This publication was financially supported by the Minister of Development Cooperation.

Development of the agricultural machinery industry in developing countries

Proceedings of the 2nd International Conference

Amsterdam 23-26 January 1984

A. Moens and A.H.J. Siepman (compilers)

Pudoc Wageningen 1984

CIP

ISBN 90 220 0864 9

Printed in the Netherlands

THE CONFERENCE WAS ORGANIZED BY:

- The Federation "Het Landbouwwerktuig", the National Federation of the Dutch Farm Machinery Industry
- RAI Gebouw B.V.

in cooperation with:

- The Agricultural University, Wageningen
- The Institute of Agricultural Engineering, Wageningen
- The Ministry of Agriculture and Fisheries, The Hague
- The Ministry of Economic Affairs, The Hague
- The Minister of Development Cooperation

Further cooperation is received from:

- The Food and Agriculture Organization of the United Nations, Rome
- The United Nations Industrial Development Organization, Vienna

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LA CONFÉRENCE ÉTAIT ORGANISÉE PAR:

- La Fédération "Het Landbouwwerktuig" Association néerlandaise de Constructeurs de Machines Agricoles
- RAI Gebouw B.V.

en collaboration avec:

l'Université agronomique de Wageningen

- l'Institut pour la Mécanisation, le Travail en Agriculture et la Construction Rurale de Wageningen
- le Ministère néerlandais de l'Agriculture et de la Pêche de La Haye
- le Ministère néerlandais des Affaires Economiques de La Haye
- le Ministre néerlandais de la Coopération au Développement

et avec la coopération de:

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Preface

The Second International Conference on Agricultural Mechanization in Developing Countries was held at the RAI Congress Centre in Amsterdam, the Netherlands, 23-26 January 1984.

The Conference was held in association with the 13th International Fair on Agricultural Machinery.

Specific themes of the Conference were:

- the actual status and the future development of agricultural mechanization;
- the actual status and the future development of the agricultural machinery industry.

These proceedings of the Conference include the final recommendations and conclusions, general reports, papers of the keynote speakers, country reports, some reports on miscellaneous subjects and a list of participants.

Some 167 experts from 49 countries, mainly from Latin America, Africa and Asia, took past in the Conference.

I trust that the large amount of up-to-date information from countries world wide and the conclusions drawn during the Conference will provide the readers with that information that they need for business, education, research or any other activity.

Adrian Moens,
Chairman of the Scientific Committee

Avant-propos

La deuxième Conférence Internationale sur la Mécanisation de l'Agriculture dans les Pays en voie de Développement s'est tenue à Amsterdam du 23 au 26 Janvier 1984 dans le Centre des Congrès, R.A.I.

La Conférence a été organisée en collaboration avec la 13-è Foire Internationale des Machines Agricoles.

Les thèmes specifiques de la Conférence ont été:

- l'état actuel et le developpement futur de la mécanisation de l'agriculture.
- l'état actuel et le développement futur de l'industrie des machines agricoles.

Ce recueil des compte-rendus de la Conférence contient des récommandations finales et conclusions, des rapports génêreaux, des communications à sujets-clé, des rapports des pays, quelques communications à sujets divers et la liste des participants.

Un nombre d'environ 167 experts provenant en grand partie des pays de l'Amérique latine, de l'Afrique et de l'Asie, ont participé à la conférence.

Je suis convaincu que la grande quantité d'information à jour, provenant des pays du monde entier, ainsi que les conclusions tirées pendant la Conférence, fourniront aux lecteurs, les informations qui sont nécessaires pour leurs affairs, pour leurs instructions, pour leurs recherches ou d'autres activités.

Adriaan Moens
Président du Comité Scientifique.

Opening address

E.M. Schoo

Minister for Development Cooperation

LADIES AND GENTLEMEN,

Let me say, first of all, how pleased I am to be here, and to make a short address to this Conference on the Development of the Agricultural Machinery Industry in Developing Countries.

I see that this Conference brings people from various disciplines together, from the world of science, the producers of food, people from government agencies of developing countries and international/donor organizations as the Worldbank, FAO and UNDRO. This will make it possible to look at the issue from various points of view. I hope that the Conference will produce new ideas and recommendations which will be useful in the formulation and implementation of policies of governments, companies and international organizations alike.

What to think about the development of the agricultural machinery industry in developing countries. That is the question this conference is going to discuss. I think this is a very important question, but a very controversial one at the same time. It is an important question because it affects the lives of millions of people in the world. The fight against hunger is one of the very first priorities of the Netherlands development cooperation. More than a third of what we do is in one way or the other aiming at the eradication of hunger or the improvement of the agricultural production in developing countries. That is necessary, because more than 400 million people in the world still suffer daily from hunger. Another 400 million are suffering from malnutrition. If we don't take effective action in this field, the situation will be hopeless. It is not just a matter of food production, distribution and stabilizing of market conditions. Sometimes we see population growth rates equal, or even exceed, economic growth rates. The result, however, is the same: misery, poverty and starvation.

It is as I said not only an important but also a controversial question. The problem is that hunger and malnutrition are concentrated in rural areas where also the large majority of the working population lives. Some people say that introduction of machinery might raise the food production but will create mass unemployment at the same time. This will translate itself into the horrible problem of slums in the large cities. In most developing countries there is a shortage in capital but an abundant labour force. So there is no real need, according to those people, for capital-intensive machinery to replace man-power.

I certainly have sympathy for the point of view that we should be careful in introducing labour-extensive equipment for food production in developing countries. On the other hand I think that we should be honest and realistic. I am sure that it will not be possible to feed the billions of people inhabiting the earth in the next century if we stick to traditional small-scale food production and a conservative approach to the introduction of modern technology. Rationalization of agricultural production is inevitable, in developing countries as well.

The situation in various developing countries differs widely. In some cases perhaps a conservative approach with labour-intensive technologies might still be appropriate. In other cases there might be room for a forward looking approach by introducing more advanced, intermediate-scale and labour-extensive technologies, which will raise food production and create the basis for income generation and job creation in the other fields as well.

We know there is too little 'trickle down' to justify an exclusive attention for the more advanced technologies and large-scale infrastructures for development. That is true, but it is equally true that an exclusive attention for development from below will not bring the solution to the enormous problems of food and development in the coming years. Traditional and small-scale labour-intensive technologies just by itself will not be able to improve the food-productive capacity of developing countries. A more rational approach is needed.

A conservative approach to the question of the introduction of agricultural machinery in developing countries will inhibit the very progress which is vital for development. It runs the risk of condemning the people in developing countries to permanent backwardness and dependence on outside aid. We should avoid that, and gear our policies at improving the possibilities for real progress in developing countries by introducing more advanced technologies for agricultural production. Creative solutions will have to be found in developing technologies suited to the resources of the poor, taking care of the urgent need for food production and the equally important need for income generation for as many people as possible. Otherwise a durable improvement in the food situation is not possible.

I know of interesting initiatives in this country of the agricultural machinery together with project people in developing countries and people in science in order to develop efficient but still small-scale equipement in developing countries.

We should not make a dogmatic choise, but a pragmatic one, and adopt flexible policies suited to different situations in different countries. Where possible and feasible, modern technologies and rational means of agricultural production should be introduced. The question of what to think of the development of the agricultural machinery industry is not a question of yes or no. It is a question of how. And the answer to that question is the answer, I hope, this Conference is going to concentrate upon.

Why is the answer important? Because strengthening of the food production capacity, distribution and pricing policies in developing countries themselves, is not only vital for the solution of the world food problem, but equally vital for the solution of the problems of development at large. This may be one of the most important lessons of the last ten years. Strengthening of the position of developing countries in the world economy by improving their own productive capacity in food as well as other sectors, is the best contribution to a durable alleviation of poverty and malnutrition. This formula of development from within, is in my view the new way to solve the problems of food security in the years to come. Strong international support and effective development cooperation policies remain, however, necessary for the time being. Provided of course that aid policies work in the same direction and aim at creating a sustainable improvement of the productive capacity of developing countries and of the situation of the poor and the hungry.

We have to target our aid to meet the every day needs of the poorest groups, the landless labourers, sharecroppers, tenant farmers and urban jobless, who make up the bottom 40 % of the Third World population. This will mean aid for water supplies, sanitation, credit for small farmers, nutrition improvement, basic education, primary health care, and, most important of all, income generating activities.

Special attention should be given to the position of women and the role of women in food production. Women should have equal access to facilities. There should be no reason why women should loose their income when modern technologies are introduced.

All this will, no doubt, have implications for the availability of funds for local and recurrent costs. Such an integrated rural development helps solving the problem of development by solving the problem of hunger and malnutrition first.

The focus on the alleviation of poverty should be maintained at the design as well as the implementation phase of the policy. This should be sharpened and reinforced by strong support for institutional improvements in developing countries and modern technology development.

And here I am back at the issue of this Conference.

Ladies and gentlemen,

That is what I wanted to say to you about this issue. I extend a sincere welcome to you all, wish you all the success you need, and have pleasure in declaring this Conference open.

Recommendations and conclusions

1. Developing countries should take immediate steps to formulate national agricultural mechanization strategies, including strategies for the implementation of necessary mechanization inputs and strategies for the required development of agricultural industries to provide these inputs. This action must be taken in the framework established by national development objectives and policies, and must be aimed at optimizing the effective and efficient delivery and support of mechanization inputs to the farmer.

2. Procedures should be established within developing countries and within the international community to ensure understanding of agricultural mechanization objectives in the developing countries, and to effect an integrated approach for achievement of common goals, taking into consideration the natural, economic and social conditions including the employment situation in the country.

3. Aid donor governments and international organizations should ensure that their assistance programmes reflect the long-term nature of mechanization as a development input. Particular attention should be given to the long-term requirements for developing institutional support arrangements and for establishment of the infrastructure for efficient operation, maintenance and repair of mechanization inputs, in order to make the most effective use of these capital sources.

4. To ensure effective and efficient support to farmers and industry, agricultural mechanization research, development and extension programmes should be designed and executed in a problem-solving context, with an objective and realistic definition of problems as they exist at the farm level, including the marketing and credit aspects.

5. Attention must be given to the complexity of farming systems and to decisions that must be made on the merit of flexing receiving systems to accommodate existing mechanization inputs or flexing the mechanization inputs to accommodate existing receiving systems. Mechanization research must be viewed as a combined responsibility, incorporating the resources of industry, public institutions and farmer users.

6. Immediate steps should be taken by developing countries, in collaboration with the international community, to develop innovative multidisciplinary approaches for the design and execution of manpower-training programmes required to ensure efficient and effective mechanization development, selection and use. It should be recognized that the present classical

manpower-training schemes are inadequate to meet either the quantitative or qualitative requirements of the future.

7. To encourage a free flow of expertise and resource capability in agricultural mechanization between the developing countries and the industrialized countries, actions should be taken to ensure adherence to international agreements in respect of patent rights. Furthermore fiscal policies of developing countries should reflect the business necessity of suitable measures to encourage the flow of capital, goods and raw materials in respect of joint ventures, licensing, subcontracting and other arrangements of local industries with industries from abroad to ensure reciprocal benefits.

8. Increased attention should be given to the early involvement of domestic and foreign farm-machinery industries in formulation and execution of agricultural development programmes. Without excluding large-scale manufacturers, particular emphasis should be placed on the utilization of the potential contribution of small and medium-size machinery manufacturers both from developing countries as well as from developed countries, whose experience, expertise and flexibility of action have so far not been fully utilized and exploited.

9. Small and medium-scale farm-machinery manufacturers from developing and developed countries should structure themselves to effect a long-term and group approach to participation in developing country markets for farm machinery. This would include a consolidated effort to inform the decision makers in the government on expertise and services that they offer.

10. All members of the international community should improve their procedures to record and validate the positive and negative results of mechanization in the wide range of development situations around the world. Focal points for the collection and distribution of this information should be established in each developing country. Concurrently, actions should be taken to establish and to support an international centre for the collection, storage and retrieval on request of such information on mechanization for world-wide use in formulating and executing agricultural development programmes.

11. To ensure the most efficient and most effective agricultural mechanization in the development process, governments of developing countries should objectively assess the respective roles that can best be played by public and private organizations for the introduction and support of mechanization.

Recommandations et conclusions

1. Des mésures immédiates doivent être prises par les pays en voie de développement pour formuler les stratégies nationales de la mécanisations de l'agriculture. Elles doivent inclures les stratégies d'utilisation des imputs nécessaires à la mécanisation, ainsi que les stratégies pour le développement exigé des industries agricoles pour fournir ces imputs. Cette action doit être réalisée dans le cadre établi par les objectifs et la politique nationale de développement et doit être dirigée vers une efficace et effective distribution des imputs de mécanisation vers les fermiers.

2. Des procedures pour assurer la compréhension des objectifs de la méchanisation de l'agriculture, ainsi que la réalisation d'une approche intégrée pour l'accomplissement des buts communs, doivent être établies à l'intérieur des pays en voie de développement, aussi bien qu'à l'intérieur des communautés internationales. Elles doivent tenir compte des conditions naturelles, économiques et sociales y compris la situation de l'emploi dans le pays.

3. Les gouvernements et les organisations internationales qui donnent des aides, doivent s'assurer que leurs programmes d'assistence reflètent la nature de long-terme de la mécanisation comme un développement imput. Une attention toute particulière doit être donnée aux exigeances de long-terme pour les arrangements d'appui pour développement institutionel et pour l'établissement de l'infrastructure pour operation efficace, maintenance et remboursement des imputs de mécanisation dans le but de réaliser l'utilisation la plus effective de ces sources de capital.

4. Pour assurer un appui efficace et effectif aux fermiers et à l'industrie, les recherches concernant la mécanisation de l'agriculture ainsi que les programmes de développement et d'extension, doivent être projetés et exécutés dans le contexte 'problèmes à ressoudre'. Elles doivent être accompagnés d'une caractérisation objective et réaliste des problèmes tels qu'ils existent au niveau de fermes, les aspects du marché et des crédits, inclus.

5. On doit faire attention à la complexité des systèmes agricoles et aux décisions qui doivent être prises en faveur de systèmes récepteurs flexibles pour accomoder les imputs existents dans le domaine de la mécanisation ou flexibiliser les imputs dans le domaine de la mécanisation pour accomoder les systèmes récepteurs existents. La recherche au terrain de la mécanisation, doit être regardée comme une responsabilité combinée incorporant des devoirs envers les ressources de l'industrie, les institutions

publiques et les fermiers usagers.

6. Des démarches immédiates, pour développer des approches innovatrices multi-disciplinaires pour le dessein et l'exécution des training programmes d'encadrements, doivent être faites pour assurer un développement, une sélection et une utilisation efficace et effective de la mécanisation. Il faut reconnaître que les présents schémas du training classique d'encadrements ne convienent pas aux exigeances quantitatives et qualitatives de l'avenir.

7. Pour encourager le flux libre d'expertise et la faculté de développement des ressources dans la mécanisation de l'agriculture entre les pays en voie de développement et les pays industrialisés, des actions doivent être envisagées pour assurer l'adhesion aux agréments internationaux en relation avec les droits des brevets. De plus, la politique fiscale des pays en voie de développement doit refleter les nécessités des affaires, par des mésures appropriées à l'encouragement du flux du capital, des marchandises et des matières premières en relation avec sous-contracts et autres arrangements de l'industrie locale avec l'industrie étrangère pour assurer un benefice reciproque.

8. Une attention croissante doit être donnée à l'embarras dé debut de l'industrie des machines fermière locale et étrangère dans l'établissement des programmes de développements agricoles. Sans exclure les manufactures de large échelle, un accent particulier doit être donné à l'utilisation du potentiel des manufactures de machines agricoles petites et moyennes, tant de pays en voie de développements que des pays développés. C'est parce que leur expérience, leur habileté et leur flexibilité d'action est loin d'être utilisé et exploité.

9. Les industries manufacturieres des machines agricoles d'échelle petite et moyenne des pays en voie de développement aussi bien que des pays développés, doivent s'organiser elles-mêmes pour effectuer des approches de longterme et en groupe, pour la participation au marché de machines agricoles dans les pays en voie de développement. Ceci suppose un effort renforcé pour informer les auteurs des décisions des gouvernements sur les services qu'elles peuvent offrir.

10. Tous les membres d'une communauté internationale doivent améliorer leur procedure pour enregistrer et valider les résultats positifs et negatifs de la mécanisation dans de larges schémas des situations de développement dans le monde. Des points focaux pour la collection et la distribution de cette information doivent être etablis dans chaque pays en voie de développement. Simultanément, des actions destinées à la fondation et à l'assistence d'un centre international pour la collection et le magasinage des informations concernant la mécanisation dans le monde entier, utilisables dans la formulation et l'exécution des programmes de développements agricoles, doivent être stimulées.

11. Pour assurer la plus efficace et effective mécanisation agricole, les gouvernements des pays en voie de développement doivent évaluer objectivement les rôles des organisations publiques aussi bien que privées, dans l'introduction et la stimulation de la mécanisation.

Future role of farm mechanization in development

Graham Donaldson

World Bank, Washington, D.C.*

INTRODUCTION

The process of mechanization has been characteristic of agricultural development for over 2 000 years and will clearly remain an integral part of the development process in the future. The role of mechanization in improving agricultural productivity needs no emphasis. Mechanization contributes to agricultural growth by augmenting the power, expanding the processes and increasing the precision employed in farming operations. These changes, in turn, may facilitate secondary adjustments in production technology and farm operations. Mechanization is a continuing process, with the rate of change and the appropriate level of mechanization at any one time determined by location specific socio-economic factors.

CONTRIBUTIONS

The process of mechanization contributes to agricultural development in several ways, but primarily through enhancing the power, processes and precision of farm operations. It most often augments the power used in farming operations by substituting power sources; first, substituting draft animal power for human labor; and second, mechanical for draft animal power. Mechanization also frequently expands the processes that are used in farming operations by the introduction of new equipment, such as centrifugal and axial flow pumps to enable groundwater irrigation, and grain dryers for artificial drying. Mechanization can also increase the precision of farming operations by permitting more control, such as in the depth and placement of seed and fertilizers. At higher levels of mechanization most machinery provides varying mixes of power, process and precision augmenting elements to fit particular factor endowments and farming systems.

In addition, the process of mechanization acts as an enabling factor for other changes in technology. For example, fertilizer spreaders, pesti-

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* The views expressed in this paper are not necessarily those of the World Bank.

cides sprayers, and irrigation pumps all permit the effective use of new production inputs. Similarly, mechanization enables farmers to increase control over their production, especially by improving the timeliness of operations, such as seeding, and multiple cropping. All of these secondary changes tend to increase yields. However, mechanization leads to direct increases in yield only in exceptional circumstances. While direct yield increases are often anticipated, in practice such increases are seldom observed and yield declines are at least as common (Binswanger, 1978). Rather, mechanization makes its direct impact on the farming system and in economic terms by substituting for other inputs. Thus, higher levels of mechanization usually substitute for labor, or, where they are already in use, for draft animals.

But, mechanization also facilitates structural changes in agriculture. For instance, it may augment the land available by permitting land that is difficult to prepare, to be brought into production, or by permitting multiple cropping. In addition, it may permit idle land to be brought into production in situations where land is plentiful but its use constrained by limited means to cultivate it. In this way mechanization is, in all situations, the key facilitator of farm size growth. Whether by bringing uncultivated land into production or by transfers of land through sales or rental, the 'iron law of mechanization' is that the control of land accumulates to those with the power to cultivate it (Donaldson & McInerney, 1973).

DETERMINANTS

Mechanization is typically a sustained process of innovation induced by its private profitability. The profitability of mechanization is influenced greatly by economy-wide factor scarcities and other macro-economic variables such as a country's land and labor endowments, the non-agricultural demand for labor, and the conditions of demand and supply for farm products. The history of agricultural growth and of mechanization in the developed world (including the USA, Europe and Japan) illustrates this generalization (Binswanger, 1982).

Mechanization is most profitable and contributes most to growth where land is abundant, where labor is scarce relative to land, or where labor is being rapidly absorbed outside the farming sector. The abundant land situation is well illustrated by the North American situation in the 19th Century, but it may still apply in some situations in developing countries in South America and Africa. The labor scarce situation is also seen in some of these countries. And the rapid labor absorption situation can be seen in many countries or regions within countries where development is rapid, e.g. Japan, South Korea, Malaysia and the Indian Punjab. However, in the latter case a slower rate of mechanization and a larger inward migration might have solved the labor problem at a lower capital cost, and resulted in a wider sharing of benefits from the 'green revolution' (Blyn, 1983).

Within such situations as those described above larger farms tend to adopt new forms of mechanization considerably faster than small farms. This rule applies to technological innovations of all kinds, and is attributable to larger farmers having better access to information and being better able to accept the risks associated with technical change. However, in respect of mechanization two other factors apply. First, it is now well understood that the opportunity cost of capital relative to that of labor differs between different farm size groups. It is higher on small farms which typically have little capital or few assets for use as collateral, but abundant family labor. It is lower on larger farms which have better access to capital and have to depend on hired labor (Donaldson & McInerney, 1973).

Second, is that certain machine processes are subject to genuine economies of scale. It is technically more efficient to design a large rather than a small machine. Machines tend generally to be developed for larger farms even in countries where all farms are large relative to those in most developing countries. However, engineers can develop machines suitable for small farms and plots once the opportunities arise, as they did in Japan and parts of Europe. While technically less efficient in terms of cost and horsepower or unit capacity, such machines are still the least cost options for small farms and cause less pressure for land consolidation and farm size growth. Thus engineering limitations have become progressively less important than in the past.

High capital costs relative to labor retard mechanization in several ways. First, they reduce the profitability of all forms of farm investment. Second, they direct investment away from mechanical inputs towards other forms of investment. Third, they lead to a selective emphasis on power intensive activities, where the production constraints are greatest. Finally, they influence the design of machines towards simpler, less durable designs, with less convenience features.

