 1973 the ruling party, the Tanzania African National Union (TANU), stressed in a directive the need for a technological revolution in rural areas to be based on control of enterprises by the people and the application of available raw materials and indigenous skills. The Small Industries Development Organization (SIDO) was given the task of formulating and implementing the small-scale industries development policy.

PRESENT POLICIES

In 1972 the National Executive Committee of TANU adopted a policy paper highlighting the need to revolutionize agricultural operations. Top priority was accorded to raising productivity, crop diversification, fertilizers and improved tools. To increase the total volume of locally manufactured farm tools and implements and thus reduce dependence on imports, the Government decided to expand the Ubungo Implement Company while at the same time opening up a new farm implement factory in Mbeya, in the south of the United Republic of Tanzania.

Changes to remove obstacles to speedy progress included the restructuring of national education to emphasize technical education and to increase training facilities relevant to small-scale industrialization. In addition non-governmental agencies such as missionaries, the Parents Association and the Young Men's Christian Association (YMCA) are being encouraged to establish technical training facilities for post-primary leavers. Most of them offer training in basic skills such as woodwork, sheet-metal work, iron work, welding, mechanics, masonry and electrical engineering.

Present manufacturing status

Mass production. Until the Ubungo Farm Implements (UFI) factory was founded in 1969, all hand tools and ox-drawn implements for farms were

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imported. Mass production of all these has been the factory's sole responsibility. UFI also imports and, when necessary, distributes farm tools and ox-drawn implements in the country. UFI production figures are given in table 1.

TABLE 1. UFI PRODUCTION FOR THE YEARS 1973–1977
(Number of units)

Item	*1973*	*1974*	*1975*	*1976*	*1977*
Hand hoes	232 234	327 956	357 685	344 000	440 317
Grass slashers	16 422	4 066	18 634	41 532	39 682
Ground-nut shellers	61	65	–	84	3
Mould-board ploughs	8 034	5 793	3 813	10 047	3 836

Medium-scale production. Medium-scale production is carried out by the Tanzania Agricultural Machinery Testing Unit (TAMTU) and its six rural craft workshops in various parts of the country. The range includes ox-carts, ploughs (single and double furrows), hand-operated maize shellers, pyrethrum dryers and animal-drawn planters. TAMTU production figures are given in table 2.

TABLE 2. TAMTU PRODUCTION FOR THE YEARS 1972–1976
(Number of units)

Equipment	*1972*	*1973*	*1974*	*1975*	*1976*
Two-furrow mould-board plough	34	40	55	60	80
Ox-drawn carts	250	320	360	550	1 000
Animal-drawn planters	21	25	31	36	40
Inter-run cultivator	–	–	10	25	40
Ridger	–	–	–	10	20
Harrow	8	8	5	7	10

Small-scale production. Village and cottage industries produce essentially for a village or a number of villages (ward), with emphasis on hand tools, equipment and spare parts and with a view to achieving self-reliance as soon as possible. The common tools include axes, knives, machetes and hoes. Other products include ox-drawn ploughshares and watering cans.

Product specification

High-quality materials, whether wood or metal, are used to achieve maximum strength and minimum weight. However, village and cottage craft workers and blacksmiths sometimes have to use local materials and in fact are encouraged to do so.

Efforts are made to standardize spare parts, particularly with thread, bolt sizes, ploughshares, mould-boards, cultivators, tines, plough handles etc. Most

plough parts on the single-furrow mould-board plough manufactured at UFI can be fitted to the two-furrow mould-board plough being made at TAMTU. Table 3 contains projections of anticipated demand.

TABLE 3. PROJECTIONS OF ANTICIPATED DEMAND UP TO 1986

Product	*1979*	*1982*	*1986*
		Millions of units	
Hand hoes	2.2	2.2	2.2
Pangas	1.35	1.47	1.65
Axes	1.016	1.115	1.249
Pickaxes	23.00	24.00	25.80
Sickles	95.00	102.00	110.60
		Thousands of units	
Shovels	60	65	70
Slashers	90	92	95
Hand sprayers	18	25	36
Mould-board ploughs	21	27	41

Source: UFI, Dar es Salaam.

Demand for ox-drawn implements may rise as the result of a national campaign, but it is difficult to estimate now.

Concept of interlinkage

Expanding UFI, opening the new factory in Mbeya and assisting the village cottage industries and rural craft workshops are measures towards reducing dependence on outside sources for farm tools and implements. Currently UFI plans to decentralize production and the SIDO UTUNDU[1] programme is at the take-off point. The objectives are to raise rural standards of living, encompassing the dual objectives of economic growth and improved income distribution between both regions and rural and urban areas; to increase the self-reliance of villages; and to reduce unemployment.

The plan will also promote the objectives that SIDO outlined for the country's third five-year development plan, namely:

(a) To utilize local resources and skills;

(b) To raise technology in rural areas by upgrading existing skills, and introducing new skills;

(c) To undertake production for import substitution;

(d) To provide employment opportunities, especially for rural craftsmen;

(e) To encourage the decentralization of industries and ensure balanced development of regions;

(f) To reduce disparities in income and welfare;

[1]A Swahili word which, freely translated, means invention in the face of opposition.