Finally, while farm size plays an important role in determining optimal machine size, this is less important for operations where rental markets are fairly easy to establish. Evidence from South and South East Asia confirms this observation. Surveys show that most farmers own their animals, carts, plows and harrows, but harvesting and threshing equipment, tractors, and motor vehicles, are used on 5 to 7 times more farms than own them (Herdt, 1983).

PATTERNS

The process of mechanization is commonly perceived in terms of the shift from one power source to another, and indeed this is its most dramatic aspect. Historical and recent evidence supports the proposition that when new power sources become available they are used initially for power intensive operations. These are generally stationary functions, especially those associated with post-harvest activities, threshing and winnowing, crushing and milling, but also for water lifting or pumping. Emphasis on power shifts, and especially on tractorization thus tends to obscure the selectivity of the mechanization process in terms of the operations that are mechanized.

This process of substituting one power source for another has continued progressively since ancient times. Replacement of human labor by cattle is recorded for China over 3 000 years ago. Water power of milling, grinding and water lifting was widely used in China and Mesopotamia over 2 000 years ago. Wind power was harnessed in the Mediterranean region from a similar period. Oxen attached to a capstan with shafts were used to provide power for milling, crushing and pumping purposes in Mesopotamia and Egypt in pre-Roman times, and this spread throughout most of Asia and Europe.

In South Asia and many other regions, animals continue to drive Persian wheels, sugarcane crushers and oil crushers, but they are being progressively replaced by stationary engines. Mechanical threshers have spread widely in Asia, and their adoption has been rapid since efficient small-scale designs became available and where high yielding variety (HYV) technology raised yields and increased wages. In general, the mechanization of power intensive processes, including pumping, always precedes the mechanization of harvesting and tillage operations, and because increased power permits improvements in these processes, such mechanization can be profitable even where low wages prevail (Binswanger & Pingali, 1983).

Once a new mobile power source becomes available primary tillage is one of the first operations to be mechanized. The use of oxen and subsequently horses for tillage has followed the mechanization of stationary processes in all parts of the world. In developed countries, and progressively in developing countries, primary tillage is being done with tractors. But even where this occurs, secondary tillage operations often continue to be performed by the old power source for many years. For instance, horses remained side by side with tractors for as long as 10-25 years in countries such as Canada and the USA. Tractors were used for selected field operations and as a mobile source of 'pulley and belt' power but did not replace horses fully until their relative costs changed.

Generally, once the most power intensive operations are mechanized, the marginal cost of mechanizing additional activities is very low and these become mechanized quickly. In particular, where distances are relatively short, and haulage contracting not well developed, farm-to-market transport is one of the first uses of new mobile power sources (Donaldson & McInerney, 1975). This phenomenon was not characteristic of the early tractorization process in North America and Europe, because early tractors were unsuited to road use. But, in Asia where farm sizes seldom support the purchase of a truck, farm-to-market transport is increasingly done by tractors, although hired trucks are used where distances are long. Rubber tires have given tractors a high comparative advantage for on-farm transport.

The mechanization of processing activities such as harvesting and hay making, takes place only where labor costs are high or rapidly rising. Harvesting is generally very labor intensive, but different crops vary widely in the types of labor required, viz. in the power and precision required. Harvesting root crops is probably the most power intensive. The harvesting of fruits and vegetables generally are precision intensive, but require little power. Most grains occupy an intermediate position. In most precision-intensive harvesting operations the threat of yield loss associated with higher levels of mechanization has been the principle problem confronting engineers.

But, in many parts of the world there has been a considerable time lag between the mechanization of power intensive operations and mobile processing operations, such as harvesting, that cannot be explained by the lack of appropriate technology solutions. The adoption of cereal harvesting equipment began in North America in the mid-19th century, but this technology only made a substantial impact in Europe fully 40 years later. Reaper-binders became widespread in Europe only after 1900, but in Japan had a perceptible impact only in the 1960s. This was fully 100 years after the USA and 60 years after Europe, and 30 years after power intensive stationary processes such as threshing, winnowing and pumping were mechanized in Japan. It seems unlikely that this lag was caused by a lack of technology. Rather, it appears that the mechanization of processes such as harvesting is directly dependent on the levels of labor costs and rarely profitable in low-wage situations. The higher the control intensity of the operation, the higher must labor costs be in order to warrant adoption of a machine to perform it.

The mechanization of operations requiring a high degree of precision seem to follow a different rule. Seeding and planting seem to be among the few farm operations where machines are capable of greater precision than hand methods. Mechanization may therefore lead to modest direct yield effects, through saving seed, preventing the micro-ecological effects of plant crowding, improving germination through depth control, and permitting inter-row cultivation. Mechanical seed and fertilizer placement may thus be attractive in land-scare, intensive cultivation systems.

Indeed the first seed drills were developed in China and Mesopotamia in the third millenium BC, although their use was subsequently abandoned. Improved seed drills were developed in Europe in the 18th and 19th centuries, and in all parts of the world the use of seed drills has preceded other advances in mechanization by several decades if not centuries. The use of simple drills has been growing rapidly in India since the mid-1960s, and in Senegal, where animal traction is a relatively recent development, seed drills are one of the most popular implements. In these cases, it is not so much the saving of labor as well as the improvement of yields, through better weed control and saving of seed, that led to their success. Thus in labor-abundant situations grain seeding tends to be mechanized before grain harvesting, but the order tends to be reversed in labor-scarce environments (Binswanger, 1982). For other precision-intensive operations however, such as crop spraying, the use of equipment such as hand and power sprayers, is largely determined by the availability and use of new inputs (pesticides and herbicides), and is common even in low-wage situations.

These historical patterns of mechanization suggest that there should be no expectation that farms will in the future be mechanized uniformly across all operations nor across all farming situations. There seems no reason why the selective use of new power sources, particularly of tractors, should be considered inefficient or irrational. Given that wages remain relatively low, there is every reason to expect that a selective pattern of farm mechanization will continue.

ADOPTION RATES

The spread of adoption of farm mechanization in any situation is determined primarily by the potential profitability of the particular innovation. This in turn is determined by prevailing market conditions for farm products, on the one hand, and the expected costs associated with introducing and supporting the new technology, on the other. The costs are determined largely by labor costs, but are also greatly influenced by the extent of the concomitant changes required in the farming system and the broader rural system in which the farm operates. These can differ significantly with the type of technology being introduced.

The substitution of power sources has two distinct stages. The shift from human to draft animal power (stage 1), and subsequently from draft animal to mechanical power (stage 2). These require substantially different system adjustments, which, while widely perceived, are only now being seriously studied.

Stage 1 necessitates significant changes in the external support system. Primarily, it involves a transition from shifting to sedentary agriculture. Also, in order to use draft animals the farmer has to have substantial knowledge and skill in animal husbandry. Since large animals (bovine or equine) are seldom found on smallholdings, unlike small animals (chickens, sheep, or goats), there is a significant learning process involved. Combined with this knowledge there are necessary changes in cropping patterns (especially to produce fodder), capital requirements (for animals and equipment), and new patterns of labor demand which have to be accommodated. These involve significant internal farming system adjustments.

On the other hand, relatively modest changes are required in the external support system. These include meeting the demand for veterinary services, livestock breeding and new equipment. These services are all divisible and require mainly local changes. The services required generally involve relatively small increases in cash expenditures by the farmer. This situation is characteristic of most African countries.

Stage 2, by contrast, involves relatively modest shifts in the internal farming system, but far more significant shifts in the external support system. Institutional arrangements and skills have to be provided for the manufacture and distribution of tractors and equipment, repair and maintenance, spare parts supply, fuel and lubricant supplies and often formal credit facilities. All of these require a higher level of infrastructure for transport and communication, and all services have to be organized on a national or regional basis. Such changes are therefore beyond the direct control of farmers. In addition, paying for such services requires a much higher saleable surplus and a greater commercialization of agriculture, involving the growth of rural finance and trading systems. However, where private enterprise is relatively untramelled, supply bottlenecks in production, distribution and servicing of machines are rarely a cause for slow adoption of new machines.

In practice, where the cost advantages are large or change rapidly, selective operations are mechanized in short periods of time, in the order of 10-15 years for given locations. Historical data which focus on power sources at a national level, tend to obscure the rapid rates of adoption that are often achieved in mechanization. Once a suitable locally adapted design is available, the cost advantage is the overwhelming influence and adoption is rapid, as in the case of, for instance, threshers in many parts of Asia.

The engineering solutions for farm operations are generally quite sensitive to agro-climatic or soil variations. In addition, they are also sensitive to the nature of the farming system, the type of crop, kinds of other inputs used, intensity of land use, and the level of control that is practiced. This in turn is responsive to the economic environment, especially the factors endowments of land and labor, the related wage and other cost levels, and farm product prices.

Since most machine designs combine power, process and precision enhancing elements to suit a particular farming system and related set of factor endowments and costs, design adaptation is necessary, if a machine is to be transferred successfully from one system to another.

In the early phases of mechanization inventions and adaptations are usually done by small workshops or manufacturers in close association with farmers. The contribution of the farm machinery industry increases over time, and is the most important element in engineering optimization. From a global perspective, public sector activities have contributed little to machinery development and adaptation.

INTERVENTIONS

The rate of technology adoption is fastest and least disruptive in a social sense, if the technical package, the receiving environment, and the overall policy framework in which they are to function, are in harmony (McInerney, 1978). Unfavorable consequences can arise if the introduction of an inadequately adapted or inappropriate machinery package is artificially induced. The innovation may either fail to be sustained or may cause adjustments in the farming system that are inefficient or inequitable. For instance, the introduction of power tillers into Bangladesh has not yet become sustained, though it has been attempted several times. On the other hand, the introduction of tractors in many situations has been achieved only at the expense of premature farm size growth, some negative effects on productivity, and increased rural unemployment.

It is wrong, however, to attribute such unfavorable effects merely to the mechanical innovation. Rather, the evidence suggests that these effects are the consequence of a complex interaction between the farm machinery package and the receiving agricultural system (especially the institutional arrangements such as land tenure), in the context of an inadequate or unsatisfactory (distorted) economic and policy environment. Thus governments have an important, if indirect role to play.

Clearly, governments can play a positive role in the provision of rural infrastructure, such as roads, telephones and electrification; and institutions, such as land tenure and rural financial systems. They can also have a constructive role by regulating commercial practice, through such measures as stabilizing and enforcing grades and standards (e.g. to prevent dilution of fuel and oil), and a system for contract enforcement (e.g. in respect of transactions, patents and warranties). They may also have a positive role to play in improving the receiving environment through education and training, and providing information both to the adapters and adopters through machinery testing and demonstration.

Not infrequently, governments have had an unconstructive, if not negative impact where they have attempted to play an active role in mechanization. Such activities have included the provision of machinery hire services, selection or restriction of the technical packages available, selective allocation of equipment to farmers, import controls and taxes, and the provision of subsidies through inflated exchange rates, and cheap credit. Generally, mechanization has been facilitated where governments have adopted a supportive role (though often quite pervasive, as in the case of Thailand). Adverse consequences have almost invariably arisen where governments have adopted a directly interventionist role (as has happened in developing countries too numerous to mention).

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The role of agricultural mechanization in the national development of low income countries

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INTRODUCTION

Today the average West European spends 20 % of his income on food. The North American only 16 %. In the last century the European had to spend more than 50 % for his daily food, and very often he had to worry about its availability. Crop failures led to shortages and increases in prices, and overproduction brought about surpluses with decreases in prices for farm products. Famine in the cities and widespread poverty of the rural population were a reciprocal cause and effect. This situation, together with the large increase in population, was a major cause of the well-known stream of immigrants to the New World.

The introduction of modern technology into agriculture at the beginning of the industrial era, combined with agricultural policy measures, has changed the situation drastically. Developments in plant breeding, use of fertilizer and plant protection have been dramatic. Farm output has increased several times and the fluctuation in production has decreased. The impressive advance in farm mechanization has, however, been the main factor in this increase in agricultural productivity by enabling crucial operations like land preparation, planting and harvesting to be carried out opportunely and with greater precision, and at the same time has helped to reduce much of the drudgery of manual labour on the farm.

Today many developing countries are in a situation similar to Europe in the pre-industrial era; 60 % and more of an individual's income has to be spent for food. Poverty of the rural population and rapid urbanization, with all the known consequences, are characteristic of Third World countries.

The desire of Third World citizens to escape these miseries is demonstrated by their immigration to Europe, to America, and to the oil rich countries. This desire to immigrate will certainly increase if it is not possible to drastically change the living and working conditions in the developing countries. The development of agriculture plays a crucial role in this change. Farming and rural living conditions must become more attractive, more humane, and agricultural productivity must be increased in order to eradicate rural poverty, overcome the shortage of food, and meet the challenge of rural development.

In attempting to achieve these improvements we must start at the point of production, that is with the farmer, and in most of the Third World countries this usually means the small farmer. He must be provided with the knowledge, facilities and resources to enable him to produce more and better quality crops. He must, of course, also have security through access to land and the right to work it, if not own it, access to credit, and the means of marketing his produce with an adequate return. The role of improved technology is however crucial. It must be appropriate to his circumstances and must be complete; no single component is likely to work properly in isolation. Agricultural mechanization is in my view one of the most important aspects of this technology.

AGRICULTURAL MECHANIZATION IN DEVELOPED COUNTRIES

In the industrialized countries, particularly in Europe and North America over the past 150 years, mechanization has played a crucial role in agricultural development, the most dramatic advances having taken place since the Second World War. In the early part of the last century local blacksmiths made hand tools and simple ploughs and harrows of traditional design to satisfy a very local demand, and most importantly, were able to maintain and repair them. With the development of better communications, in particular the arrival of the railways, it became possible for those with a superior design to sell over a wider area. Thus began an evolutionary process through which the more innovative and business-minded blacksmiths developed and expanded, sometimes into large multinational organizations like Deere, McCormick, Massey and Lanz, but more commonly into small and medium sized firms specializing in particular products. Other less innovative blacksmiths continued to offer a local maintenance and repair service, and frequently developed into distributors or agents for the larger firms.

Even now the agricultural engineering industry in Europe is largely made up of small and medium sized firms supported by dealers, agents and workshops providing a very close link with the customer, the farmer, and thus being able to respond to the farmers' real needs. This is well illustrated by the number of designs which originate from farmers themselves. In Italy alone there are over 2 000 small manufacturing firms, and in the UK almost 70 % of manufacturers employ less than ten people. This close collaboration between the manufacturer, the dealer and the farmer is still the backbone of farm mechanization, and in spite of the inevitable evolutionary changes that will occur in the future, it is likely to remain so. Some of the most significant advances over the past 50 years or so have of course come about as a result of the great strides made in providing modern facilities for agricultural engineering education, research and testing, creating the human resource, promoting and developing the new ideas, testing the results and ensuring the quality of the product. The initiation and support of this type of education and research facility is particularly suited to governmental involvement.

AGRICULTURAL MECHANIZATION IN DEVELOPING COUNTRIES

One of the main reasons for the high level of agricultural productivity in developed countries is the diversity and extent of mechanization. Unfortunately, this does not generally apply to the world's developing countries, where by the end of this century will be over 330 million farm families. They will be farming about 675 million hectares of land, but many of them will have less than one fragmented hectare. The vast majority of them depend solely on hand tools and animal drawn implements to carry out their farming operations. Over 78 % of the area cultivated in developing countries is farmed in this way. Many of them cannot read or write, but all of them know about the tractors that could make their life easier, and they know that owning one is only a dream, unless someone gives the help which is often talked about, but seldom delivered. They have watched government machinery hire schemes start up with great promise, then fail to stay in operation, or only provide service to a selected few. They hear about new and fascinating farm technology on their transistor radios, but may see an extension agent, or someone else who could help them learn how to use it, once or twice a year. They go to a bank for credit to buy tools and equipment to increase their productivity, only to learn that they do not have enough or the right kind of collateral to qualify for a loan. They watch the price of all production inputs going up every year perhaps 10-15 %, and their government maintains a static price for the crops they produce, often so to enable consumer subsidies to be provided.

Mechanical-power technology in the agriculture of today's developed countries has evolved over a period of 100 years, with major advancement in the last 50 years, under conditions that do not generally exist anywhere in the world today. But many developing countries have not had, and do not have 100 years to make the transition from subsistence farming to a level of agricultural productivity that will feed their growing populations, reduce poverty and trigger overall rural development. As a key element in the required increase in agricultural productivity and overall development, agricultural mechanization is not receiving enough attention. In general the mechanization component in national development plans for agriculture, and the rural sector is weak or non-existent in most developing countries. Mechanization tends to be taken for granted by development planners. Definitive policies that deal with mechanization and its complex relationship with other technical, economic, social and political factors in development are lacking. In many cases, mechanical-power technology has been promoted without adequate planning for infrastructural and institutional support; without considering the needs of small farmers and rural labour; without recognizing the longer term implications of policies on credit, wages, foreign exchange, depreciation allowances, tariffs and taxes; and without making adequate provision for training farmers and government personnel to make the difficult transition from hand-tool to animal-draught technology or to mechanical-power technology. As a result, economic and social problems have often increased and the transition to an advanced state of land and labour productivity in agriculture has been retarded.

WHAT IS NEEDED OVER THE NEXT DECADE

There can be no doubt that the production of food needs to increase dramatically in the developing countries over the coming decade. It would be naive to assume that an increase in the level of agricultural mechanization alone will be sufficient to achieve the higher levels of farm production needed. It would, however, be equally naive to assume that farmers in the developing world can meet the food production targets of the coming decade without access to more and better farm power, and the improved implements and equipment to utilize that power effectively and efficiently.

The need for increased levels of mechanization in the developing countries is obvious. The desire of farmers for more and better mechanization inputs is beyond question. The problem is how to translate this obvious need and unquestionable desire into effective demand and how to meet it. The farmer cannot sustain the use of mechanization unless it is economically viable to do so, the input cost must be absorbed by, at least, an equal increase in output value. Farm machinery suppliers are not charitable enterprises and cannot survive in the commercial world by subsidizing the users of their products. We must ask ourselves what actions can be taken in the coming decade to create an environment in which agricultural mechanization in the developing countries will benefit both the farmer and the suppliers of inputs on an equitable basis.

AID AND TECHNICAL COOPERATION

Experience to date suggests that greater efforts are needed to bring about improved coordination, cooperation and mutual understanding of objectives and problems between governments, machinery manufacturers, aid donors, international organizations and developing country farmers. More specifically, aid agencies and financing organizations should follow a more rational approach to technical cooperation programmes with regard to:

- selection of appropriate machinery;
- effective manpower training;
- establishment of machinery serving and spare parts networks;
- institutional support for sustaining viable mechanization strategies,

giving due consideration to such aspects as employment, energy and environmental conservation;

- full recognition of the interrelationships and interdependencies between mechanization and all other factors of production.

Machinery manufacturers in industrialized countries should increase their efforts to understand the real needs of the farmers in the developing countries, and gear their activities accordingly. The developing country markets for mechanization should be viewed by manufacturers as a long term development effort and not as an alternative to pursue when the traditional domestic machinery market is in a slump.

All concerned should accept that it is unrealistic to expect that every farmer can own machinery for exclusive use on his own farm. Multi-farm use of power and equipment can increase investment efficiency and bring machinery services to a larger number of farmers. Aid agencies and manufacturers can influence recipient governments to establish machinery multi-farm use systems, keeping in mind that government operated machinery-hire schemes have generally failed, whereas farmer-contractor and commercial-contractor hire services have given impressive results.

Local manufacture of farm machinery in developing countries is a theoretically sound approach to the supply of machinery for development, but care must be taken that enthusiasm for its introduction is tempered by the realities of the local situation. This may be one of the areas in which the experience and expertise of the smaller manufacturer in the developed countries could be invaluable, and bilateral and multilateral aid organizations should look closely at the possibility of encouraging and assisting these companies in becoming involved in the Third World. The mutual benefits in the medium and long term could be tremendous.

THE DONOR AND THE RECIPIENT GOVERNMENTS

Governments and international financing institutions play a key role in the introduction and support of mechanization in developing countries. In far too many instances the policies of both aid giving and aid receiving countries or organizations have failed to recognize the long term needs of the farmer. These policies are in great part responsible for the farm machinery 'graveyards' that are an eyesore and a common theme whenever the subject of mechanization in agricultural development is discussed.

- Donor governments or financing institutions may provide loans or grants for bulk purchase of tractors, but seldom provide for long term tractor maintenance and repair, for implements which are vital to the efficient use of the tractor, for establishment of infrastructure and institutional support arrangements which will sustain machinery use, or for effective training of manpower at all levels.
- Recipient governments may eagerly accept loans or grants without any

sort of mechanization strategy which will provide the framework to ensure that the investment in machinery has a sustainable positive impact on the farmers' productivity and standard of living and on the national economy as a whole.

Governments on both sides of the development fence are very often activity-oriented instead of result-oriented. They are more interested in the short term political gain than in the long term impact on agricultural and rural development.

RESEARCH

Intensive agricultural research at national and international institutions stimulated by the success of the high yielding varieties of wheat and rice in the Sixties and Seventies has resulted in considerable advances in plant breeding and seed multiplication for nearly all tropical and subtropical crops. However, in many cases the new varieties have initially produced lower yields when grown in farmers' fields than was expected from their performance at the research institutes in which they were developed. Generally, this has been because the 'package' of inputs has been incomplete in one way or another. One of the major constraints is frequently that farmers do not own or have access to the necessary farm power (hand, animal, or tractor) and equipment to undertake timely land preparation, planting, fertilizer application, crop protection and harvesting, and are therefore not able to take advantage of the yield potential of the improved varieties.

In spite of the most important role of research in development there are still too many examples of research effort being directed to topics which, although having considerable academic merit, have very little relevance to the enormous and immediate problems facing the Third World. Much of it may be valuable in the universal search for knowledge, but when it is undertaken at the expense of more practical, applied research, it is disservice to the developing countries, who can often benefit greatly and more quickly from the application of known techniques suitably adapted to their circumstances.

EDUCATION AND TRAINING

Educational and training facilities for agricultural engineering and related subjects are now more readily available in the Third World. The quality and range of courses offered may not yet be ideal, but they are continually being improved. Long term education planning is extremely difficult and many developing countries, dependent as they often are on external funding to establish the necessary facilities, are experiencing the effects of an imbalance in the supplydemand relationship for trained manpower. Prestigious university level courses have been given priority in the past, and in many cases there are now too many graduate engineers with good theoretical knowledge but inadequate practical skills, and who are unable or unwilling to work outside of an office. At the same time there is a serious shortage of trained technicians, artisans, mechanics etc. for the support services that are so essential to any mechanization system.

DELIVERING THE TECHNOLOGY PACKAGE

Generalizations are, of course, dangerous, but mechanization, like so many other inputs to agricultural development, is very dependent on particular and often very localized circumstances. I have mentioned some of the many problems to be faced in successfully identifying the appropriate form and level of mechanization for the particular circumstances and the difficulty of developing an appropriate technology package with all the other inputs required. I have also suggested that valuable lessons can be learnt from experiences in the developed countries. With all this knowledge and experience we can, and often do, bring together an adequate and appropriate package of improved technology, and yet it does not seem to have the desired effect. I believe that the problem lies in the delivery of the 'package' to the farmer.

In many cases the farmers' point of view is not taken into account and the crucial link between him and the technical and financial resources required for development, is missing. Extension services are inadequate or non-existent, credit, marketing, transport and communication facilities are far away or infrequently available, and there are no proper support facilities in the way of blacksmiths, workshops, machinery dealers, spare parts stores, trained mechanics, all of which are so crucial to any level of mechanization from hand tools to tractors.

It is on this last point we in AGSE at the FAO have been concentrating in the past few years. You may be interested to know that we have a number of field activities concentrating on the problem of the final link with the farmer. They include a project in Zambia through which we are promoting the establishment of rural artisan workshops, privately owned by selected individuals from the locality. They are provided with basic training, credit and technical support for at least two years to enable them to provide a service for the adjustment, maintenance repair and manufacture of hand tools, animal drawn implements and similar equipmemt. In the longer term, these small business enterprises will provide the essential point of contact with the farmer in much the same way as their counterparts in Europe. This will facilitate the more rapid and effective transfer of improved technology to the farmer and also enable him to become more actively involved in selecting or even developing his own solutions to the problems he faces.

At a more advanced level of mechanization we are involved in Ghana and

Uganda, in programmes designed to make tractors available to private users, particularly those with potential to become farmer-contractors, with proper support services being encouraged through training and credit programmes for mechanics, storemen, managers and advisory personnel, and the provision of basic spare parts with the necessary stocking and distribution systems.

Experience has shown that governments in developing countries should generally not become involved in the direct management of tractors, machinery or related services to farmers. It is better that they should concentrate on establishing a sound infrastructure and on the development of national facilities for research, education, training, credit and extension. The aim should be to create an environment, through appropriate government policies and incentives, that will encourage individuals, companies and organizations in the private and public sectors to develop the essential services for the efficient supply, operation, maintenance and repair (and where appropriate, manufacture) of mechanization inputs. This will help to ensure the adoption of sustainable levels of mechanization appropriate to the socio-economic as well as technical needs of each area; thus enabling farmers to improve their productivity as well as living conditions, and thereby make the required impact on rural development.

The future role of agricultural mechanization in development

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INTRODUCTION

The Second International Conference on the Development of the Agricultural Machinery Industry in Developing Countries was held in Amsterdam, The Netherlands, from 23 to 26 January 1984. Those attending Theme A of the meeting, included economists, agronomists and agricultural engineers from developing and developed countries. Keynote addresses for Theme A by Dr Graham Donaldson of the World Bank in Washington D.C. and Dr Hartmut von Hülst of the Food and Agriculture Organization in Rome set the stage for the meeting. Both speakers emphasized that:

1. An appropriate level of mechanization will be an integral part of the agricultural development process in the future, just as it has been in the past.
2. Mechanization must be economically justified and privately profitable before its use can be sustained.
3. Mechanization has been facilitated where developing country governments have adopted a supportive role, and adverse consequences have usually arisen where governments have adopted a directly interventionist role.

SURVEY OF COUNTRY REPORTS AND PAPERS

A total of 33 country reports and papers related to the subject of Theme A - Agricultural Mechanization in Developing Countries - are submitted to the Conference. The reports reflect the agricultural mechanization situation in those countries which are primarily concerned with the role of mechanization in the agricultural development process.

The Country Reports focus primarily on the present state of the art of mechanization. Only three reports discuss in detail the future role of mechanization. Well over half of the reports emphasize the need for planning of mechanization for development. However, it is clear from the Country Reports that, while the need for planning mechanization is now widely recognized, the way to carry out the planning process is not well known.

PRESENT STATUS OF MECHANIZATION

Nearly every Country Report provides an in-depth description of the local agricultural situation and status of mechanization today. It is quite clear that each country reported upon is made up of many and highly diverse farming systems. It also appears to be widely recognized that the traditional mechanization inputs into each of these farming systems clearly reflects the circumstances of the system.

The Reports from Mexico, Argentina and Brazil, for example, show a very significant drop in sales of mechanical-power inputs over the past 3-5 years. The registered concern over this situation is mainly in respect of its long term effect on a heretofore thriving local machinery manufacturing industry.

Though many Reports portrayed a renewed interest in animal-draught technology, none gave an indication that, as yet, mechanical-power use had decreased and animal-power use had increased. It could be assumed that farmers accustomed to use mechanical power are keeping machinery longer and making other sacrifices in order to avoid reverting back to animal-draught technology. This, of course, will have implications for the mechanization pattern in the near future, unless there is a major change in the farmers production input/output cost relationship very soon.

Improved hand-tool technology received little attention in the Country Reports. It would appear that there is ample recognition of the number of world farmers limited to only hand tools. There seem to be few ideas, however, as to how their mechanization input might be improved without moving to a higher level of technology.

It is clear from the Reports that the traditional world distribution patterns of mechanization technology use are changing very slowly, if at all. Draught animal power use is still dominant in the Far East and Indian subcontinent, particularly in the paddy growing areas. Korea, Thailand and India, for example, report a significant surge of mechanical power use over the past decade, but indicate that draught animals still are the key farm power source for most farm operations. The introduction of animal-draught technology in Africa continues to be a slow and difficult process, with perhaps 85 % of the farmers having access only to hand-tool technology. In the Near East, mechanical power for agriculture continues to increase, seemingly at about the same pace as during the past 10 years. Though the current situation in Latin America with regard for mechanical power is causing concern, there is little in the Country Reports from that region to indicate a radical change in the pattern of use of different levels of mechanization technology.

ANALYTICAL REVIEW OF THE PRESENT AND FUTURE CONTRIBUTION OF MECHANIZATION IN AGRICULTURAL DEVELOPMENT

The keynote speakers categorically stated that throughout history advancing mechanization technology has been a factor in agricultural development, and they expect the same to be true in the future. There is a need for all concerned to use the term 'agricultural mechanization' in its broadest sense, i.e. encompassing mainly hand-tool, animal-draught, and mechanical-power technology. In this context the contribution of mechanization to agricultural development is no question, either directly or as an enabling factor for changes in other technology, as described by Dr. Donaldson. However, the mechanization questions facing developing country governments, are still complex. They must find answers to:

1. The total demand for farm power based on increased agricultural production requirements and goals.
2. The appropriate combination of hand-tool, animal-draught, and mechanical-power technologies for each specific situation in the country, including technical suitability and the need to meet economic and social development objectives.
3. The appropriate pace of technology introduction as determined by internal human and financial capacity.

The Country Reports and Papers submitted to the Conference reflect the widely held view that the introduction of animal-draught and/or mechanical-power mechanization technology is essential for expansion of cultivated land. Some Reports express the view that advanced mechanization had a direct effect for increasing crop yields, others consider mechanization as an enabling factor and state that yield increases are achieved only by the adoption of a wide variety of technologies. No evidence of the first view has been presented, except in a limited number of special situations. The second view, however, is compatible with a wide range of experiences, many of which have been well documented.

Many Country Reports imply a governments attitude that mechanization was essential for achieving their agricultural production and food security goals. This attitude reflects the common concern in developing countries for their future agricultural development requirements. It is apparent, however, that much of the attitude is a 'grasping at straws', implying that merely increasing the amount of agricultural mechanization 'hardware' will be adequate to achieve their objectives, which is unrealistic. Nearly all Country Reports emphasize that the future impact of mechanization in agriculture is related to the finding of solutions for a shortage of trained manpower, a weak research and development programme, and an inadequate infrastructure to support machinery maintenance and repair.

ANALYSIS OF TECHNIQUES AND RESULTS IN PLANNING FOR AGRICULTURAL MECHANIZATION

It is apparent that the developing countries represented in the Conference are beginning to recognize the need for agricultural mechanization planning. At least 20 of the Country Reports indicate that the government was at some stage in developing a formal mechanization strategy. Korea appears to be one of the more advanced countries in this regard, with a clearly defined mechanization strategy covering most aspects of the mobilization and reallocation of the mechanization resources. The procedures they have followed encompass all levels in the planning hierarchy, which helps to ensure that the strategy is an integral part of the overall national development plan.

Pakistan, Philippines and Thailand are examples of countries which are actively pursuing the formulation of a national mechanization strategy. The Indonesia Country Report presents an interesting approach to preliminary planning. The country is divided into areas according to the present level of development or capacity to adopt mechanization technology. One of three levels of technology is applied to each area: simple, intermediate or sophisticated technology. This approach will, of course, require considerable refinement and elaboration over time, but is, nonetheless, a start towards planning for mechanization. The Report from Zambia shows a similar approach, but classifies farmers as subsistence, emergent and commercial.

The paper by Moens and Wanders is the only written contribution to the Conference that provides guidelines on the methodology of planning for agricultural mechanization. It warrants, therefore, the special attention of all participants.

MAJOR CONSTRAINTS ON ACHIEVEMENT OF MECHANIZATION GOALS

It is apparent from all Country Reports that the constraint on introduction of mechanical-power technology causing the greatest concern is the initial cost of machinery and its subsequent operating costs, as related to the value of the crop output. Some Reports indicate that the expected increases in farm output after the introduction of mechanical power technology have not been achieved. It is quite clear that, in many, if not most, cases the increasing costs of mechanization inputs are not being adequately covered by either an increase in crop output or an increase in the value per unit of output.

In his keynote address, Dr von Hülst points out that research, education and training for mechanization are needed in greater quantity and quality to overcome the constraints on mechanization achieving its potential effect on development. He also emphasized the need for governments to create an environment to encourage organizations and individuals to provide efficient supply, operation, maintenance and repair (and where appropriate, manufacture) of mechanization inputs. Implying that, at present, these services are inadequate and thereby a constraint on mechanization development.

Pakistan considers the shortage of qualified, experienced and responsible manpower as the major constraint on mechanization advancement. The Reports from Zambia, Thailand, Sri Lanka, Nigeria and Mexico suggest that greater emphasis must be placed on designing of machinery, implying that inadequate machinery design is a major constraint on mechanization introduction.

Overall, the Country Reports focus on mechanical-power technology and suggest that the shortage of financial resource, inadequate maintenance and repair arrangements, shortage of trained manpower, and distorted farm input cost and output value relationships are the main constraints on introduction and long-term support of mechanization. None of the Reports, however, refers to constraints on the introduction and support of hand-tool or animal-draught technology, which is unfortunate, because there are obviously many constraints.

ACTIONS TO BE TAKEN

As a generalization, the Country Reports do not provide clear indications of the action programmes which need to be taken to overcome constraints and promote the optimum development of agricultural mechanization in low-income countries. Nonetheless, by extrapolating from the information contained in the reports, papers and addresses, it is possible to suggest some areas in which efforts are needed to effect measures, approaches and actions for the immediate future.

- Nearly every developing country needs to take immediate steps to formulate a national agricultural mechanization strategy. This action for mechanization planning must be recognized as a continuous process, and one which calls for a crossing of the traditional and disciplining lines to actively include farmers, engineers, agronomists, economists, machinery manufacturers and dealers, and most of all, the national government planning functionaries. It is not a job for engineers alone, and it is a task which must take place at the highest possible decision making levels in the country.
- Measures are critically needed in all developing countries to effect coordination and cooperation between governments, aid donors, international organizations, developing country farmers and machinery manufacturers, so as to ensure a mutual understanding of mechanization objectives and problems, and an integrated approach for achievement of common goals.
- Greater effort is needed to develop new approaches and execute dynamic programmes for developing the wide range of skilled manpower required for effective mechanization use. The classical manpower training schemes, which

have been the pattern for three decades or more, are inadequate to meet either the quantitative or qualitative requirements of the future.

- Governments and aid donor countries and organizations must revise their present policies to give more emphasis to dynamic support arrangements, which are essential, if the mechanization technology introduced today is to be sustainable over time. In this context it should be recognized that the primary function of government is to create a favourable economic environment in which maximum untilization will be made of inputs from all sources.
- Agricultural mechanization research and development programmes need to break away from the concepts followed by most crop and animal research efforts. Mechanization is a service input, not a production enterprise. The service provided must be in the context of the farming systems being served. Research must be undertaken solely in a problem-solving context, with an honest and realistic definition of those problems as they exist at the farm level. Finally, it must be recognized that mechanization advancement in the developed countries is mainly the result of inovations and initiatives by farmers. Mechanization researchers must concentrate their efforts at the farm level and stop trying to develop farm machinery solely in an isolated institutional complex.
- Major improvements are needed to improve the systematic and regular flow of mechanization information between and within developing countries, and between industrialized nations and the countries of the third world. Particular attention should be given to utilization of the potential contribution from small and medium size machinery manufacturers - a source of experience and expertise which heretofore has not been exploited.

Development of the agricultural machinery industry

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INTRODUCTION

On behalf of the United Nations Industrial Development Organization (UNIDO), I should, first of all, like to take this opportunity to thank the organizing authorities of this Second International Conference on the Development of the Agricultural Machinery Industry, for having invited UNIDO to participate and present its views and experiences in the sector. UNIDO is happy to be involved with this Second International Conference which aims at promoting the development of agricultural machinery as a mean to solve problems related to food shortages in many developing countries. In fact, UNIDO has been involved for many years with this issue looking out for long-term strategies for the sector at different levels as well as considering the development of manufacturing facilities most appropriate to the local conditions of developing countries.

UNIDO was requested to establish a system of consultations in the field of industry by the Second Conference of the United Nations Industrial Development Organization, held at Lima, Peru, in March 1975. This recommendation was endorsed by the UN General Assembly in September 1975. The Industrial Development Board, UNIDO's governing body, decided in May 1980 that consultation meetings should be organized on a permanent basis. In May 1982 it adopted the rules of procedure according to which the system of consultations was to operate. The system of consultations provides a worldwide forum at sectoral level where a dialogue is established. The most important characteristics of this dialogue are the following:

- Wide participation that include representatives of government, industry and labour from all member countries who examine general and specific problems of a given sector and suggest possible solutions to them.
- Decision making on the basis of consensus at the level of participants and of the Bureau of the Consultation, with regard to the report of the Consultation that includes conclusions and recommendations.
- Continuity insofar as a Consultation is not an end in itself, and that problems covered are analysed and discussed until solutions beneficial to all interested parties are found.

- Providing a forum where problems can be tackled continuously from a policy, economic, financial, social and technical point of view.

The Lima Declaration and Plan of Action laid stress on the development of efficient agro-related industries in order to achieve a high degree of integration between the expansion of agriculture and industry in developing countries. The subject is one of great importance because of the dominant position which agriculture occupies in the economies of most developing countries.

The agricultural machinery industry produces a variety of products from hand tools and animal-drawn implements to tractors and complex self-propelled machinery, for specific agricultural conditions of soil and climate, varying ranges of crops, animal husbandry and other post-harvesting activities, such as, handling, sorting and packing, transport and storage of agricultural output. The agricultural machinery industry has a special role in the development of developing countries because of its direct link to agricultural production on the one hand and its ability to encourage the development of engineering skills and manufacturing industry on the other.

Developed countries produce over 85 % of world output of agricultural machinery and 10 multinational companies account for most of the production of tractors and specialized equipment. Developing countries produce only 15 % of total world output of tractors of more than 10 H.P. and only 8 % of other agricultural machinery. Moreover, this production is concentrated in a few developing countries and a vast majority of other developing countries do not manufacture even simple hand tools. The critical aspect of this situation was forcefully revealed during the Regional Consultation in Addis Ababa when it was demonstrated that present day farming in Africa is carried out 80 % with hand tools, 15 % with animal drawn equipment and 5 % with tractors, and that this situation was likely to worsen by the year 2000 which will witness the maintenance of more or less the same ratios between the implements used while population shall have doubled.

The fact that the majority of farmers in developing countries own small tracts of land, creates a constrained demand for implements limited to small volumes per type of product. This offers little or no incentive for the major manufacturers who produce equipment specific to the agricultural conditions in developed countries which cannot be duplicated elsewhere or to the requirements of those developing countries which generate a sizeable demand.

The activities undertaken by UNIDO within the System of Consultations, activities which included country experiences, studies and survey based on interviews with entrepreneurs in several countries, have led to the conclusion that no progress would be made without mutually beneficial international cooperation in which both commercial and industrial relations were taken into account.

The continuity of the Consultation process in the agricultural machinery sector have permitted to identify and examine in detail, a.o. the problems related to the development strategies of the sector, as well as the characteristics of the basic facilities required by developing countries.

DEVELOPMENT STRATEGIES

A consistent consideration of the many interrelated aspects of industrial and agricultural development is of fundamental importance, as they affect the choice of appropriate technology in agricultural mechanization and the right strategy to adopt in the production of agricultural machinery, so as:

- To enable the agricultural sector to make its own contribution to economic development.
- To facilitate progressive structural change in agriculture and smooth transition of human resources from agricultural to non-agricultural based occupations, without loss of social cohesion in rural communities or excessive levels of urban unemployment.
- To distribute as widely as possible amongst all agricultural producers, the opportunity to contribute to the development effort.

The First Consultation, convened in Stresa, Italy, 15-19 October 1979, agreed on the main premises for the formulation of a strategy for the development of the agricultural machinery industry. The Consultation agreed that the strategy should be formulated at the national level, starting from a compilation of information and the elaboration of a diagnosis of the sector in the country. The next step would be to formulate the strategy within the framework of national policies and objectives on economic and social development with the assistance of the data and diagnosis mentioned above. In that connection, the Consultation revealed the importance of the organization of exchanges of experience, particularly with countries and enterprises that were conducting research on new types of equipment with the objective, a.o. of stimulating design and manufacture of machinery and equipment suited to the varying conditions of developing countries. The Consultation made evident the necessity of increased assistance from government and enterprises of developed countries in the area of training and planning for the agricultural machinery industry.

The premises on the development strategies arrived at during the First Consultation crystalized in a tentative proposal for the formulation of an African development plan for agricultural machinery and equipment as presented by the UNIDO secretariat at the First Regional Consultation in Addis Ababa, Ethiopia, 5-9 April 1982, with two main objectives:

1. Formulation of a top urgent programme, the main thrust of which would be directed towards conserving the existing production apparatus, threatened by the shrinking of the markets, increasing productivity, and making full use of installed production capacity in the region.
2. Formulation of a medium-term programme, consisting of two complementary

categories of sub-programmes:

- integrated national programmes for agricultural machinery supported by multilateral and bilateral co-operation;
- subregional programmes for the development of agricultural machinery and equipment.

The Regional Consultation led to the conclusion that a vigorous international co-operation should be developed in order to contribute to the implementation of the African agricultural mechanization programmes.

As a first follow-up action to the above-mentioned Addis Ababa meeting, during 1983 a joint UNIDO/FAO Mission on rural and agricultural mechanization in Yaoundé, United Republic of Cameroon, developed the preliminary proposals for the establishment of a national ten-year rural and agricultural mechanization plan.

FACILITIES REQUIRED IN DEVELOPING COUNTRIES FOR THE MANUFACTURE OF AGRICULTURAL MACHINERY

The agricultural machinery sector is complex. Its products are aimed to satisfy restricted and unstable markets, of a wide spectrum of products. At the same time it forms part of the metalworking-family industries, where problems related to vertical and/or horizontal integration, planning, specialization, design and standardization have to be considered. If the mechanization adopted is both technically and economically appropriate, the production of agricultural machinery will result in a key element for the attainment of the development objectives. In developing countries the manufacturing approach, to be self-reliant has to be supported by (a) technology of low-cost small-scale agricultural machinery capable of being manufactured locally in developing countries, and (b) an integrated approach agricultural machinery/capital goods to sustain their industries infrastructures.

During the First Consultation, held in Stresa, 1979, the scope of international co-operation for the development of the agricultural machinery industry was considered particularly important taking into account that developing countries need assistance in the fulfilment of their objectives by the provision of linkages with international research and development institutions, national institutions in developed countries and between themselves, and in the flow of technological information and supply of prototypes. Many developing countries had insufficient information on specifications and availability of the right type of raw materials and products manufactured in other countries.

Special attention was devoted by the Consultation to the potential offered by rural artisans and family workshops, which could be developed through adequate incentives, upgrading measures of the available equipment, improvement of their accessibility to training facilities, proved design, credits, co-operative marketing arrangements, institutional support on standardization and others. Moreover, it was stressed that small-scale industries should be promoted and encouraged in different possible contexts. However, small and medium enterprises of developed countries as well as programmes of large international manufacturers should also be oriented to the actual needs of developing countries as an effective way of international co-operation.

Since the First Consultation had also been instrumental in focusing the attention of the participants on the fundamental structural imbalance existing in this sector between developed and developing countries, it was felt that for the Second Consultation held in Vienna, Austria, October 1983, it would be desirable to narrow down the discussions to certain specific and basic issues. The following two issues were selected for this purpose:

1. Integrated manufacturing approach to production of agricultural machinery and capital goods, and perspectives for international co-operation.
2. Model contracts for import, assembly and manufacture of agricultural equipment, including training.