(g) To organize ancillary production for large units so as to reduce overall costs of production.

Workshops have been selected for incorporation in a network of decentralized production units. Support activities will include:

(a) Design improvements of implements and tools;

(b) Supply of prototypes;

(c) Supply of equipment parts that can be more efficiently produced on a large scale;

(d) Training craftsmen in new production methods and use of new equipment;

(e) Market assistance.

It is intended that in the long run these units will supply most of the country's requirements.

Supporting rural development

Basically some ox-drawn equipment and carts will be produced in the rural craft workshops with assistance from SIDO through its UTUNDU scheme, UFI through its decentralized production operation banks (National Bank of Commerce and Tanzania Rural Development Bank) for credit, the Uyole Agricultural Research Centre, and TAMTU for research and development (R and D). The UTUNDU workshops will complement production and provide improved technology equipment to village blacksmiths who are producing hand tools. A projected R and D input at Uyole Agricultural Research Centre and TAMTU would be able to help supply technical drawings and training facilities.

The National Bank of Commerce and the Tanzanian Rural Development Bank would provide working and fixed capital loans. Most of the initial capital will be provided by SIDO.

Co-operation among developing countries

Areas of priority for co-operation among developing countries should include:

(a) Technology sharing, particularly where the use of appropriate tools is vital. A common diagonal interlinkage will ensure that each benefits;

(b) Marketing. Trade arrangements to protect locally manufactured equipment should be initiated and practised.

Conclusions

Industrialization of the rural areas is being hindered by the lack of appropriate technical know-how, and of basic infrastructure; roads are often unreliable or absent, water is sometimes scarce or unsuitable, electicity is

expensive to introduce, managerial skills are lacking and supplies are irregular. It is therefore not easy to move into most villages other than with craft workshops and handicrafts. A "site and service" approach in which growth points are selected and provided with infrastructure for industrialization may be the best way to achieve rural industrialization and full employment and prevent migration of youth to urban centres. This is an area for the international community such as the Commonwealth, United Nations Development Programme and bilateral aid donors to explore, as it can be a heavy strain on national budgets.

Appropriate technology application in the agricultural machinery and implements industry in Yugoslavia

*B. Grgić**

This paper briefly surveys the swift and dynamic industrial development in Yugolavia based on agricultural progress and appropriate technologies in the machine-building industry.

Programme development and the business orientation of the agricultural machinery and equipment industry in Yugoslavia is based on the principles of socialist self-management of society and on the conditions of economic activity.

Up to the Second World War, the Yugoslav agricultural machinery and equipment industry could be said to have developed at the level of artisan workshops and industrial units dispersed in large and small towns and in larger villages with a high concentration of agricultural activities.

Administrative guidance was provided by the Government during the period of development when agriculture bore the greatest burden in the renewal and construction of the country, although the agricultural machinery industry did not receive full attention. After a time, however, progress was made in the organization of existing plant capacities and the construction of new ones. Newly constructed plants produced agricultural machinery on the basis of the existing industrial technologies available in Yugoslavia.

With the commencement of planned development and the organization of particular economic branches, the modern agricultural machinery and equipment industry was established on the basis of licence and technology purchases. Production of farm machinery and equipment was indispensable for the organization of modern agricultural production.

In the early days after the war, agriculture had the lowest rate of growth. The result was that, after having been an exporter of agricultural products, Yugoslavia became a large importer of food. However, with economic reform and acceptance of market economy principles, more attention was given to the agricultural sector. It was at first necessary to import modern agricultural technology and materials, since the economic branches responsible for providing technical equipment and raw materials for agricultural production were not immediately in a position to satisfy the new demand.

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Under the Government's "Green Plan" domestic manufacturers had to reconstruct existing factories and develop modern productive capacities for the manufacture of equipment required for large-scale modern agricultural production. As a result of the changes, artisan production units and tractor service stations are being used both to repair imported machinery and to train operators in mechanization. Five-year plans have been introduced to promote the development of the agricultural machinery industry, with the nucleus of large-scale industrial production located in the vicinity of bigger towns, and medium and small industries dispersed throughout the country.

Clear and consistent national rural development policies have had a decisive influence on the speed and size of the mechanization development process. Progress is made in general without changes in attitudes towards agriculture, villages or individual producers, who own approximately 80 per cent of all cultivated land. Their work is done alone or in co-operation with producer organizations in the socialized sector.

Existing attitudes concerning farm policy and the possible effects of internal demand should be understood. Domestic machine building using installed capacities will not and cannot be stopped, nor could all imports be substituted from domestic production. Accordingly, the Yugoslav agricultural machinery and equipment industry should be oriented to the international division of labour, efforts must be made to capture markets abroad, and foreign competition should have optimal access to the national market.

In view of the problems faced by big cities in the provision of housing and other facilities, the future development of manufacturing capacities for certain products will be predominantly achieved in the country.

The pace of mechanization has been reflected in the increase in the area under cultivation and the total yields of grain.