In selecting the above issues and in the preparatory work that was undertaken by the UNIDO secretariat, guidance was obtained through a series of meetings and discussions with developed and developing countries. A meeting was held in Beijing, China, 20-27 October 1980, on exchange of experience and co-operation in the field of agricultural machinery and equipment among developing countries. To specifically consider the design and development of agricultural equipment in Africa, a workshop was organized at Cairo, Egypt, 17-28 October 1982. The consultations have revealed the reluctance of large manufacturers to adapt the agricultural machinery and equipment to the needs and markets of developing countries. Consequently, the necessity to mobilize the small and medium enterprises of developed countries seemed to be indicated. They would not only help establish industrial capacities in developing countries, but could also assist them in activities related to training, adaptation, design, testing, spare parts, maintenance etc. This was considered extremely important in order to secure the necessary logistical support to develop this sector.

The Regional Consultation in Addis Ababa provided an important opportunity to recognize the vast potential for co-operation between Africa and the rest of the world. It also demonstrated the possibility to initiate long-term programmes for agricultural and rural mechanization of Africa, mainly based on a different manufacturing approach. This approach was examined in depth and was agreed to, during the Second Consultation, when the multi-purpose plant concept emerged as a valid tool to promote the agricultural machinery industry in many developing countries. In addition, this concept and its validation through the consultation process is a significant development in the strategy, leading to an integrated manufacture of agricultural machinery and capital goods.

Given the linkages of the agricultural machinery industry with other industrial sectors, such as agro-food industries equipment, common-purpose capital goods, transport equipment etc., and the nature and duration of relationship required to develop this sector, the elaboration of long-term arrangements recommended by the Second Consultation are considered to be an important step towards placing international co-operation on a more durable basis.

As a focal point within the United Nations system for industrial development, UNIDO is committed to assisting developing countries, within the limitation of its resources, in their industrial effort. I should, therefore, like to reassure this Second International Conference the UNIDO's readiness to intensify its assistance to developing countries in the development of strategies and manufacturing facilities for agricultural machinery and equipment.

In conclusion, I wish to express UNIDO's appreciation to the authorities of this Second International Conference and the government of The Netherlands for this important effort towards finding solutions to the most urgent problems of developing countries.

Le role d'une organisation de constructeurs et les organisations gouvernementales dans le machinisme agricole international

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QUELQUES NOTIONS INDISPENSABLES

Specificité et originalité de l'industrie du machinisme agricole

- C'est une des seules à regrouper les industriels non par la nature du produit, mais par la destination unique, l'agriculture, de produits variés.
- Elle n'a donc qu'un seul client : l'agriculteur.
- Mais si le client est unique, l'agriculture, elle, est infiniment diverse (variété de climats, de sols, de productions animales et végétales, de méthodes culturales, de moyens financiers, etc.).
- D'où l'obligation, pour cette industrie, d'offrir une variété plus grande encore de matériels agricoles (450 types principaux).
- C'est donc une industrie de petites séries, composée en immense majorité de petites et moyennes entreprises, et ceci dans tous les pays producteurs.
- Elle met en oeuvre pratiquement tous les matériaux, tous les usinages et toutes les technologies des autres industries.
- Elle ne dispose annuellement que d'un court banc d'essai, la nature, avec ses saisons et ses aléas climatiques.

Importance de l'industrie européenne du machinisme agricole représentée par le CEMA

C'est la plus importante du monde occidental. Quelques chiffres:

- 4 000 unités de production;
- 450 000 personnes y travaillant directement (250 000 à la production);
- 1 000 000 de personnes en comptant la sous-traitance;
- 12 milliards de $US de chiffre d'affaires annuel, dont 33 % exportés, répartis ainsi:
  - . tracteurs: 5,7 milliards de $US
  - . machines agricoles: 6,3 milliards de $US.

Sa production va du plus simple matériel, à main ou à traction animale, jusqu'aux machines les plus puissantes et les plus sophistiquées. Elle peut résoudre n'importe quel problème mécanique, où que ce soit dans le monde.

Conjoncture actuelle du machinisme agricole

C'est, depuis 1975, une conjoncture de crise mondiale, dont on peut ainsi analyser les causes dans les pays industrialiés:

- une mutation rapide des données économiques et scientifiques;
- une diminution du nombre des exploitation et des agriculteurs;
- une diminution relative des revenus agricoles;
- le plein équipement en matériels classiques de culture et de récolte, d'où une activité réduite au renouvellement (le plus tard possible);
- le double choc pétrolier, augmentant de façon anormale les consommations intermédiaires indispensables, au détriment des investissements;
- une diminution des exportations, notamment intraeuropéennes, non compensée par les ventes vers les pays en voie de développement.

Les conséquences sont:

- Une surcapacité mondiale de production de matériels agricoles, et donc un climat de concurrence aigüe.
- Mais, conséquence positive cette fois, l'aiguillon de la concurrence encourage le développement de la recherche, de l'innovation, et l'application au machinisme de toutes les nouvelles technologies, même les plus révolutionnaires, au service de la productivité, de la fiabilité, de la sécurité et de l'ergonomie. Les industriels du machinisme agricole consacrent, en moyenne, 5 % annuellement de leur chiffre d'affaires à la recherche et au développement.

RÔLE DU CEMA DANS LA PROMOTION DE LA COOPÉRATION INTERNATIONALE

Définition; représentativité; limites à son action

Créé en 1959, le CEMA est l'association de 12 associations nationales de constructeurs de tracteurs et machines agricoles, appartenant aux pays suivants: Grande-Bretagne, France, R.F.A., Italie, Pays-Bas, Belgique, Danemark, Suède, Finlande, Espagne, Suisse et Autriche.

Le CEMA est représentatif à près de 90 % de la production européenne de matériels agricoles. Ses buts: Par la mise en commun de données statistiques, techniques et économiques (a) aider les constructeurs à connaître la conjuncture et tenter de prévoir son évolution à court et moyen terme, (b) être présent dans tòus les organismes internationaux officiels ou privés chargés d'harmoniser, normaliser, réglementer ou promouvoir la production, la commercialisation et l'utilisation du matériel agricole, afin d'y faire connaître les imératifs industriels, et (c) lutter contre les entraves, techniques ou non, aux échanges et promouvoir l'équipement de l'agriculture.

Ses limites: une association de constructeurs étant une association d'industriels complémentaires, mais aussi concurrents sur le terrain, s'interdit de s'immiscer dans les affaires commerciales de ses adhérents. Le CEMA ne peut à fortiori que respecter la même règle. Il ne peut donc jouer un rôle commercial direct.

Action du CEMA en matière de coopération

Dans leur diversité géographique, politique, ethnique, nombre de pays en voie de développement ont malheureusement un problème majeur en commun: la mal-nutrition face à une démographie rapidement croissante. Pour aider à résoudre ce problème crucial, le CEMA poursuit de multiples actions:

1. Soutenir toute action, technique ou réglementaire, officielle ou privée, tendant à supprimer les entraves aux échanges de toute nature et à promouvoir l'équipement rationnel de l'agriculture de tous les pays.
2. Agir auprès des organismes internationaux des pays industrialisés signant des accords de coopération scientifique et économique avec un ou plusieurs pays en voie de développement, ou des groupements de ces pays, pour que l'équipement de l'agriculture soit retenu comme l'un des thèmes prioritaires de coopération. (Exemple du récent congrès de Kuala-Lumpur entre la CEE et l'ASEAN).
3. Promouvoir auprès de tous les dirigeants responsables un certain nombre d'idées:

a. A la lumière de l'expérience, il semble nécessaire de réviser la notion même d'aide à la lutte contre la faim. Il n'est pas question de dimineur les dons en nourriture, bien au contraire, mais il faut corrélativement la compléter par une formation technique accélérée des agriculteurs de ces pays et par des dotations en matériels agricoles, simples au début, leur permettant:

- tout d'abord, de préserver leurs récoltes vivrières actuelles, par des moyens adaptés de traitement et de stockage, ces récoltes étant trop souvent détruites par le climat et les prédateurs;
- ensuite, d'augmenter cette production vivrière et développer les productions exportables;
- enfin, de développer dans des ateliers polyvalents de mécanique la fabrication locale de matériels adaptés.

b. Prendre conscience que, quels que soient leur bonne volonté et leur dynamisme, le problème ne peut être résolu par les seuls industriels des pays producteurs. Aucune petite et moyenne entreprise ne dispose des moyens et des hommes pour être présente partout dans le monde.

c. Il n'y a pas de problème unique, il n'y a donc pas de solution unique. Par exemple, l'idée de la 'motorisation intermédiaire' pour satisfaisante qu'elle soit pour l'esprit, ne répond qu'à certains besoins bien précis. Plusieurs, constructeurs, pour s'y être consacrés, ont connu de graves problèmes.

d. Il n'y a pas de problème technique qui ne puisse être, à court délai, résolu par l'industrie. Le vrai problème est : Quels sont les besoins exacts, qualitatifs et quantitatifs? Y-a-t'il un marché? Est-il solvable?

Pour améliorer la situation actuelle, le CEMA pense donc que les trois clefs sont: information - formation - moyens financiers. C'est-à-dire:

- Une mise en place d'un organisme centralisateur de l'information exacte des besoins par les états demandeurs, et des solutions offertes par les constructeurs.

- Une prise en charge par les états et les grandes organisations internationales de la formation technique minimale des futurs utilisateurs et de ceux qui seront chargés de la maintenance des équipements.
- Une meilleure harmonisation et coordination des actions excellentes déjà menées par ces grands organismes que sont la FAO, l'ONUDI, la CEE etc., mais aussi, individuellement, par les gouvernements nationaux.

General report on the future role of the agricultural machinery industry in developing countries

W. Adema

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INTRODUCTION

For the conference Development of the Agricultural Machinery Industry in Developing Countries, to be held in Amsterdam, 23-26 January 1984, the organizers have invited a number of experts in the field of farm mechanization and agricultural machinery in developing countries to report about the developments in these countries. Thirty-seven contributions were received, to be divided into subject or country of origin as general: 5; Far East: 10; Near East: 5; Africa: 12; Latin America: 5. The reports have already been handed out to the participants of the conference. Subsequently in this document you will find a synopsis of the key items of these 37 reports. Also included are certain supplementary tables and graphs which might be of interest for further study. We have purposely not prepared summaries of the key items of each individual report. In order to be able to present a broad perspective without too many details, the emphasis has been placed on a summary of the most important developments and facts gleaned from all the papers contributed.

GENERAL INFORMATION

The origin of and the motivation for farm mechanization lies in the fact that more and more people have to be fed. The rapid increase in the world population is shown in Fig. 1.

It is evident that the growth of the world population is increasing at a faster rate. In the period up till the year 2000 a further increase of about 2 billion is estimated in the world population. It is estimated that the total world population at the turn of the century will be about 6-6.5 billion, the population growth being mainly concentrated in the developing countries (Fig. 2; Table 1).

As the food supply is already a very serious issue now in many areas of the world, it is clear that the rapidly increasing world population will worsen this situation even further. Therefore much emphasis must be placed on increasing the food supply. Food production can be improved by an in-

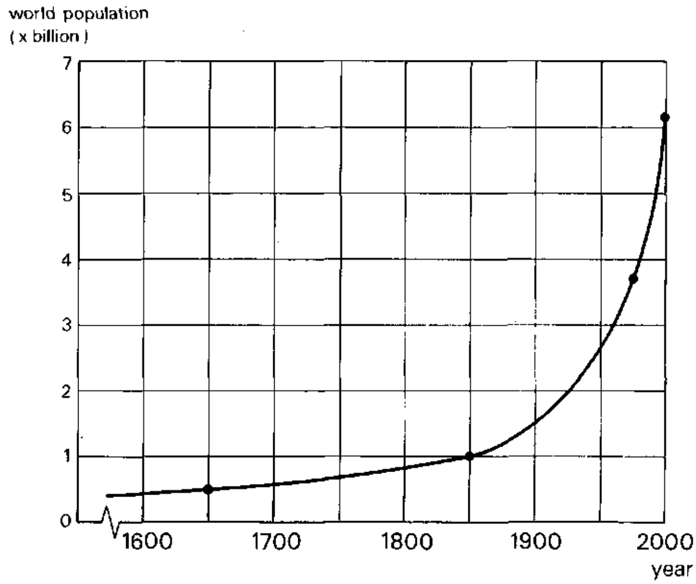

Fig. 1. Growth of world population.

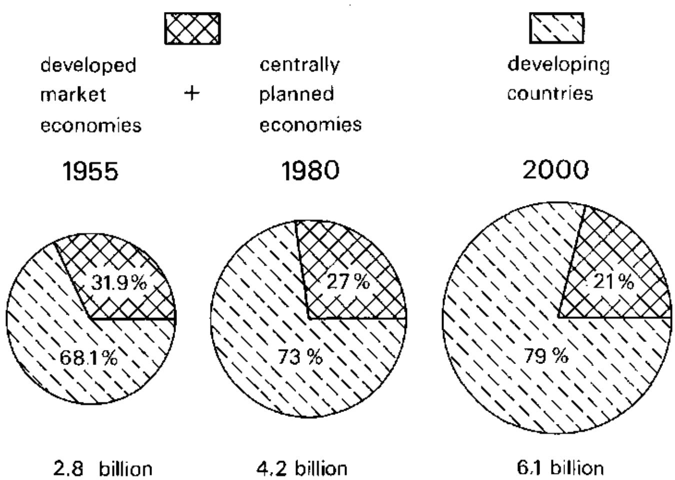

Fig. 2. World population 1955 - 1980 - 2000.

crease in cultivated areas (limited possibilities), and by higher yields per area (better crops, better cultivation and processing). This presentation will concentrate on better cultivation and processing. An indication of the world food production is given in Table 2.

The present volume of the agricultural machinery industry (worldwide)

Table 1. Population growth.

	Growth in millions		Growth in %
	1980	2000	
world total	4 326	6 100	40
developed market economies	786	905	15
centrally planned economies	380	440	15
developing countries:			
Far East	2 200	3 085	40
Near East	220	380	73
Africa	370	680	84
Latin America	370	610	65

Table 2. *Food production per region* (1981).

	wheat (tonne/ha)	rice (tonne/ha)	Average milk production per cow (kg/year)
EEC	4.4	5.4	4 100
The Netherlands	6.7	-	5 104
USA	2.3	5.5	5 510
Japan	3.1	5.6	4 543
Developing Countries			
Far East	1.6	2.3	514
Near East	1.5	4.2	640
Africa	1.0	1.4	361
Latin America	1.5	1.9	951

can only be estimated. Little information is available and when available, the estimates often do not agree. On the basis of the information which is available, we tried to make an estimate of the volume of this industry, and have concluded that it represents a production value of about 35 billion dollars (1980 level). A rough estimate of how these 35 billion dollars are spread over the three geographical areas is given in Fig. 3. From this it appears that the developed market economies account for the largest part of the production. Most of the available statistical information also relates to these countries. With respect to the centrally planned economies and developing countries, statistical information is not available or very difficult to obtain. For these areas we have made a number of estimates based on 'common sense'. The figures must only be regarded as very indicative. It is to be expected that the agricultural machinery industry will increase to a production value of approximately 55 billion dollars by about 1990. The largest growth will probably take place in the developing countries, viz. 160 %.

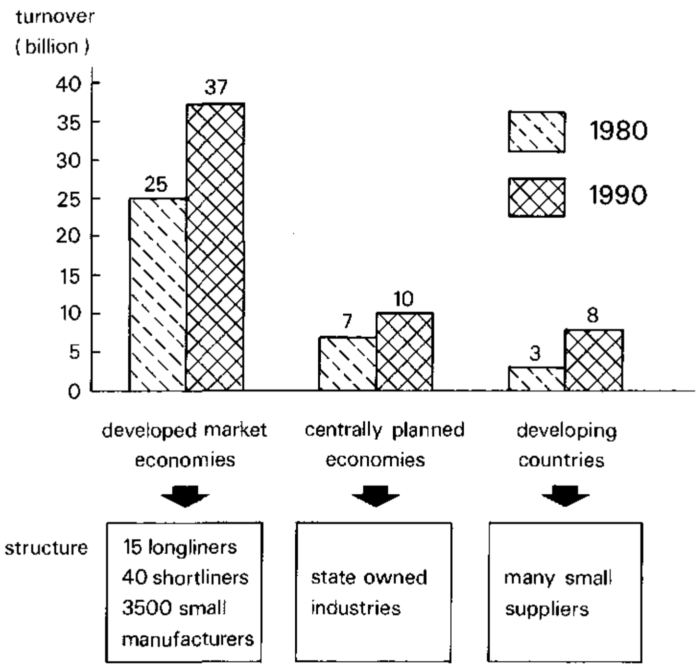

Fig. 3. Development of agricultural machinery industry.

ACTUAL STATUS OF THE FARM MECHANIZATION AND AGRICULTURAL MACHINERY INDUSTRY IN THE DEVELOPING COUNTRIES

An indication of the degree of farm mechanization is to be found in the number of tractors per 1 000 cultivated hectares. Some significant data in this regard are shown in Table 3. Recently the FAO presented a comparison of power input in agriculture in the various developing areas which is of interest in this context (Fig. 4).

Actual status of farm mechanization

1. The rural population fluctuates in the various developing countries from 18 to 85 % of the total working population, indicating large differences per country. The percentage is declining in all countries, which means that people are transfering from agriculture to industry. A similar development took place in the developed market economies at the time of the beginning of urbanization.
2. Most farms are still very small (much less than 5 ha per farm). In many countries the rural population still cultivates parcels of land of less than 1 ha. These small land-holdings hinder a rapid mechanization.
3. In many countries a gradual, and sometimes a fast move from rural area to the urban industrial centres takes places. This development is favour-

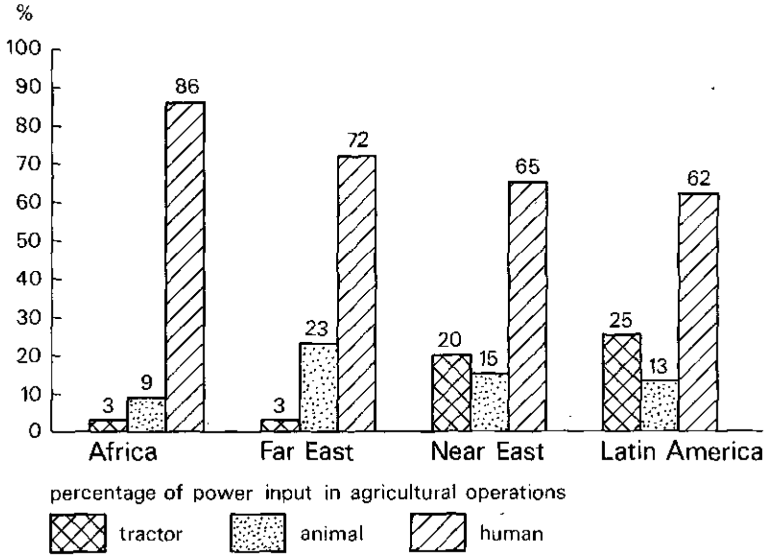

Fig. 4. Indication of mechanization.

able for farm mechanization and the agricultural machinery industry.

4. Sophisticated equipment is mainly imported (from western countries), but

Table 3. Indication of degree of mechanization.

	Number of tractors per 1 000 ha
EEC	51.0
The Netherlands	90.0
USA	23.0
developing countries	
Far East	2.2
Near East	3.5
Africa	1.2
Latin America	5.0

Percentage of civil population employed in agriculture (1981)

	%
EEC	8.1
The Netherlands	5.1
USA	2.2
Japan	11.0
developing countries	
Far East	62.4
Near East	52.3
Africa	68.4
Latin America	33.3

there is an obvious tendency towards manufacturing and or assembling simple machines locally.

5. There are big differences between countries concerning the development and volume of the national agricultural machinery industries. In many countries the national industry consists primarily of very small workshops or companies, which manufacture mainly equipment to be used with animal power. In some countries the local agricultural machinery industry got of the ground as a result of cooperation with an agricultural machinery industry in the developed market economies.

6. It appears that the transfer of 'western' equipment to the developing countries without any modification often results in great disappointments and surprises. In most countries the government underestimates the desire for an active policy aimed at an improvement of the infrastructure, level of education, trainings, etc.

7. In many countries a shortage of labour can be observed during the relatively short harvesting and planting period, which has a stimulating effect on the enhancement of farm mechanization.

8. The quality level of the machinery manufactured by the local agricultural machinery industries is often poor and can clearly be improved.

FACTORS PROMOTING AND HAMPERING FARM MECHANIZATION

Factors (a number have already been mentioned) which have a stimulating effect on farm mechanization and the starting-up of a local agricultural machinery industry are:

1. A fast growing population. An important positive factor in introducing farm mechanization is the rapidly increasing population in many countries. In some countries feasibility studies are being made in order to determine to what extent objectives, goal settings, etc. can contribute to farm mechanization.

2. A scarcity of labour in planting and harvesting periods. This scarcity will increase further during the coming years as a result of the continuous move from the rural areas to the urban centres. Consequently this will result in a strong urbanization, with all the social problems concerned.

3. Government places high priority on self-sufficiency. In most countries government policy strongly concentrates on 'food security' and national self-sufficiency. It is clear that this can only be obtained by having an active policy aimed at farm mechanization. Governments in many countries pay a lot of attention to education, training, seminars, infrastructure, etc. Actually much is being done to improve the situation which favours the possibilities for introducing agricultural machinery. Insufficient education, for example, often turns out to be the cause of machines not being used properly, which has a negative impact on the reliability of the machines. In several countries training centres are being established to

improve the (technical) know-how in the practical use of agricultural equipment.

On the other hand, there are still many factors which hinder the starting-up and further development of farm mechanization and the agricultural machinery industry, among others: illiteracy, a big shortage of skilled labour, an extremely defective infrastructure in many countries, a shortage of foreign currencies, the high purchase price of imported machines, combined with the low income of the farmers, too small farms, and the quality and reliability of the locally manufactured machines.

Apart from the above, the displacement of labour caused by mechanization is a drag on the development of farm mechanization, unless other employment can be created. In addition, high maintenance and repair costs and the very small home market in some countries do not stimulate the starting-up of a local agricultural machinery industry. The developing countries often still depend on the developed countries with respect to technology.

The lack of capital and the high energy costs in many countries do not contribute to a positive development. It often happens that the imported equipment cannot be used for the local circumstances without modifications. The consequence of too rapid unmodified imports is that the machines stand idle. There is a shortage of trained operators, service men and spare parts.

A very important fact is the lack of statistical information. The limited knowledge of agriculture, the lack of clear objectives, a sense of reality, and the real committment are sometimes restrictive factors. The strategy and objectives generally underestimate the actions needed to reach the desired results.

SOME CHARACTERISTIC EXAMPLES

From the contributions received two examples have been taken. One shows how (in Korea) in a reasonably short time (20 years) an agricultural machinery industry can be set up by means of clear objectives, an active government policy and cooperation with another country (Japan) (Table 4).

Table 4. Supply of farm machinery in Korea (in 1 000 units).

	1967		1981	
	produced	in use	produced	in use
power tillers	2.2	3.8	79.5	350.0
tractors	-	-	1.2	3.9
sprayers	2.0	12.8	28.6	262.0
pumps	-	31.6	7.0	219.0
harvesting machines	-	-	3.0	18.0
rice transplanters	-	-	4.1	15.0

Korea

1. Active government policy of farm mechanization intergrated with a general industrialization.
2. Start of program 1960.
3. Annual reduction of rural population from 1968 onwards averages 1.8 %.
4. Present state of agricultural machinery industry:
   5 bigger, integrated manufacturers;
   13 small, specialized manufacturers;
   300 small-scale manufacturers.

The present government policy in Korea is based on:

1. an increased supply and production of quality machinery,
2. utilization of cooperatives,
3. strengthening of after-sales-service, and
4. continuous training and education.

In the contribution about a farm mechanization project in Indonesia a clear warning is stated that a too rapid and unmodified transplantation of western technology can bring along many disappointments. Indonesia is an example of a small-scale farm mechanization project, where small tractors are used in unchanged and unadapted farming conditions. The findings after approximately 5 years of experiments are:

- cost-benefit ratio is negative compared with available human and animal power;
- training, education and restructuring of farming operations, combined with local equipment production, will make mechanization worth-while.

Both contributions show in a clear way how and how not to start-up mechanization programs. As such, both reports are very studious and can also be used as examples for similar projects in other countries. The other contributions also contain very informative examples which, as in this respect fall between the two examples mentioned above.

RECOMMENDATIONS AND CONCLUSIONS

From the reports the following conclusions can be drawn:

- Mechanization is one of the main solutions for solving food problems.
- An integrated approach per country is required for:
  . education and training;
  . improvement of the infrastructure;
  . distribution and marketing;
  . financial support;
  . restructuring of farming operations;
  . starting-up a local agricultural machinery industry and after-sales services.
- Clear objectives are essential.

- Without cooperation with western research and educational institutes and manufacturers of agricultural machinery, mechanization will take too long.

The evolution of farm mechanization in the developed countries took about two centuries. Some developing countries still are at the stage the western countries were 200 years ago. With good intentions only little can be achieved. Clear achievable goals have to set and striven for; these goals have to be the basis on which one proceeds. Further, without cooperation with western research and educational institutes and the agricultural machinery industry, the development to an optimal farm mechanization programme certainly takes many more years (if not decades). This cooperation has a positive effect only when all parties benefit from it.

What can The Netherlands offer in the sense of cooperation with developing countries in relation to the aforementioned integral approach? The facts are that The Netherlands is in agriculture one of the leaders in the world with respect to know-how and output: 25 % of Dutch exports are agricultural and horticultural products. Furthermore The Netherlands is very advanced in the application of highly efficient multiple use, reclamation and drainage/ irrigation technologies. In agriculture The Netherlands is very progressive and very innovative because there is an excellent cooperation between agricultural education, agricultural research institutes and the agricultural machinery industry. What California means for chips, The Netherlands means for agricultural and horticultural development and mechanization, know-how and applications.

An integral approach could be a cooperation between the Agricultural University Wageningen (education and training), IMAG (research and development), Dutch government (financial aid), and the Dutch agricultural machinery industry (transfer of know-how, management support, assistance at starting-up local production, and supply of key components). In a developing country similar institutions could act as a counterpart. Both countries would have to form a small project team based on common sense and a consensus on the goals to be reached. Both countries have to benefit from this cooperation. Such a cooperation will only be successful when the project is clearly described. The project will have to be started up with as a basis a feasibility study, the available statistical information, the clear goals to be reached in a period of 3-5 years, and clear agreements about the responsibility for the project. During the realization period interim go/no go decisions would have to be taken with respect to further progress. Similar projects could be started-up in three to five different countries.

Agricultural mechanization and agricultural machinery manufacturing in Pakistan

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CHARACTERISTICS OF AGRICULTURE

Geographically Pakistan is situated from 61° to 76°E longitude and 23° to 37°N latitude. The climate, soils and habitat etc. differ a lot from one region of the country to another. Physiographically, the country has five distinct zones, viz., (1) mountain and intermountain valleys, (2) pothohar plateau and the adjacent foothills areas, (3) indus plain, (4) sandy desert and sand dune area, and (5) marsh lands. The soil in the mountain and inter-mountain areas in the north consist of mixed glacial, alluvial and colluvial materials. In pothohar plateau there are deep silty soils, developed from extensive deposits, while soils in the indus plains are principally deep alluviums, varying in texture, while soils in the indus plains are principally deep alluviums, varying in texture from sandy to clayey types. In marshy areas the soils are made up of silty detritus accumulations. Climatically, the northern parts fall in the semi-arid zone, where the annual rainfall varies from 500 to 1 000 mm. Most of the plains and the Baluchistan plateau, where the annual rainfall varies from 125 to 300 mm and 125 to 180 mm, respectively, lie in the arid zone. Most of the rainfall in indus plain, is received during the monsoon season, i.e. mid-July to mid-September. Some winter rains are also received in December and January. In northern hilly areas the mean annual minimum and maximum temperature range from -5 to 37 °C, while in semi-arid areas the temperature ranges from 3 to 45 °C. In the arid zone, the temperature ranges between -0.5 and 47 °C, and for Baluchistan it is between -5 to 42 °C.

On the basis of physiography, agricultural land use and water availability, there are 10 distinct agro-ecological zones in Pakistan. The various zones transgress the provincial boundries and in some cases similar zones encompass adjoining areas from three provinces. Within the same ecological zone and even within the same village, there are several categories of farmers - large, medium, small, landless etc. and with different attitudes, traditions, problems, aspirations, and competence in the management of their resources. According to latest estimates there are nearly 5 million farming families, of which 3 million (67 %) are small. A farmer is classified as small if he is cultivating up to 5 ha of land. The small farmer has presented a real challenge to the agricultural mechanization experts in the country. They have extremely low productivity and income. A typical small farmer makes Rs. 2 500/- per ha under irrigated conditions and Rs. 800/- per ha under rainfed conditions in one year.

Pakistan has a total geographical area of nearly 80 million ha, of which 32 million ha is cultivable. At present 20 million ha is under cultivation, of which 14.36 million ha is irrigated and the rest is rainfed. The greater part of the irrigated area (10.95 million ha) depends on canal irrigation, while the remaining is irrigated by tube-wells. The land use and cropping intensity is shown in Table 1. The crops are grown in various sequences with a view to maintain increased farm income, besides soil fertility, and to keep the insect and diseases infestations under control. The sequences generally followed are:

rice-berseem-sorghum/guar-wheat
rice-berseem-sugarcane
sugarcane-cotton-maize-Indian cloves
maize-wheat-millet-turnips
moong/millet-chickpea/lentil
cotton-wheat-moong.

The major crops are wheat, cotton, rice, chickpea-pulses and sugarcane. The country is self-sufficient in wheat and sugar, and is exporting cotton and rice.

Livestock in Pakistan is generally kept in an integrated system of mixed farming with crops, mainly on small farms. Large scale well-organized farms are very few and are mostly maintained in the public sector. The livestock population in various provinces of Pakistan is shown in Table 2. The biggest increase has been in poultry sector, where it has quadrupled in 10 years. There are at present 3 000 commercial poultry farms, producing 52 000 tonnes of meat and 111 000 tonnes eggs in a year. The overall pro-

Table 1. Average land use/cropping intensities in Pakistan.
Source: Pakistan Census of Agriculture (1972).

Unit	Land use intensity*	Cropping intensity**
Pakistan	89	111
NWFP	77	109
Punjab	94	112
Sind	85	118
Baluchistan	59	71

$$* \text{ Intensity of land use} = \frac{\text{cultivated area}}{\text{total cultivated area}} \times 100$$

$$** \text{ Cropping Intensity} = \frac{\text{total cropped area}}{\text{total cultivated area}} \times 100$$

Table 2. Livestock population per 1 000 heads. Source: 1976 Livestock Census.

	Cattle	Buffaloes	Sheep	Goat	Camels	Assess	Horses	Mules	Poultry
Punjab	8 108	7 979	8 037	7 767	338	1 139	286	29	13 783
Sind	2 854	1 834	1 829	4 237	144	373	94	2	6 295
NWFP	3 000	762	3 675	4 686	95	381	29	28	9 708
Baluchistan	684	33	5 075	4 441	212	244	23	2	1 958
Northern area	209	3	321	562	24	20	7	188	289
Pakistan	14 855	10 611	18 937	21 693	789	2 157	439	61	32 033

duction of meat from all sources, including poultry, is 869 000 tonnes, which is one-third of the recommended nutritional level per capita basis.

AGRICULTURAL MECHANIZATION POLICY

The policy is very well explained in the sixth five year plan (1983-1988). The quantum jump envisaged during the sixth plan in the agriculture sector (Table 3) would not be possible without large-scale modernization and mechanization of the agriculture sector. The government has, therefore,

Table 3. Crop production targets (million tonnes).

	Computed benchmarks	Estimate 1982-1983	Targets* 1987-1988	Percentage increase over benchmarks **	
				overall	annual
grains	16.72	17.39	21.80	30	5
wheat	11.80	12.34	15.50	31	5.6
rice	3.31	3.44	4.20	27	4.9
maize	0.97	1.01	1.38	43	7.3
others	0.64	0.60	0.72	12	2.4
cash crops	35.89	33.42	42.07	17	3.2
cotton (lint)	0.82	0.82	1.03	26	4.7
(million bales of 375 lbs)	4.83	4.83	6.07		
sugarcane	35.00	32.53	40.94	17	3.2
tobacco	0.07	0.07	0.10	47	8.0
oilseeds	2.00	2.08	2.86	42	7.3
cotton seed	1.64	1.64	2.07	26	4.7
traditional	0.33	0.42	0.44	42	5.6
non-traditional	0.03	0.02	0.35	1 029	64.4
pulses	0.70	0.71	0.79	15	2.8
grain	0.50	0.50	0.58	18	3.3
others	0.20	0.21	0.21	7	1.4
vegatables and spices	2.61	2.73	5.11	96	14.4
onion	0.45	0.48	0.80	77	12.1
potatoes	0.46	0.52	0.85	85	13.1
others	1.70	1.73	3.46	104	15.3
fruits	2.20	2.68	3.59	63	10.2

* The crop targets used here indicate maximum technological possibilities. Value added in agriculture for GDP computation is, however, based on more conservative estimates in certain cases.
** Discrepancies may occur as a result of rounding.

decided to shift, as expeditiously as possible, from bullock-based farming to tractor-based farming. The tractors with power ratings of 30 kW and 20 kW have been recognized to be suitable for Pakistan agriculture. At present, there are nearly 125 000 tractors operating in the country. Nearly 90 % of these tractors are of 30 kW size. In order to mechanize small and the medium farms in Pakistan the government has decided to import and progressively manufacturing small tractors (20 kW). It is envisaged that nearly 50 000 small tractors per year will be imported or produced. By the end of 1988, these efforts will bring the total fleet of operational tractors to 337 000. It is worth noting here that 5 plants for the production of medium-size tractors have been sanctioned and 2 plants for small tractors are being negotiated.

While increasing mechanization conjures the idea of creating labour surpluses, in practice this is not necessarily so. The speedy cultivation and crop sowing, made possible by modern farm equipment, in fact has intensified production, increased and diversified labour role, and in many cases contributed to population growth control through acceptance of birth control measures. Customs of hiring labour from the farms to the towns and overseas has eliminated any semblance of controversy, and increased mechanization has become a necessity for the farmer also.

With the provision of modern farm equipment through import and local manufacturing, the government of Pakistan is establishing an agro-services network. The position paper on the subject has been finalized and the project proposal is now in the pipeline. The project envisages to set-up complete and up-to-date nation-wide repair, maintenance and rental services for modern farm equipment in the public/private sector. The agro-services have also been charged with the responsibility of advising and training of farmers in the use of modern farm equipment.

At present only 15 000 out of nearly 50 000 villages in Pakistan have electrical power supply. It has been recognized by the government of Pakistan that electrification has significantly improved the rural life and is a catalyst in the promotion of farm mechanization. Therefore, in the sixth five year plan, an ambitious rural electrification programme has been chalked out. The programme calls for electrification of nearly 4 000 villages per year. Closely connected with this is the programme of rural roads. The Government of Pakistan has decided that the programmes of rural electrification and road shall work together. The electrified village will be linked by a road to the nearest agricultural market. This will ensure efficient transportation of farm produce and inputs. Other programmes to ensure supply of drinking-water, creation of health and education facilities, and housing for the rural population in Pakistan, also have been approved and launched.

It is worth mentioning here that Pakistan has a National Board of Agricultural Mechanization. The board is headed by the Federal Food and Agriculture Minister, and carries the representations of manufacturers, planners, researchers, educationists, farmers, and chamber of industry and commerce. The board is the highest decision making body as far as agricultural mechanization is concerned. The board has also appointed two sub-committees, namely the Farm Machinery Standardization Committee and the Farm Mechanization Promotion Committee. The farm machinery standardization committee takes care of the standardization of farm equipment in the country and advises the board on the selection of farm machinery to be imported. The Farm Mechanization Promotion Committee is charged with the responsibility of advising and preparation of background documents for consideration and approval of the board. Farm Machinery Institute serves as technical arm to both of these committees.

AGRICULTURAL MACHINERY MANUFACTURING

There are nearly 500 agricultural machinery manufacturers in Pakistan; 460 are small, 32 medium and the rest is large. The assests (exclusive land and building) of a small manufacturer are limited to Rs. 5 million, whereas the medium manufacturer has assets of more than 5 million and is making up to 5 different farm machines. The large manufacturers exceed the preceeding limits.

There are five makes of tractors which are being locally assembled or manufactured in the country. These are Massey Ferguson, Fiat, INT, Belarus and Ford. The farm implements/machines currently manufactured in the country are: cultivators, scraper rear blades, land levellers, border discs, ditchers, cultivators, mold board ploughs, discs, disc ploughs, disc harrows (imported discs), seed-cum-fertilizer drills, cotton/maize planters, potato planters, peanut planters, manually and power-operated knapsack sprayers, tractor-mounted sprayers, reaper-windrowers, cutter-binders, combines and threshers.

The major centres of farm machinery manufacturers are marked in Fig. 1. These manufacturers have the capability of making all types of farm machines, provided the proper materials are readily available, Table 4 shows the 1982-1983 estimated sales volume of both locally manufactured and imported farm machines, and gives an idea of the contribution of local farm machinery manufacturing industry to the country economy.

The government has provided several incentives to the farm machinery manufacturers, such as exemptions from income tax, refund of custom duty paid on the import of raw materials, and permission of importing workshop machines, etc. These incentives have helped in rapid expansion of the local farm machinery manufacturing industry in the past decade.

The farm machinery manufacturing capability of the country is not fully utilized. Some areas require strengthening and/or improvements. The research and development facility (R & D) is almost non-existing in this

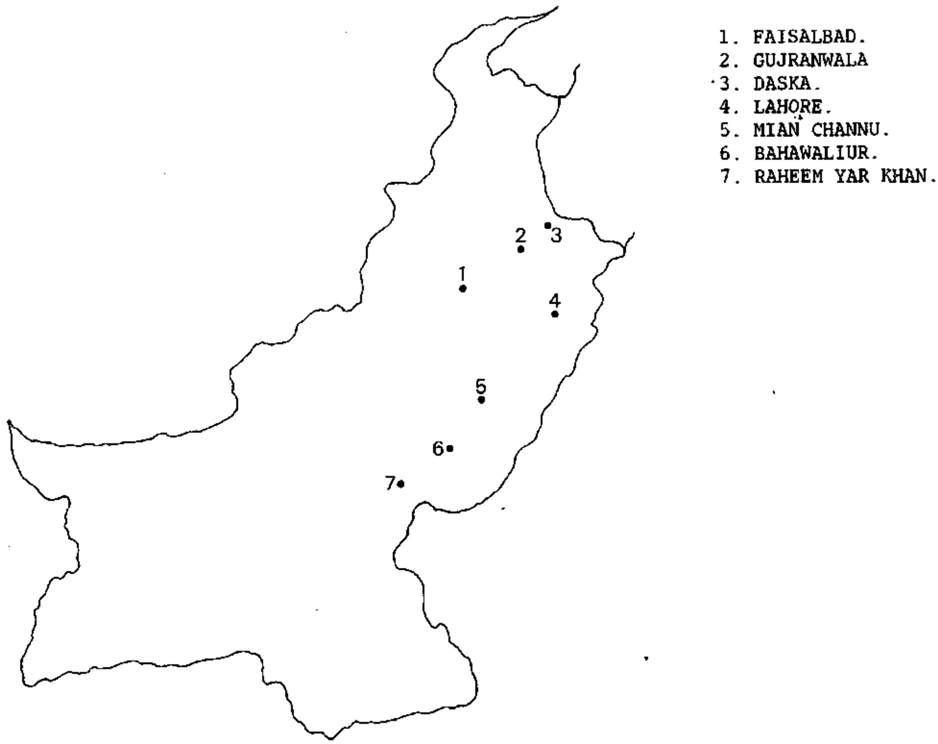

Fig. 1 Major farm machinery manufacturing centres in Pakistan.

industry. There are only a few large farm machinery manufacturers who have separate R & D sections in their premises, whereas the rest of the manufacturers do not have even a single person on their staff who can read a drawing, or consult a reference book or a guide on design. The graduate engineers or qualified technicians prefer government or semi-government jobs. The training they receive in these positions is mostly administrative and very little technical. Therefore, the performance of engineers have not impressed the manufacturers and they are in general reluctant to hire them. Due to lack of participation of graduate engineers or qualified technicians, the R & D activities are minimal and is affecting the commercialization of new farm machines developed by the farm machinery research institute, as local manufacturers do not have ability to read drawings and the institute is not in a position to supply prototypes to all of them.

The government incentive of establishing design and development facilities is limited only to exporting industries. As mentioned earlier, the majority of the farm machinery manufacturers is small and is not in a position to export their commodities. In order to benefit the group from government R & D incentive and to promote R & D facilities in the country, the export condition has to go.

Table 4. Sale of locally manufactured and imported farm machines/implements.

Farm machines/implements	Origin	Local content (%)	Unit price (Rs.)	Quantity sold* (1982-1983)
tractors				
Belarus MTZ-50 (55 hp)	USSR	25	93 000	600
Fiat-480 (50 hp)	Italy	15	101 750	6 000
Fiat-640 (64 hp)	Italy	-	146 800	400
Ford-4610 (62 hp)	UK	-	126 000	410
Ford-3610 (50 hp)	UK	-	112 000	11
IMT-560 (64 hp)	Yugoslavia	-	98 600	305
IMT-540 (52 hp)	Yugoslavia	40	76 400	3 740
MF-2 (62 hp)	UK	-	115 000	1 500
MF- (47 hp)	UK	40	85 000	7 769
MF-210 (25 hp)	Japan	-	57 000	300
power tillers				
Dung-Fong (12 hp)	Peoples Republic of China	-	24 300	100
land development implements				
front blade	Pakistan	100	4 900	270
rear blade	Pakistan	100	1 800	5 400
land leveller	Pakistan	100	2 700	200
cultivator	Pakistan	100	3 200	23 000
cultivator	UK	nil	8 000	60
planting implements				
seed drill	Pakistan	100	4 100	1 250
seed drill	Denmark	nil	12 000	22
maize and cotton planter	Pakistan	100	5 000	618
groundnut planter	Pakistan	100	3 900	14
ridger	Pakistan	100	3 700	444
ridger	UK	60	7 500	26
post hole digger	UK	nil	16 250	15
potato planter	Pakistan	100	3 500	107
weeding and hoeing implements				
bar harrow	Pakistan	100	2 600	180
sprayers and broadcasters				
power sprayer	Pakistan	100	11 000	177
power sprayer	Italy	nil	15 000	3
scraper	Pakistan	100	11 000	170
plank (iron)	Pakistan	100	1 100	20
border disc	Pakistan	100	4 100	164
border disc	UK	60	5 000	20
ditcher	Pakistan	100	3 000	71
primary tillage implements				
M.B. plough	Pakistan	100	4 400	250
disc plough	Spain	60	17 000	43
chisel plough	Pakistan	100	3 600	520
chisel plough	Spain	nil	8 000	25
rotavator	Italy	nil	15 000	25
rotavator	Yugoslavia	nil	16 000	250
rotavator	West-Germany	nil	12 000 - 16 000	240
sub-soiler	Pakistan	100	1 800	55
secondary tillage implements				
disc harrow	Spain	60	4 500	175
disc harrow	Yugoslavia	nil	7 100	50
disc harrow	Australia	nil	11 000	15
wheel-barrow sprayer	Pakistan	90	3 500	10

Farm machines/implements	Origin	Local content (%)	Unit price (Rs.)	Quantity sold* (1982-1983)
harvesting machinery				
reaper-windrower	Pakistan	100	14 000	461
combine harvester	Denmark	nil	115 000	33
potato digger	Pakistan	100	5 700	19
groundnut digger	Pakistan	100	3 500	155
threshing machinery				
wheat thresher	Pakistan	100	16 500	12 300
multicrop thresher	Pakistan	100	21 000	16
sunflower thresher	Pakistan	100	11 000	63
maize sheller	Pakistan	100	4 100	80
handling and haulage machinery				
trolley	Pakistan	100	12 000	12 800
others				
cane crusher	Pakistan	100	1 900	17 700
chaff cutter	Pakistan	100	600	20 000
manure spreader	UK	nil	196 967	1
grain dryer	USA	nil	140 000	7
sugar extractor	Pakistan	100	1 200	10
p.t.o. pulley	Pakistan	100	950	2 000
pump	Pakistan	100	2 500	3 300
diesel engine (high speed)	China	60	8 500	802

* The sales figures for imported items are actual, while those for locally produced items are projected from a limited survey carried out by the Farm Machinery Institute.