Much attention is devoted to the production of spare parts for maintenance and repair. Reconditioning of engines and tractors has been introduced, and the dynamic development of Yugoslav agriculture has been reflected in domestic industries. During the past 10 years the number of manufacturers of implements and equipment has trebled, and in some Republics, e.g. Slovenia, has even increased fivefold.

Since 1968 tractor production has approximately quadrupled from 10,929 to 43,360. The introduction of new technology has led to a marked increase in the past two years. The same applies to walking tractors introduced in 1970. Production by the three manufacturers has risen from 393 to 23,000.

Within the framework of heavy machinery manufacture, seven tractor manufacturers produce for domestic requirements and export 27 different models of wheel tractor and caterpillar in the range of 18–220 hp (14–165 kW). Five others produce 16 models of cultivators, rotavators, grass-mowers and single axle tractors in the range of 2.8–15 hp (2–11 kW). In addition they produce harvesting combines for wheat, with implements for maize, rice and other cereals. The cereal capacity for five models ranges from 4 to 9 kg/s, and engine capacity from 65 to 165 hp (49–124 kw).

More than 50 manufacturers of implements and machinery have directed their efforts to meeting requests for modern agro-techniques by large social estates and small individual farms, and are also able to supply the world market.

They make more than 60 different types of machines and machinery for mechanization of plant production.

Basic groups of machines produced include the following:

(a) Attachments for soil treatment; mounted, semi-mounted and draw-bar mould and board disc ploughs and rotavators (five producers);

(b) Mounted and draw-bar machines for fertilizer spreading, capacity 3–8 t (seven producers);

(c) Seeders, mounted and draw-bar, for wheat, maize, sugar-beet and corn cereals, working width up to 12 rows, and planters, working width two, four and six rows (four producers);

(d) Inter-row cultivators, working width 2–12 rows, with arrangements for fertilizing and crop protection (four producers);

(e) Stationary, mobile and self-moving equipment for water spraying (four producers);

(f) Plant protection machines: mobile, mounted and draw-bar sprayers, atomizers and dusters with engine or tractor drive (three producers);

(g) Aircraft carrying 1–2 t of freight (one producer);

(h) Equipment for cattle-food preparation using all types of light and medium tractors: side and rear mower and hay machines; self-loading trailer, volume up to 30 m^3; silo-combines and draw-bar (five producers);

(i) One-row and two-row draw-bar maize pickers with and without cutter for chopping staples (two producers);

(j) Multi-row disc-lifter, as complete six-row draw-bar line of machines for sugar-beet harvest, defoliator, lifter, loader and mobile combine for sugar-beet (three producers);

(k) Choppers of agricultural waste, working width 2–4 m (two producers);

(l) Single- and double-axle standard and tipping trailers, side and rear unloading, capacities 3–15 t (11 producers);

(m) Dryers with direct and indirect air heating (three producers).

(n) Dehydrators and dryers for clovers and grass (two producers);

(o) Separators, dehydrators and other equipment for waste water (one producer);

(p) Cleaning and selecting equipment (three producers);

(q) Animal draw-bar ploughs, spike-tooth harrow, seeders, multi-row cultivators, rakes, trailers etc. (seven producers);

(r) Complete plants for silo and manipulation equipment in storehouses (four producers);

(s) Installation and equipment in stables for growing cattle, pigs, sheep and fowl (four producers);

(t) Milking equipment, refrigerators (two producers);

(u) Factories and smaller plants for cattle fodder (three producers).

It is estimated that the value of tractor, implements, machines and equipment produced for the mechanization of work processes in agricultural production in the year 1977 was approximately $468 million, which makes the

industry second to the automobile industry in terms of installed productive capacity, with a level of development comparable to that of the industrially developed countries. The implementation of further development plans should make it possible to achieve by 1980 the level of countries with the most intensive agriculture in the world, as reflected in the table.

TRACTOR PRODUCTION ESTIMATES, 1980–1985

Year	*45 hp (34 kW)*	*46–90 hp (35–67 kW)*	*91–160 hp (68–120 kW)*	*161–250 hp (121–188 kW)*	*250 hp (188 kW)*	*Total*
1980	48 000	13 500	1 500	300	–	63 300
1983	54 000	12 000	3 500	490	10	70 000
1985	60 300	10 000	4 000	600	100	75 000

The Government of Yugoslavia, through its Chamber of Economy, encourages and emphasizes co-operation among developing countries in the area of agricultural development, machine building, chemicals etc. within the programme "Struggle for Food". Easier co-operation among developing countries raises the question of standardization of machine production.

The following recommendations are designed to assist the mechanization process:

(a) Establishment of centres for applied agricultural mechanization technology;

(b) International co-operation, possibly with UNIDO, to set up a centre for standardization of machines and equipment;

(c) Establishment of centres for instructors to train end-users in modern technical methods;

(d) Expert exchanges through UNIDO for the organization of industrial production and the development of machinery;

(e) Preparation of feasibility studies;

(f) Exchange of industrial information through UNIDO;

(g) Inclusion in rural youth education of courses based on modern agricultural production;

(h) Spezialized courses for technical personnel on the development of designs and agricultural techniques adapted to regional requirements.

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Annex I

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Annex II

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