The purchasing and storing of raw and manufacturing materials and parts is a very important activity in a manufacturing concern. This activity is to be managed in such a way so that financial resources of the company are not strained and the manufacturing process does not slow down. The majority of the farm machinery manufacturers do not have training and experience in this respect. Their purchasing activity is either very hectic or they do it at the eleventh hour. The storage space is often very poorly arranged, and the record is about non-existent. The result is that it is difficult to trace out the required materials and/or parts. Often there is only one person entrusted with the job of store. In case the person is on leave or absent, great difficulties are encountered.

The manufacturing machines and the buildings of most of the farm machinery manufacturers are outdated. To update these facilities capital is required, and in many cases no outlet for the sale of used machinery, furniture, etc. is available. The approved plans for constructing a modern manufacturing facility incorporating safety features, use of local materials, etc. are not available. The present situation is that workers of farm machinery industry are working under unsafe conditions with inefficient machines. This activity is poorly managed by the local farm machinery manufacturers. It is common that manufacturers make exhorbitant profits.

They vary the prices from customer to customer and do not care to set-up a dealer net-work. No manufacturer in the country issues warranty certificates. The farmers generally feel that in spite of the virtual absence of taxes on the farm machinery manufacturing industry, the prices none the less are high. The manufacturer who is also the dealer/distributor does not care to arrange credit to the farmer for the sale of his machine. The main reasons for all this are poor education and lack of business-like attitude of the manufacturer. The manufacturers do not provide any literature such as an operator's manual or a spare parts catalogue alongwith the machine at the time of sale. The farmers face a great difficulty in proper adjustment, maintenance of the machines, and procurement of spare parts. The result is earlier poor performance or break down of a machine.

The marketing sector is completely ignored by this industry. The field demonstration of various locally manufactured field machines is being handled by research institutes in the country. Similarly, the demand surveys of farm machines are also being conducted by the research institutes. As a matter of fact such activities should be undertaken by a farm machinery manufacturers association. In Pakistan, such an association does exist, but it is not yet functional and effective. There is a need to activate this association for the promotion of this industry in the country. The Farm Machinery Institute is playing here an active and leading role.

The Agricultural Development Bank of Pakistan (ADBP), the Industrial Development Bank of Pakistan (IDBP), the Pakistan Industrial Credit and Investement Corporation (PICIC), the National Development Finance Corporation (NDFC), and most of the commercial banks provide loans to the manufacturers. The rate of interest of these financial institutions varies from 9 % to 15 %. The manufacturers generally consider this too high. Besides this, the procedure for obtaining these loans is quite lengthy and complicated. Since the production of farm machines is a not so profitable business as compared to the manufacturing of some of the other products, the manufacturers take a long time in repaying these loans. As a result, they have to pay more than twice the amount, initially borrowed. In addition, this industry carries a high risk of failure, hence, there is an urgent need to provide loans for the farm machinery manufacturers on low interest rates, i.e. 5-6 %, during the initial stages of the development.

All credit institutions require a feasibility study from the manufacturer to ascertain the profitability of the business venture, so that loan recovery is certain. Such studies cannot be prepared by the manufacturer, due to low educational standards of the majority of them. They also cannot hire a consultant, since none working in Pakistan specializes in this activity. In the absence of a feasibility report, the credit institutions provide credit against collateral, and usually the manufacturer cannot arrange collateral to match the required credit.

AGRICULTURAL MECHANIZATION INFRA-STRUCTURE

The infra-structure falls into the categories of educational, research, vocational training, service and extension institutions. There are three universities in the country awarding BSc. degree in agricultural engineering; they turn out 100 graduates annually. Today only one university has started a MSc. programme in agricultural engineering. Two universities are offering BSc. degree in agricultural mechanics; they turn out approximately 25 graduates annually. There are three institutes in the country awarding diploma in auto and farm machinery, and approximately 50 persons qualify each year. There are three research institutes in the country. All of them have been established in the recent past (less then 10 years). They are: the Farm Machinery Institute (FMI), Islamabad, the Agricultural Mechanization Research Institute (AMRI), Multan and the Agricultural Mechanization Research Cell (AMRC), Hyderabad. FMI coordinates the activities in agricultural mechanization research, and is the focal point of international cooperation. An agricultural mechanization research institute in NWFP and one in Baluchistan will be established soon. In addition, four testing sub-stations at various places in the country are being established by FMI with the assistance of the World Bank.

There are a dozen institutions in the country which offer vocational training and turn out tractor mechanics, operators and workshops technicians. Three large farm machinery manufacturers have the necessary infrastructure to impart short-term training (up to 3 months) to farm machinery operators and farmers, etc. Only a few farm machinery manufacturers (only five of them) maintain a dealer network on nation-wide basis. They provide after-sale service, repair and parts through their dealer. The rest of the manufacturers do not maintain any dealer network, and instead sell parts to handware stores around the country. These stores can only provide parts supply to the farmers, but cannot render service or repair facility. The service usually is provided by a local workshop, often run by unqualified mechanics, poorly equipped and built. Therefore, most often the service is unsatisfactory, and hence make the farmers unhappy.

The agricultural mechanization extension activities fall into two categories, viz. industrial extension and agricultural extension. Industrial extension is aimed at manufacturers and is carried out by research institutes. FMI enjoys great respect and good relations with the farm machinery manufacturers in the country. Help and guidance is provided in manufacturing and field testing of farm machines. In many cases help in design improvement, workshop layout, store reorganization and staff training has been provided by the Farm Machinery and other provincial research institutes.

Agricultural extension in farm mechanization is rather poorly staffed and organized. As a matter of fact this activity is the responsibility of provincial governments. FMI and provincial institutes are playing their role through demonstration, field days, newsletters, radio and T.V. programmes, no opportunity is allowed to go unavailed as far this aspect is concerned. Recently FMI has launched mechanization cultivation trials at farmers field on limited scale.

CONCLUDING REMARKS

Today every one concerned in Pakistan is not only familiar with farm mechanization, but also supports this activity whole-heartedly. The major constraint is the qualified, experienced and responsible man-power. The government of Pakistan is extremely responsive and has provided maximum support to all viable activity in the area. The Pakistan Agricultural Research Council has arranged a crash training programme to overcome the problem of man-power shortage. As the man-power situation improves and infrastructure gets strengthened, the farm mechanization role in the improvement of Pakistan agriculture will be considerable.

Agricultural mechanization in Korea

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PROGRESS AND PRESENT STATUS OF AGRICULTURAL MECHANIZATION

General information in agriculture

Of the total 21 800 000 ha of the cultivated land about 60 % is comprised in the paddy-fields and the remaining 40 % is upland. Rice and barley are the main grain crops in the nation. Only about 25 % of the paddy-land is used for barley production as the double crop.

The land-holdings per farm household in Korea average only about 1.35 ha. About 37 % are between 0.5 and 1.0 ha, about 30 % are smaller than 0.5 ha, and 33 % are larger than 1 ha.

The annual average rainfall in Korea is about 1 200 mm. About a half of the total rainfall occurs during July and August. Because of the insufficiency of water volume by rainfall only, it is sometimes required to pump water during the transplanting and rice producing seasons.

The Republic of Korea has achieved an epoch-making annual economic growth rate of 8.3 % with the successful implementation of four consecutive Five-Year Economic Plans during the last two decades. In the course of modernization of national economy the socio-economic conditions of rural areas have been also remarkably changed. At the end of 1981 the farm population approached 10 million, which correspond to about 25.8 % of the total population. The reduction of rural population in the past 10 years has been very rapid, averaging about 1.8 percentage points reduction per year. This brought the shortage of rural labour especially in the two peak labour demand periods in spring and autumn. The decline of rural labour also caused a rapid increase of rural wage, and thus of the cost of farming.

Progress of farm mechanization

The beginning of farm mechanization in Korea may be the early 1960's, when the power tiller was first introduced to the Korean farms. It was the first attempt to operate the farming function by use of the powered machinery. There were some kinds of powered farm machinery used on farms before the 1960's, however, none of these were classified as field machinery.

The farm mechanization development for about 20 years history can be divided purposely into two phases based on diffusion of required machinery and major government policy of farm mechanization. The first phase, the infancy of the farm mechanization, was from 1962 to 1976, in which three Five-Year Economic Development Plans were executed. The second phase, the rapidly promoting period of farm mechanization, was from 1977 to date, in which the fourth Five-Year Economic Development Plan was enforced and the fifth Plan is now underway.

Due to successful execution of the first two Five-Year Economic Development Plans the growth of non-agricultural sectors with light industries out-paced the agricultural sector. This resulted in decreasing the rural population with the expansion of employment opportunities in cities. Accordingly, from 1968 not only an absolute decrease in the farm household population proceeded, but also with the establishment of policy objectives for concentrated development in the farm mechanization project were pushed ahead in real earnest.

The first national agricultural mechanization programme was launched with enforcement of the second Five-Year Economic Development Plan (1967-1971), and efforts were concentrated on dissemination of water pumps and power sprayers.

The farm mechanization project was formally included in the third Five-Year Economic Development Plan (1972-1976). As the postulate for farm mechanization was fully matured from this period, along with the positive support of the Government, the supply of various machinery during the decade of 1970 was accordingly increased. Major machinery supplied in the early 1970's were power tillers, water pumps, power sprayers, and threshers. However, these farm machinery did not much contribute to the reduction of two peak labour requirements in spring and autumm. This was the reason why such machinery as the rice transplanter, barley seeder, binder and combine harvesters were included in the items with a high priority supported by the Government. The supply of farm machinery by year is shown in Table 1.

Present status of farm mechanization

As stated above, major farm machinery being used from soil preparation operations to harvesting in the rice farming can be seen on farms. However, a still quite limited number of them is disseminated, and thus the contribution to the mechanized agriculture may be partial. In addition, there are many other areas besides the grain crop farming (livestock, vegetable and fruit, etc.) for which the farming functions may be relatively primative and open a wider room for a variety of farm machinery.

The degree of farm mechanization can be expressed in terms of the human-, animal-, and mechanical-power inputs per hectare (PIPH). The PIPH may not be accepted universally to be used as a gross index for expressing the progress of farm mechanization, however, it has been recognized as a good index for the comparison of the similar-type agriculture among different

Table 1. Supply of farm machinery by year (in 1 000 units).

	1967		1971	
	supply	possession	supply	possession
power tillers	2.2	3.8	5.0	16.8
tractors	-	-	-	0.2
power sprayers	2.0	12.8	26.3	59.4
water pumps	-	31.6	-	59.9
harvesting machines	-	-	-	-
rice transplanters	-	-	-	-
other	-	26.5	-	63.3
total	4.2	74.9	31.3	207.8
	1976		**1981**	
	supply	possession	supply	possession
power tillers	42.0	122	79.5	350
tractors	0.2	0.8	1.2	3.9
power sprayers	30.4	164	28.6	262
water pumps	13.7	86	7.0	219
harvesting machines	-	0.2	3.0	18
rice transplanters	-	-	4.1	15
other	6.2	147	15.5	471
total	92.5	520	138.9	1 205

regions and countries. The present PIPH in Korea is about 1.5, which may be advanced a little compared to the break-point between the developing and developed agricultural countries. It may be noticed that the rate of change of the PIPH for the recent years is in remarkably increasing trend, giving about 0.214 on an average.

Soil preparation work (ploughing, harrowing, etc.) is done mostly by use of mechanical power. Manual means in water pumping and spraying operations presently are rarely seen. Most of the power sprayers are of the self-propelled type. On the other hand, almost all the pumps use the power tiller as the prime mover.

One of the important characteristics of present mechanization can be seen from the progress in the mechanical power input in the farming operations of two seasons which require the peak labour. At the end of 1981 the proportion of the paddy-field covered by the disseminated rice transplanters was about 6 %, by the binders and combines about 9 %, and by the grain dryers less than 1 %.

SUPPLY/PRODUCTION OF FARM MACHINERY

Farm machinery production/supply system

Development of farm machinery manufacturing in Korea can be stratified into two stages. The first stage was up to 1976. By the time the government offered the licence of a specific farm machinery manufacturing to only two manufacturers. We may refer to this as the dual manufacturer-supply system. The licensed manufacturers had been fostered considerably under the planned production assigned by the government supply plan. However, the system was criticized in that the licensed manufacturers did not make much effort to the product localization and after-sale services.

To remedy the problem it was inevitable to intensify the competition among manufacturers. This was why the second stage of system of the government production/supply of farm machinery was newly formulated and enacted in 1977. In the new system manufacturers are divided into two classes: the integrated farm machinery manufacturers (IFMM) and the specialized small- to medium-sized manufacturers (SSMSM). There are three basic requirements to belong to the IFMM class: (1) the manufacturer should produce internal combustion engines for agricultural use in addition to at least one item of farm machinery classified in the IFMM, which includes power tillers, farm tractors, rice transplanters, binder harvesters and combines; (2) those which satisfy the facility, man-power, and quality control requirements separately set by the government, and (3) the products must pass the national inspection test. Presently there are five manufacturers in IFMM class.

The manufacturers belonging to the SSMSM class are generally smaller in manufacturing capability, but should obtain the licence from the government. They can get a licence to manufacture at least one of the items classified in the SSMSM category (grain dryers, power sprayers, power threshers, and water pumps) if the company fulfils various requirements set by the government. Thirteen manufacturing companies are presently classified in this category.

Besides the government-licensed manufacturers, it is estimated that there exist more than 300 small-scale factories which manufacture mainly small tools, simple farm machinery such as the semi-auto thresher, various processing machines, and agricultural machinery parts. However, the sales volume of these unlicensed factories are very small.

Farm machinery localization

The domestic production of the modern agricultural machinery in Korea may have only about 20 years in history. It was in the early 1960's when Dae Dong Industrial Co. began to assemble the power tiller with partial use of locally manufactured components and parts under the technical cooperation with a Japanese company. It was the first attempt for a local manufacturer to produce modern powered farm machinery.

It may be noted that agricultural machinery production in Korea has been in general developed by following many stages. In the first stage of the supply of farm machinery it was imported as knock-downs. Based on the agreement between the domestic supplier and the foreign technical-cooperative manufacturers the farm machinery is locally assembled mostly with the imported components and parts and some locally manufactured. A domestic manufacturer makes copies of the components and parts according to manufacturing drawings and technical guidances offered by the counterpart foreign manufacturer. It takes a long period to attain full localization. For instance, it took about 10 years to reach nearly 100 % localized production of power tiller. The design changes of the localized power tillers were rarely expectable before a complete localization. The completely localized model with design change of many components and parts can be seen presently in some domestic products of power tillers.

Many powered agricultural machinery supplied in Korea has been kept up about the same process as the power tiller. Localization ratio of major farm machinery at the end of 1982 is about 43-55 % for tractors, 28-37 % for rice transplanters, less than 30 % for binders, and none for combines.

FARM MECHANIZATION POLICY AND STRATEGY

The Government policy in the pursue of farm mechanization is well presented in the Agricultural Mechanization Promotion Law, which was enacted and promulgated in 1979. The Law was enacted as a device which could integratedly, systematically and consistently push shead the farm mechanization programme, such as the production, supply and utilization of farm machinery, creation of funds, inspection, research and development, etc., thus firmly establishing a project-propulsive system.

Basic policy of the government for the promotion of agricultural mechanization may be divided into four areas: (1) extended supply and production of quality machinery; (2) establishment of the cooperative utilization systems to maximize the use of disseminated farm machinery; (3) strengthening of after-sale service, and (4) enlargement of training facilities and strengthening of farmers training.

Supply/production policy and strategy

The government set up the overall goal of farm mechanization by 1987 as a part of the fifth Five-Year Economic Development Plan. As stated above the plain field mostly consists of paddy-land, and about a half of the upland will be fully mechanized. Major farm machinery to be supplied will be power tillers and their attachments, and those machineries with emphasis on the reduction of the peak labour requirements, such as rice transplanters and various harvesting machinery. Large-sized machinery, such as tractors and their attachments, combines etc., is also going to be supplied for the large-size farming in plain area and for the cooperative utilization. Supply plan by year is given in Table 2.

To achieve the goal of farm mechanization the government is strengthening the enterprise-oriented supply system by which the competition of products

Table 2. Supply plan by year.

Type of machine	Possession at end of 1982 1 000 units	Supply plan by year					Possession at end of 1987
		1983	1984	1985	1986	1987	
power tillers	422	78	80	85	85	80	525
tractors	6	2.5	3.5	5	5	15	35
rice transplanters	20	5	6	10	15	20	60
seedling machines	3	1	2	3	4	20	60
combines	4	2	5.5	7	10	15	40
binders	17	4	7	15	20	20	80
mowers	-	5	10	20	27	8	70
sprayers	171	25	25	25	25	30	200
power sprayers	232	13	10	10	10	10	190
thresher	254	10	10	10	12	10	220
dryers	2	1	2.5	4	6.5	12	30
water pumps	246	10	10	10	10	10	180
total	1 377	-	-	-	-	-	1 795

and after-sale service among the manufacturers could be induced. The government financing to support local manufacturers and the farmer as the end-user is also planned. It is very important to achieve the full localization of all the agricultural machinery as early as possible from the view-points of not only the national economy, but also the stable supply of machines and repair parts. Thus, the government established a farm machinery localization plan, which specifies the yearly minimum target and final year of the localization for major agricultural machinery.

One of the most important policies in pursue of farm mechanization may be the Government loan provided for purchase of agricultural machinery. Total amount of loans yearly allotted is a little over US $ 0.2 billion. Farmers can apply for the loan in the purchase of the farm machinery designated to be disseminated by the government. The loan conditions, such as the pay-off period, interest rate, and the credit proportion to the machinery price, differ by machinery and are subjected to change by year. The loan conditions by farm machinery in 1983 are shown in Table 3.

Cooperative utilization policy and strategy

Maximizing the utilization efficiency of the farm machinery already disseminated may be important especially in small-scale farmings like those of Korea, for the average farm here is much smaller than the optimum coverage of a powered machinery capacity with even its smallest size. The selection of a large-size machinery without any plan to make use of its full capacity would result in over-investment, which may be undesirable as viewed from the machinery owners as well as national stand-point. Thus, the government policy is aimed at maximizing the use of farm machinery capacity disseminated and at preventing in advance over-investments.

The government strategy for the strengthening of the cooperative utili-

Table 3. Loan conditions for purchase of farm machinery in 1983.

Items	Number of machinery to be supplied	Conditions of loan*			
		% of credit	grace period	pay-off	interest rate
power tillers	78 000	70-100	2	5	10
tractors	2 500	80	2	5	10
power sprayers	25 000	70	2	3	10
mist and dusters	13 000	70	2	3	10
water pumps	10 000	100	2	3	10
rice transplanter	5 000	100	2	3	6
binder harvester	4 000	90	2	3	6
combine	2 000	90	2	5	6
thresher	10 000	70	2	3	10
grain dryer	1 000	100	2	5	10
barley seeder	1 000	100	2	3	10

* Total amount of loans: 149,3 billion won (US $217,950 thousands).

zation is to enlarge the village-based Saemaul Mechanized Farming Group by establisling 14 600 groups by 1987, which may correspond to about one group in each village. The guidelines applied for the establishment of the group are: (1) its core members should be composed of the Saemaul youth-club members; (2) the group should not be organized indiscriminately and should reflect the peculiar regional conditions, and (3) the farm machinery owned by the group should be used for the custom work as well as for the member.

After-sale service system

With the propulsion of a full-scale agricultural mechinization project, an intensified after-sale service system is being considered of utmost importance to maximize an efficient use of machinery already disseminated. There were many instances that lack of repair facilities, supply of parts, etc. caused inconveniences in the utilization of farm machinery.

As was the case with the supply system, the after-sale service system for farm machinery was dualized with the local NACF and the private repair centres. 807 service centres of local agricultural cooperatives and 709 private repair centres were established at Eup or Myon level basis at the end of 1981. Also, in order to secure smooth supply of parts for after-sale service the manufacturers and suppliers were bound to produce and supply a fixed quantity of parts according to the number of machines they have supplied. Further a parts-security responsible system is being enforced by systematic linkage from provincial parts centres to Eup or Myon village service centres and repair shops through city/country local agents. Besides, 12 billion won of parts-security fund to support the private service centres are being put in operation, which could be used for the stocks of parts and improvement of repair facilities.

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Present state of agricultural mechanization in the Philippines

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AGRICULTURAL MECHANIZATION SITUATION

The Philippines is an agricultural country, although its national economic goal is to achieve a balanced agro-industrial development. It has a total land area of 30 million ha. Of the 8 217 510 ha planted to food crops, rice accounts for 3 503 050 ha and corn for 3 318 670 ha. Commercial crops are planted in 3 905 890 ha, of which 3 145 260 are planted to coconut and 424 620 ha to sugarcane.

Farms are rather small, averaging about 2 ha per land-holding. The degree of mechanization, which can best be expressed in terms of power input to Philippine farms, is only 0.2 hp/ha, compared to Japan's 3.0 hp/ha and U.S. of 1.0 hp/ha. Sugarcane employs the highest degree of mechanization, while coconut farming is barely mechanized. It is estimated that there are about 5.0 million work animals, which will ultimately have to be replaced by mechanical power.

The industry imported US$ 37 million worth of agricultural machinery and equipment in 1979, US$ 25 million worth in 1980, and US$ 28 million worth in 1981 (Table 1). Due to declining market importations for 1982 and 1983 have further decreased. Very limited exports are being undertaken. These

Table 1. Importation of agricultural machinery and tools. (x 1 000 $). Source: AMMDA, National Census and Statistics Office.

machines/tools	1979	1980	1981
tractors	4 564	5 389	3 086
power tillers	1 384	376	458
implements (ploughs, harrows, etc.)	2 448	1 392	2 032
planting/weeding equipment	129	161	705
engines	17 184	5 888	8 353
pumps	2 656	1 098	3 156
harvesting equipment	541	--	254
post-harvest equipment (threshers, rice mills, etc.)	6 693	7 492	8 598
sprayers	2 269	1 856	1 238
total	37 328	24 660	27 881

are principally in intermediate technology agricultural equipment such as power tillers, threshers, batch dryers, rice reapers, etc. which are exported to neighbouring Asian countries and Africa.

Agricultural mechanization has developed from the manual to animal-draught power stage to intermediate technology stage. Such development has been affected by the following factors:

1. Farmers have very low purchasing power, hence, find difficulty in buying machinery.
2. Land is fragmented, 1-2 ha on average, and cooperatives are not very strong.
3. Manufacturing is limited to intermediate technology like: implements, threshers, sprayers, batch dryers, low-head pumps, simple power tillers, and others.
4. Complicated machinery like tractors, combines and others are imported from developed countries like the United States, Japan and Europe.

The following changes are being experienced:

1. Transformation from manual to work animals to low technology equipments, like the use of simple power tillers and threshers, specifically those designed by the International Rice Research Institute (IRRI).
2. Recent demand for agricultural machinery had diminished in volume due to high energy cost and high cost of the machinery itself.
3. In many cases the average horse-power had been reduced due to the high cost of machinery and the fragmented lands due to government land-reform programme.

GOVERNMENT POLICIES AND PROGRAMMES

NEDA policy

In line with its policies and strategies for a balanced agro-industrial economic development, the National Economic Development Authority (NEDA), in its Five-Year Development Programme indicates that mechanization will be applied on a selective basis and will be adopted to local conditions and available resources. This policy follows the 'appropriate agricultural machinery concept' pursued by many developing countries with abundant labour, but scarce capital.

Determined efforts are being undertaken by government to develop the engineering and metalworking industry sector, of which agricultural machinery is a part. Several measures designed to provide encouragement of new industries in the agricultural machinery sector are being implemented or being considered.

BOI incentives

The government's Board of Investments (BOI) has listed agricultural machinery manufacturing in its Investment Priorities Plan (IPP). Enterprises registered with the BOI are granted several incentives, such as tax credit on the basis of compliance with export or local content performance. Deductions of tariff duty and compensating tax for equipment that are purchased, are applied against this performance credit.

Importation policies

Prior to October 1983, there were no import restrictions for agricultural machinery, except that Monetary Board Circular No. 37 lists some locally manufactured products under close monitoring of the Central Bank. All these measures are being done in order to reduce the country's balance of trade gap. Importations are generally covered by letters of credit and draft acceptances. Upon opening of letter of credit, marginal deposits are imposed by commercial banks.

The present foreign exchange crisis that the country is facing resulted in the temporary freezing of all imports, except those indicated in the Central Bank's priorities. A 10-50 % tariff duty ad valorem and an advance sales tax of 10 %, based on 125 % of landed cost of imported agricultural machinery and equipment, is imposed. There is no distinction between knocked-down (KD) and built-up (BU) equipment, except for a few equipment. In line with the government restructuring programme, tariff duties of finished products will be increased progressively, while duties for raw materials will be reduced.

Finance and credit

The upward trend in sales of agricultural machinery and equipment from 1965 to 1976 was due largely to the availability of the three CB-IBRD loans. Apart from the Rural Credit Programme (CB-IBRD), the following government institutions provide credit for farm machinery and equipment: Development Bank of the Philippines, Farm Systems and Development Corporation, and Philippine National Bank. Private banks are also required by Central Bank Circular No. 473 to allocate 25 % of their loanable portfolio to agriculture.

PICAM

The Permanent Inter-Agency Committee for Agricultural Mechanization (PICAM) has been proposed for creation as a coordinating body for agricultural mechanization. Various ministries and private sector organizations involved in agricultural mechanization will be members of this Committee, which will have the following areas of concern: research and development, manufacturing, marketing and financing, and education and extension. Policies, strategies and programmes are now being finalized.

MANUFACTURING SITUATION

Records of the National Census and Statistics Office show that there were 80 manufacturers and assemblers of agricultural machinery and equipment. Fifteen of these were classified as large firms. The industry employed about 6 000 people. The firms produced about P 205 million worth of agricultural machinery and equipment.

The following agricultural machinery are now being manufactured in the Philippines in commercial quantities: power tillers, single axle type, tractor implements (ploughs, harrows, furrowers, etc.), pumps (low-head centrifugal, line-shaft turbines, propeller and hand (piston) pumps), hand sprayers, harvesting equipment (rice reapers), post-harvest equipment (rice mills, threshers, dryers, hammermills, feedmixers, etc.), hand-tools, and animal-drawn implements. In addition, there is a manufacturer of small diesel engines with very limited production.

Basic facilities, such as foundry, forging, metal forming, machining and welding are available. There is, however, need to upgrade quality and introduce low-cost and better production techniques. Component manufacturing and heat-treatment facilities are required. The government's car manufacturing programme has resulted in the mass production of gasoline engines, transmissions, and body stampings for both the domestic and export market. Given the opportunity, these facilities can be utilized for agricultural machinery manufacture.

The government has begun setting minimum standards for farm machinery and equipment, such as threshers, rice mills, grain driers, and corn shellers. Manufacturers are required to comply with the minimum standards before they can sell to the public. For example, the National Food Authority conducts tests on threshers, driers, and rice mills offered for sale. A certification of compliance with set standards is issued only after a successful test run.

The Agricultural Machinery Distributors Accreditation Committee (AMDAC), a government body which accredits agricultural machinery distributors and manufacturers for them to avail of government financing, sets minimum standards for each product. An Agricultural Machinery Testing Centre has been set up at The University of the Philippines, Los Baños, to assist in this function.

In addition to problems of lack of basic facilities, standardization and quality control, the manufacturers face other problems such as: inadequacy of good quality raw materials and components, high production costs due to high input costs, inadequate financing, poor productivity, and inadequate volumes of production.

MARKETING AND DISTRIBUTION

Sales figures for 1979 to 1981 were provided by the Agricultural Machinery Manufacturers and Distributors Association, Inc. (AMMDA). Tables 2 and 3 show local production and importation values during the period and their shares of the total sales of agricultural machinery and equipment. Increased production and importation were made possible by the Farm Mechanization Programme with financial aid from CB-IBRD. But from 1976 to 1978 consumption and production declined substantially because the CB-IBRD loan had been exhausted. Manufacturers and distributors operate through mixed channels of distribution: dealers and company-owned outlets.

FUTURE DEVELOPMENTS

It has been noted that agricultural machinery in developed countries is becoming more and more sophisticated. In developing countries such sophistication is not available because of the absence of so many factors. Manufacturing for agricultural machinery tend to be sophisticated also in developed countries, utilizing mass production techniques. There is, therefore, a need to increase capabilities for accelerating agricultural mechanization in developing countries, as agricultural mechanization increases crop yields.

The following specific areas have to be considered in order to increase production and productivity:

1. tillage, including proper cultivation of the soil;
2. proper planting techniques;

Table 2. Sales of agricultural machinery and equipment (in thousand pesos).

Year	Production		Importation		Total sales	
	value	% share	value	% share	value	% increase (decrease)
1979	79 481	13	512 499	87	591 980	-
1980	59 272	18	273 438	82	332 710	(44)
1981	74 591	15	412 252	85	486 843	46

Table 3. Sales of selected agricultural machinery 1978-1982 (in number of units).

Farm machinery equipment	1978	1979	1980	1981	1982
standard four-wheeled tractors	971	836	494	566	522
compact four-wheeled tractors	295	388	161	162	131
power tillers	6 301	5 379	2 993	2 901	1 157
engines	40 526	47 388	33 312	35 731	28 247
irrigation pumps	4 331	4 106	2 155	1 753	1 596
farm processing equipment	3 169	3 916	3 652	2 957	908

3. seed quality, through the use of appropriate and high yielding varieties;
4. fertilization, through application of organic or chemical fertilizers;
5. crop protection, through proper control of application of insecticides;
6. harvesting technology, through the use of agricultural equipment;
7. proper storage and preservation;
8. transportation, through effective and appropriate transport.

Manufacturing plans

A workshop conducted by the government, represented by the Board of Investments, Ministry of Trade and Industry, Ministry of Agriculture and other agencies, and agricultural machinery manufacturers, proposed the development of manufacturing programmes for various products and components. For inclusion in the Investment Priorities Plan (IPP), as pioneer projects, the following have been suggested:

1. mini-tractors;
2. hydraulic cylinders;
3. gearboxes;
4. blades and tynes;
5. control valves;
6. hand-tools.

Hand in hand with inclusion of the said products in the IPP, a manufacturing programme has been proposed in order to save or earn foreign exchange and create manufacturing activities. This programme, if implemented, will require progressive increases in local content. Products proposed are as follows: power tillers, rotary tillers, planters, sprayers, cultivating, post-harvest and irrigation equipments, etc.

COOPERATION IN AGRICULTURAL MACHINERY

ASEAN Cooperation

For their mutual benefit, developing countries, especially within a region, must cooperate in the agricultural machinery industry in order to accelerate its development. An example of such type subregional cooperation is ASEAN (Association of South East Asian Nations), which aims to achieve economic cooperation among the five Asian countries. Cooperation is being developed in all areas of economic activity. In the field of agricultural machinery, the UN-ESCAP Regional Network for Agricultural Machinery has initiated information exchange among countries of Asia.

In addition to the large potential domestic market for agricultural machinery there are opportunities for an expanded market due to export and Asian Cooperation. The Asian Agricultural Machinery Federation (AAMAF), organized 4 years ago, has embarked on various programmes aimed at increasing intra-Asian trade, such as:

1. Preferential trading arrangements in the form of margins of preference on tariff duties, now being implemented for a few products, with further moves to expand preferences to a wider range of agricultural machinery.
2. Mini-tractor programme, wherein an opportunity study has been conducted by UNIDO, starting February 1983, and completed in September 1983. The report is now being evaluated by the Asian Agricultural Machinery Federation. It is envisioned that the mini-tractor gearbox will be a joint venture project located in an Asian country, and the rest of the components to be part of an industrial complementation scheme.

Cooperation with small and medium-sized agricultural machinery firms may be more ideal for the developing countries, rather than with large firms, as such large firms employ different management, marketing and manufacturing concepts, which are difficult to implement in developing countries. Small firms, through their trade or industry associations or government agencies, should be encouraged to cooperate with their counterparts in developing countries, as their techniques and methods are flexible.

Agricultural mechanization in Sri Lanka

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INTRODUCTION

The total land area of Sri Lanka is 6.56 million ha and has a population of 14.5 million (1979 statistics). Annual growth rate is 1.5 % per year. Out of the total area of 6.56 million ha, 2.22 million ha is under cultivation. Perennial crops are grown in 1.13 million ha. Out of which 0.68 million ha is paddy. The remaining comprises a wide range of subsidiary food crops.

The country is divided into three agro-ecological zones according to the rainfall pattern, viz. the wet zone (annual rainfall over 2 300 mm), the intermediate zone (between 1 700 and 2 300 mm), and the dry zone (below 1 700 mm). The hill district (up country wet zone) is distinct from these three zones where tea is the dominant crop.

The agricultural land resources both in the wet zone and intermediate zone are fully utilized. However in the dry zone there is about 1.2 million ha of rainfed cultivable land, of which about 0.4 million ha is also being developed under various irrigation projects for increasing cropping intensity.

Agriculture accounts for 33 % of GDP, 75-80 % of the exports, and about 50 % of the total employment. Tea, rubber and coconut are the main export crops (60 % of the total export), while rice is the main staple food.

ECOLOGICAL INFLUENCE IN MECHANIZATION

Ecological factors combined with the social and economic characteristics of a region determine the farming pattern and influence the level of mechanization. For instance, the boggy nature of soils in the wet zone and the small size of holdings and easy availability of labour result in less utilization of mechanical power for land preparation. On the other hand a short rainy season, the practice of dry tillage for rainfed crops of comparatively large holding sizes and scarcety of labour have contributed to encourage the use of tractors in the dry zone. The level of mechanization in the intermediate zone lies somewhere between that of the wet and dry zones. In the hills the terraces are a major constraint on the use of mechanical power, which cannot operate efficiently on steep slopes, where the human labour is used for land preparation.

FARM POWER UTILIZATION

From the early 60's the traditional farm power source in Sri Lanka has generally given way to mechanization from a complex of human labour, farm animal and mechanical power. Table 1 shows the power utilization pattern in various cultivation practices and the implements used.

Land preparation.

Human power is used mainly in the wet zone and partly in the intermediate zone for land preparation. The hoe (mammoty) is the implement used for the primary and secondary tillage operations. Buffaloes are extensively used for cultivation of paddy-land in the intermediate and dry zones. The use of cattle for paddy-land preparation is limited geographically to a small area in the country. Mould board ploughs and country ploughs are used

Table 1. Use of farm machines and implements by source of farm power and by type of rice farming operation.

Rice farming operation	Power-driven machines and implements	Animal-drawn machines and implements	Manually-operated machines and implements
primary tillage	4-wheeled tractor and disc plough	country plough	hoe
	power tiller and plough	mould board plough	-
secondary tillage	4-wheeled tractor and tine tiller	spike tooth harrow	hoe
	power tiller and rotavator	--	-
puddling	tractor with cage wheels	water buffalo	hoe
levelling	--	water buffalo drawn leveller	hand leveller
manure spreading	--	--	hand
seed bed preparation	--	--	hoe
transplanting	--	--	manual
fertilizer application	--	--	manual
pest and insect control	power sprayer	--	hand sprayer
weeding	--	--	Japanese made weeder
irrigation and drainage	water pump	--	-
harvesting	--	--	sickle
threshing	4-wheeled tractor power tiller	water buffalo	-
transporting	4-wheeled tractor power tiller with trailer	--	-

for primary tillage, and spike tooth harrows for secondary tillage. Levelling is done by levelling boards. 70 % of all paddy in the dry zone is cultivated mechanically. The distribution of farm power source for paddy-land preparation, is as follows: mechanical: 46 %; animal: 40 %; manual: 14 %.

Seeding and transplanting

Most of the area is cultivated by broadcasting pregerminated seed. About 25 % of the total area is transplanted by hand, out of which about 3-4 % is row transplanted, while the rest is done by random transplanting. Manually-operated transplanters (IRRI type) are being now introduced to the farmers. Seeders for mud land and dry land are being developed by the research stations.

Other practices

Fertilizer is broadcasted manually. Power-operated and hand-operated knapsack sprayers are manufactured locally and are being used by farmers for pest control practices. Hand-operated rotary weeders are used for weeding of row crops. Harvesting is done manually. Power-operated reapers are being introduced to farmers now. Harvesting is done by hand using serrated sickles. Threshing is done by stumping of buffalo or by 4-wheeled tractors running over harvested crop on the threshing floor. Mechanized threshers of the IRRI type are now being introduced gradually. In dry cultivation land is tilled twice by 4-wheeled tractors. An additional operation of culivation is done after broadcasting the seed to cover the seeds.

The traditional sowing seasons in respect of paddy in the wet zone are from September to October (Maha) and March to April (Yala). In the intermediate zone rainfed paddy during the Maha season is sown at the end of October, and in the Yala season by the end of April, to get full use of the rains. Sowing rainfed paddy in the Maha season in the dry zone is completed by the end of October.

Land preparation and planting of rainfed crops are priorities of the farmers in their time schedules. Delay in planting results in losses due to insufficient water from rains. As a result the tendency for the farmers is to leave their land fallow, rather than plant lately, where they stand to lose the crops.

OWNERSHIP AND UTILIZATION OF FARM POWER

About 40 % of the farmers own their water buffaloes. The rest hire the animals. Most of the buffaloes are owned by farmers with 4 ha of land or less.

According to a survey done in 1979 60 % of the 4-wheeled tractors and 90 % of the 2-wheeled tractors were owned by medium and small farmers. Most farmers prefer to hire out their machines for other purposes, e.g. for transportation. It is estimated that for a 1 000 hour use a year for a tractor only 500 hours are devoted to purely agricultural activities.

Animal power-hire service is traditional in Sri Lanka. Large herds of draught-buffaloes were owned by a few people and rented out to farmers. This practice has shown a declining trend in the past two decades due to shortage of animals. This in turn was due to slaughter (for food consumption), the reduction of grazing areas (due to expanded cultivated area), and popularization of farm machines like 2-wheeled tractors.

Due to the high cost of mechanical operations at present the government is taking steps to increase the capacity of draught-animals by establishing breeding centres and draught-cattle farms.

Mechanization input supply

The liberalized import policy of the government since 1977 allowed the import of agricultural machinery like tractors, engines for water pumps and sprayers, mammoties, rice mills and other allied equipment. The Sri Lanka State Trading (Tractor) Corporation is one of the major importers of tractors. The present tractor population is around 36 000 (19 000 4-wheeled tractors and 17 000 2-wheeled tractors). The 4-wheeled tractors are of about 45 hp and are imported mostly from the United Kingdom (Massy Ferguson & Ford). The 2-wheeled tractors are from Japanese origin (Kubota and Yanmar). Engines are imported from Japan, the United Kingdom, India and West Germany. Rice mills are obtained from India and Taiwan. Chillington mammoties are imported from the United Kingdom. The average duty on imported items is about 5 % and the importer has to pay a business turn-over tax of 1-2 %.

AGRICULTURAL MACHINERY INDUSTRY

Farm machinery and equipment are manufactured in both the public and private sectors. The manufacturers are catagorized into four different levels:

1. Heavy engineering units capable of turning out complete products, basic components or assemblies requiring a series of engineering operations such as forging, heavy casting, heavy duty welding, a range of machines operations and heat treatment.
2. Light engineering units not having forging capacity but capable of light or specialized castings, press work, machining, sheet metal work, welding and limited heat treatment.
3. Speciality workshops having limited equipment, but specializing either in welding and fabrication or machining.
4. Individual blacksmiths or cooperatives working in wood or metal at village level who supply farmers and households with their needs for simple tools and hardware, including animal-drawn equipment and carts.

The following products are manufactured or past manufactured in Sri Lanka:

- nine-tine tillers;
- trailers for 2-wheeled and 4-wheeled tractors;
- reversible plough for 2-wheeled tractors;
- cage wheels, puddling wheels, wet-field wheels, levellers, and tail skids for tractors;
- sprayers and mist blowers (hand-operated and power-operated);
- water pumps, mainly centrifugal type 5-10 cm categories;
- hand-tools, such as mammoties, axes, pick axes, shovels, sickles, forks, and weeders;
- spare parts, such as high quality nuts, bolts, pins, gasket, seals, and tiller points;
- points for traditional ploughs and hardware for all types of animal-drawn equipment;
- tyres, batteries and radiators;
- threshers for paddy (IRRI type).

The percentage of local content varies from near 100 % for tractor attachments through 85-90 % for nine tine tillers and trailers, down to 30 % for power sprayers. At present engines are entirely imported.

The State Trading Hardware Corporation, which has a complete heavy engineering unit, is the only manufacturer of mammoties. Approximately 40 000 mammoties were produced monthly, using three shifts; with the introduction of the new plant the production capacity has increased to 1 million mammoties per year.

The level of technology employed varies considerably, not only with the size of firm, but also according to the product. There is a sharp division, engineering-wise, between firms operating machine-tools and those only employing metal working and welding technology for the manufacturer of trailers and simple tractor attachment. The only factory engaged in mass production is the State Hardware Corporation.

For the manufacturing industry in Sri Lanka the facilities and high quality steel are available. Heat treatment is common place and laboratory as well as visual testing is done. However, there is a shortage of engineering expertise, and quality standards are markedly lower in firms lacking professional engineering staff. Only the larger companies employ professional engineers.

FARM MECHANIZATION RESEARCH

Farm mechanization research in Sri Lanka is done by the Farm Machinery Research Centre of the Department of Agriculture. This centre has designed and developed prototypes of seed drills, rotary weeders and threshers. It also conducted tests on tractors and farm machinery with the objective of ascertaining the suitability of the imported equipment for Sri Lanka conditions and to provide guidance to the buyers. The infra-structure of this centre has been strengthened with the aid from the government of the Federal Republic of Germany. A programme of field testing of selected equipment and industrial extension of proven implements are given priority under this aid.

EXTENSION AND TRAINING ON FARM MECHANIZATION

The Department of Agriculture provides training on farm mechanization through the District Training Centres (FMTC), where farmers are given a short-duration training in the operation and maintenance of plant protection equipment. FMTC is the only institution which provides training to farmers, tractor operators and government employees on subjects such as repairs, maintenance, operation of machinery and on-farm mechanization management. These courses at FMTC vary from 1 week to 6 months.

University level education is given at the University of Peradeniya, which admits 6-12 persons each year to a post-graduate course in agricultural engineering.

CONCLUSIONS

Three levels of technology describe the present state of farm mechanization in Sri Lanka:

1. hand-tool technology,
2. animal-draught technology, and,
3. mechanical-power technology.

In each of these levels are many alternatives in mechanization: input design, size, quality, cost, and source of supply. As the appropriate selection of technology is both complex and critical, it is necessary for the National Farm Mechanization Committee to: (1) coordinate studies and surveys in order to determine appropriate mechanization inputs, and (2) cooperate and laise with all entities concerned with mechanization, to ensure that a strong input into the national development planning process is made.

Status of agricultural mechanization in Bangladesh

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ABSTRACT

Bangladesh is an agricultural country where about 90 % people are engaged in agriculture and 54 % of gross national product comes from this sector. Holdings are very small (less than 0.5 ha) and total mechanization is unwanted. From land preparation to storing most of the operations are done by animal and human power. The greatest impact is on irrigation, and during the last 10 years total irrigation coverage increased from 14 % to 25 % of total cultivated land. This was achieved by commissioning more shallow tube wells, deep tube wells and power pumps.

Draught power available is only 0.356 kW/ha for crop land in Bangladesh, which is below the minimum threshold of power requirement of 0.373 kW/ha. The share of power contributed to agriculture by human, animal and machine is 51 %, 46 % and 3 %, respectively. The number of tractors and power tillers used in private farm is virtually nil. Some improved manually operated and animal-drawn implements have been developed by different research institutions, but their impact on overall agricultural development is negligible. Agricultural machinery industries are facing problems of marketing agricultural machinery, patronization from proper authority, shortage of capital, machinery, etc. A clear government policy is required in order to introduce selective agricultural mechanization in Bangladesh.

INTRODUCTION

Bangladesh is predominantly an agricultural country with about 90 % people engaged in agriculture. The soil is of the alluvial flood plain type because of the three-river system of Padma, Brahmaputra and Jamuna, and is very fertile. The total area of the country is 0.14 million km^2. Bangladesh is bounded by the Bay of Bengal in the south, India in the west, north and east, and Burma in the south-east. It lies roughly between 20.70° to 26.80° north latitude, and 88.01° to 92.75° east longitude. There are three distinct seasons, namely summer, rainy and winter. Maximum temperature seldom exceeds 38 °C, and minimum seldom goes below 12 °C. The annual rainfall varies between 2 000 mm and 2 500 mm. Fluctuation of temperature is small and the climate is more or less warm, pleasant and humid throughout the year.

The land use pattern of Bangladesh for 1981-1982 is given in Table 1. Out of 14.29 million ha 8.58 million is under cultivation, of which only 25 % is under irrigation. Cropping intensity is 156 %. Rice is the main staple food. Recently the total area and production of wheat has increased tremendously. Total area and production in 1972-1973 was 0.12 million ha and 0.09 million ton, respectively. In 1980-1981 both have increased to 1.46 million ha and 1.08 million ton, respectively. Potato cultivation has also increased in recent years: total production in 1972-1973 and 1980-1981 was 0.75 million ton and 0.98 million ton, respectively. Jute is the most important cash crop of Bangladesh; it contributes about 70 % to the total export value. Sugarcane is also an important crop, as the country is almost self-sufficient in sugar.

Although the soil of Bangladesh is, in general, very fertile, the average yield per hectare for all crops is very low. This is due to poor land preparation, lack of good seeds, inadequate irrigation facilities, etc. Major emphasis in agricultural mechanization is thrusted on increasing irrigation coverage.

PRESENT STATUS OF AGRICULTURAL MECHANIZATION

Bangladesh is still far behind many developing countries in respect of agricultural mechanization. Animals are still the main source of power for most agricultural activities. A recent estimate has indicated that only 0.356 kW/ha is available for crop land of Bangladesh, which is below the threshold of power requirement of 0.373 kW/ha. The share of power contributed to agriculture by human, animal and machine is 51 %, 46 % and 3 %, respectively. From land preparation to processing, quite a number of operations have been mechanized, mainly through government agencies, by the introduction of imported tractors, power tillers, and tube wells, locally made irrigation pumps, push type weeders, pedal threshers and sprayers.But the impact of most of these innovations was very limited, localized, and

Table 1. Land use data of 1981-1982. Source: Monthly Statistical Bulletin of Bangladesh (June 1983).

Land use type	Area (million ha)	Percentage
not available for cultivation	2.77	19.39
forest	2.14	14.98
culturable waste	0.25	1.75
current fallows	0.55	3.84
cultivated area	8.58	60.04
total area	14.29	100.00

short-lived in the overall agricultural mechanization programme of Bangladesh. This was mainly due to the fact that the major part of the mechanization scheme was initiated in some selected areas without giving due consideration to providing back-up facilities and without ensuring that the necessary infrastructure exists for making such a scheme successful. As a result imported machines and equipments were already unserviceable after a short period of operation, due to shortage of spare parts, trained operators and adequate workshop facilities.

In 1970, the total number of tractors and power tillers was 2 072 and 2 571, respectively. After the cyclone of 1970 the Bangladesh Agricultural Development Corporation procured 125 tractors and 569 power tillers under the Mechanized Cultivation and Power Pump Scheme. These implements were distributed in selected areas of the Noakhali and Comilla districts. This was a scattered effort, and the mechanization programme could not prove to be significant. So, the Mechanized Cultivation Scheme was abondoned and the Power Pump Scheme is still continuing.

The Bangladesh Academy for Rural Development initiated tractor mechanization in 1960 with the name Mechanized Farming on Cooperative Basis in Comilla. Tractors were hired by farmers on custom service basis for tillage operation. Later the tractors were mainly used for industrial purposes, instead of agricultural purposes, as the former seemed profitable.

Most of the planning efforts in agricultural mechanization have been focussed on irrigation in order to grow additional crops during the dry season. Coverage of land under irrigation is increasing very rapidly, which is clearly understood from Table 2. The coverage of irrigation in 1975, 1980 and 1982 was 1 million, 1.45 million and 2.2 million ha, respectively. It is expected that coverage will be further extended to 2.9 million ha in 1985. Presently all the centrifugal pumps required for low-lift pump and shallow tube wells are manufactured locally and engines are mostly imported from abroad. Unfortunately, due to lack of proper water management, about 50 % water is wasted. Excess application also sometimes reduces the crop yield.

Table 2. Area irrigated by different methods (x 1 000 ha). Source: Monthly Statistical Bulletin of Bangladesh (June 1983).

Methods of irrigation	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983
power pump	554.43	580.33	621.61	665.72	704.18	
tube well	127.07	160.26	180.49	221.77	271.15	
doon *	396.60	389.32	395.39	369.08	356.53	
swing basket	62.32	69.20	73.65	82.96	85.79	
canal	119.79	99.55	122.22	150.14	163.09	
others	191.83	182.92	174.02	149.32	144.88	
total	1 452.04	1 481.58	1 567.38	1 638.99	1 725.62	2 185.35

* Doon is a kind of manual water lifting device made of small wooden boat-shaped structures.

With the introduction of high-yielding varieties the farmers have been motivated to use more irrigation water and chemical fertilizers. In 1960 only 4 % of farm holdings used fertilizers, whereas in 1975-1976, 51 % of the farm holdings used chemical fertilizers. All the fertilizers are applied by hand-broadcast methods. Pest control is a vital issue as pests compete with humans for food. In 1975-1976 about 13 % of land holdings reported using plant protection materials. Sprayers are mostly imported from abroad. Due to shortage of sprayers plant protection measures have been impaired.

All the harvesting operations are done manually. Pedal-operated threshers for rice have been introduced in some parts of the country. This thresher could easily be extended to farmers if supply of quality threshers is ensured. Almost all the drying operation is done by sunning. Mechanical dryer is rarely used in Bangladesh. During the rainy season harvest about 5 % grain is lost due to inadequate drying facilities. Owners of rice mills are interested to buy mechanical dryers. Efforts are going on to develop this kind of mechanical dryer.

Storage of most cereals, pulses, oilseeds, etc. is taken care by individual farmers in their farm houses in locally made bins, earthen pots, etc. Loss due to improper storage is about 7.5 % for paddy. Potatoes are kept in cold storages for long-term preservation, as the temperature after harvest of potatoes exceeds 30 °C.

Table 3 shows that 59.37 % of the households with 8.33 % of the total cultivated land have less than 0.4 ha each. So it is very clear that lands are fragmented. Agricultural labour is plentiful. So government does not recommend total mechanization, as it will displace labour. The industrial sector is not expanding rapidly, so the agricultural sector has to absorb the surplus labour. Selective mechanization, based on land holdings and the socio-economic conditions of the country, is thought to be one of the most important tools for maximizing production. Irrigation has been proved to be the most important factor in maximizing crop production. So government has

Table 3. Land holding distribution in 1978. Source: Agricultural yearbook of Bangladesh (1982).

Size of holding (ha)	Number of house holds (%)	Area (%)
0	14.69	-
0 -0.40	44.68	8.33
0.41-0.80	15.21	12.78
0.81-1.21	8.69	12.28
1.22-1.62	5.16	10.29
1.63-2.02	3.08	7.93
2.03-4.05	5.82	22.91
4.06-over	2.67	25.48
total	100.00	100.00

set top most priority in expanding irrigation coverage, and is also trying to promote local products. Credit facility will also enhance the production of agricultural implements. Import duty on agricultural equipment is only 15 %, as compared with duties of up to 100 % and more for most other items. In addition, manufacturers may apply for tax concessions on certain raw materials which are used in the manufacture of agricultural implements. The Bangladesh government has undertaken a massive rural electrification programme, which is giving connection to irrigation pumps, rice mills, oil expellers and other agricultural processing plants. This is to reduce the costly engine-operated plants.

MECHANIZATION RESEARCH AND TRAINING

In the past the government had imported western sophisticated machinery and equipment, namely tractors, disk ploughs, disk harrows, mouldboard ploughs, rotavators, combines, etc., but lack of trained persons and spare parts, poor economic condition, fragmented lands, etc. inhibits the success of such mechanization programme, and the western imported technology proved inappropriate in Bangladesh. This led to undertake research and training to develop appropriate agricultural machinery and equipment. The Agricultural Engineering Faculty of the Bangladesh Agricultural University is developing programmes in different aspects of agricultural mechanization within its limited facility. These include the development of low-cost agricultural implements, irrigation and water management techniques, a small-scale dryer, storage and food processing.

The Agricultural Engineering Division of the Bangladesh Agricultural Research Institute has developed a bullock-drawn improved plough, seed-drill, weeders, threshers, shellers, storage structures and dryers. Besides research, the scientists also give training to engineers, mechanics, extension workers and farmers. The Agricultural Engineering Division of the Bangladesh Rice Research Institute is working on different aspects of rice mechanization. The scientists are also engaged in training extension workers and farmers on rice mechanization. The Bangladesh Agricultural Research Council is responsible for coordinating research and training work within various research organizations and universities. The council also finances short-term contract research. A research programme usually concentrates on the development of equipment suitable for farming conditions of Bangladesh. Most of the time adaptive research is undertaken instead of basic research. Here the objective is to improve upon the performance of indigenous implements or to develop a new implement, which can either increase the labour productivity or mechanize the operation completely wherever a labour or power shortage is felt in completing the work in time.

PRESENT STATUS OF AGRICULTURAL MACHINERY MANUFACTURING INDUSTRY

As major thrust in agricultural mechanization in Bangladesh is towards bringing more land under irrigation. Agricultural machinery industries mainly manufacture centrifugal pumps of 0.5, 0.75, 1 and 2 m^3/s capacity, and the progress in this sector is very fast. Recently more than 60 firms started producing centrifugal pumps and the demand of pumps is meet up from local products. Deep-well turbine pumps are also manufactured by two local industries. Diesel engines for water pumps are mainly imported. Three local industries are producing diesel engines of different power range. These engines are used for water pumps, rice mills, saw mills, oil mills, etc. A good number of local industries manufacture hand-operated sprayers made of brass and steel sheet.

Four-wheel tractors imported previously are not in use for private purposes. Only governmental farms use this type of tractors. There is a good demand for power tillers, but their cost is beyond the reach of most of the farmers. Two industries were manufacturing power tillers, but due to their high cost they could not be marketed satisfactorily. Efforts are going on to design simpler power tillers so that the cost could be reduced. About 80-90 % of total paddy is processed through locally made manuel-operated pestle and mortar, called Dhenki. The rest of the paddy is processed through approximately 8 000 rice mills spreading all over the country. Most of these are of the husking type, with 0.25 ton/hour capacity. Most of the rice mills are locally produced. Oil expellers and sugarcane crushers are also locally produced.

A number of manually-operated or animal-drawn implements like ploughs, seed treaters, seed drills, weeders, pedal threshers, etc. is manufactured by 6-7 industries. In the context of Bangladesh these implements are very useful, as they are more efficient than traditional machinery and equipment, their cost is within the reach of most of the farmers, and they do not displace labour drastically. But owing to a good government institution to extend this implements farmers are not getting the benefits of these.

The Bangladesh Agricultural Research Council conducted a survey to appoint the status of agricultural machinery industry in the country. They were asked about their problems. Each industry had indicated 2-6 problems. Out of 28 respondents 19 have mentioned about marketing problems of agricultural machinery, 18 have indicated shortage of capital and raw materials, 7 have mentioned about acceptable design and technology, and shortage of electricity, 6 have pointed out problems of patronization from proper authority, and 5 have mentioned about shortage of machinery.

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Status of agricultural mechanization in Indonesia

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INTRODUCTION

The ever increasing pressure of Indonesian population growth, which is accounted for 2.3 % yearly, brought consequences in economic development plans, one of them is to place self-sufficiency in domestic food supply as the highest priority. This strategy measure in planning of overall Indonesian economic deve opment is considered as one of very fundamental way to achieve and sustain a better quality of human life, especially in relation to improving the nutritive balance and values. In this regard the agricultural sector had a significant role in the process of national economic development, which is specified to generate equity, growth and stabilization.

Uneven distribution of population and fragmented agricultural land, greater percentage of households engaged in agriculture, abundance of natural resources, and progressive technical inovation are variables that characterize the food crop production system in Indonesia. More than 60 % out of 152 million population (1981) dwell in Java island, while its size is only 7 % (out of 1.92 million km^2) of the total Indonesia archipelago's land.

Population growth planning and transmigration programmes were some of the government efforts that had been consistently undertaken to balance and rationalize the distribution of population as well as its growth by regions or geography. New agricultural land is sizably developed to bear or support the transmigration programme in scarcely populated areas outside of Java island. About 2 ha of agricultural land will be allocated for each transmigrant household, which means that around 2 million ha of food crop land should be developed in the coming five years.

In densely populated areas as Java and Bali islands the increase of domestic food supply was mainly derived from technology-based inovation rather than from natural resource allocation. In the last three years, the sharp increase in food production in the intensification areas was the particular result of the combination of efforts: institutional and management efficiency improvement, optimal application of agricultural, biological and chemical technologies, and production credit supports through the farmer group approached.

The agricultural sector accomodates more than 62 % employements in 1971 and gradually decrease to 55 % in 1980. Meanwhile, its relative contribution in the gross national product was 47 % in 1970 and 25 % in 1982. These relative indicators can be considered as a signal to the structural transformation, at least in the beginning stage: from agrarian economic based to industrial and service welfare. The shift of great numbers of labourers from lower payment and seasonal opportunity in the rural agriculture to non-agricultural sectors in the urban areas induced higher agricultural labourer wages. Consequently, efficient usage of production functions and resources, particularly labourers and energy, become important.

Alternative mechanical power to satisfy efficiency requirements in the farming system is particularly needed. In fact, mechanization technology as part of agricultural engineering, had been introduced 30 years ago to support the food production programme with different degree of fail and success.

HISTORICAL EVIDENCES

It has been more than one third of century agricultural mechanization introduced to support agricultural production, particularly food production. There are four development stages with regard to the characteristics of the evolution of agricultural mechanization in Indonesia.

First stage

The first-stage of mechanization transfer in agriculture, perhaps, started in the yearly 1950's and continued until 1960/1961. The introduction of agricultural mechanization was based upon industrial impact or diffuse technological hypothesis. Progressive agriculture in industrialized countries was greatly influenced by industrial products, which were regarded as agricultural production functions (fertilizer, pesticides and big machineries). It was therefore in Indonesia the aplication of big tractors, water pumps and processing unit, operated by government or semi-government enterprise to help small-farmers, should contribute great increase in food production. Unfortunately by the end of the decade 1950-1960, there was no significant increase in agriculture and yet almost of big machineries disappeared.

Second stage

The second stage (1960-1970) was characterized by technical correction and ownership or management adjustment. Size and degree of sophistication of farm machinery were scaled down toward smaller and less sophisticated machineries. Ownership and operation of these machineries were more spreaded over to private sectors and farmers themselves. Government efforts were stressed on extension activities. In this decade, plant protection equipment number in used was drastically increased and small rice milling unit gradually replaced the functions of big rice mill. Field and laboratory experiments, field trials and testing were intensively undertaken to generate more reliable information for extention works.

The process of changes illustrated trend to better development pattern relative to the first stage of mechanization technological transfer. The expansion of small farm machinery utilization in this decade was still dependent to foreign imported machineries. Consequently change of international monetary system and design of machinery had greater impact and economic risk to users or farmers.

Third stage

The third stage (1970-1980) run into reverse theory of agricultural mechanization development, that was agricultural impact to industrial development. It was recognized that the steady increase of nominal agricultural contribution in the national economic drove or induced to private sector to transplant design for local manufacturing, government for more research and extension and loan provided by the rural Bank.

More university graduates partcipated in the mechanization extension. Research was more intensified, and in the middle of this decade selective agricultural mechanization was sanctioned as operational policy guidance. Debates on private benefit versus social cost at farm level arised in this early transfer process. The dilemma focused on possible displacement of agricultural labourers by efficient mechanization.

In the end of this third phase of technological transfer it was clearly noted that there was strong real demand for agricultural machinery, but locally produced machinery could not be sold due to heavy market competition and in appropriateness of machinery design related to farmers need.

Fourth stage

The fourth phase started in 1980. This phase is started where the operation of selective agricultural mechanization policy was evaluated through area test at provincial level. Farm system research approach was used to identify the need of agricultural mechanization and suggest possible alternate solutions for specific problems. Farmers specific need and perception are considered as determinant factors in this bottom up planning rather than based on technological approach. Those combination of the results of evolution process and farm system research were regarded as feed back inputs for policy reorientation in the present mechanization development. Local manufacturers were more encouraged to produce machineries to meet farm requirements which were: (1) simplicity in design, usage and maintenance; (2) made of locally available raw materials; (3) effective enough, and (4) low price. In this phase of development government purchase for agricultural machineries is directed to help domestic manufacturer products.

POLICY STRATEGY AND OPERATIONAL APPROACH OF AGRICULTURAL MECHANIZATION

It is recognized by planner and policy maker that agricultural mechanization is one of the technological inputs needed in the farming system in Indonesia. Agricultural mechanization as a technological input is one of the fundamental means to help farmers to make themselves able to increase their productivity to achieve better living. Development of appropriate agricultural mechanization, therefore should be encouraged or pursued to help farmers to accomplish their farming system goals toward better living. Inovation in agricultural mechanization will enable farmers to help themself minimizing drudgery, production cost, product losses increasing quality of work, efficient use of time and other limited natural resources, farming return and generation of new field areas of employment opportunity. This will enhance the national economic goals which are directed to generate growth, equity and stability. Therefore, the overall system of agricultural mechanization in Indonesia comprises components of: (1) political will strategy, planning, monetary and trade as an umbrella of (2) industrial/farm machinery manufacturing, supported by (3) research and development, and (4) extension, training and education for farmer, artisan and local manufacturer. with (5) financial support by bank, and (6) agricultural machinery management at farm level.

The profile of the Indonesian farmer is small farm holding, and lack of capital and skill. Considering the social structure at rural area, farm machinery needed for food crop production should have specific criteria: simple in design, simple in usage and maintenance, availability of raw material in the local site, effectively workable enough, and low price. Social structure in the rural area, physical condition, possible undesirable impact of mechanization are selective agricultural mechanization policy and lysis. Therefore, two approaches were applied in the operational phase for selective agricultural mechanization: specific location and technological aspect.

The areas are classified in four specific locations:

- Established area or area type I-A, defined as the location were the agricultural mechanization is already satisfactorily progressing.
- Immediate area or area type I-B, where the machanization programme can be similar to I-A type above-mentioned, but still need more intensive extension work.
- Intermediate area or area type II, where the mechanization programme is not economically operated and can only be developed by government subsidy and require credit facilities as well as more intensive extension work to assure continuity of the mechanization programme.

- Limited area or area type III, when the mechanization programme may not be introduced due to limitation of technical and physical environment.
Alternative technological means deal with the appropriate design of farm machineries to decide what size of machinery and level of mechanization should be developed. Three levels of technologies, such as simple, intermediate and sophisticated, are considered.
. The problems faced in the operation of selective agricultural mechanization vary from one place to another. Generally, the main problems with cases of tractor utilization are lack of spare parts and credit repayment (Bali and South Sulawesi provinces).

INDUSTRIAL EXTENSION PROGRAMME AND PROBLEMS AT FARM LEVEL UTILIZATION

Industrial extension program

Appropriate small farm machinery and equipment technology has been developed by IRRI. The basic criteria in developing this technology are that it should be simple and unexpensive to build, even in small general purpose workshops at district level, and easy to operate, repair and maintain in rural areas.

Indonesia has started industrial extension projects in order to transfer this technology to the predominantly rice growing country. This programme has been implemented since 1980 in cooperation with the Directorate General of Food Crop Production. The main aim of this project is to enable Indonesia to become self-reliant and self-sufficient in the requirements of small farm machinery and equipment. During September 1980 to August 1982 69 prototypes are built, modified and field tested. This program will be ended in 1985 and will concentrate its field extension work in the four pilot provinces, which are: South Sulawesi, South Kalimantan, West Sumatra and West Java. More emphasis will be laid in the manufacturing of tractors, trailers, reapers, transplanters, axial flow pumps, etc.

Since 1979/1980 35 local farm manufacturers have been guided to improve their capability to produce small farm machinery designed by IRRI. The total production of those 35 local manufacturing is presented in Table 1.

Table 1. Total production of 35 artisans (small farm manufacturers) guided by IRRI industrial extension in Indonesia (September 1979 - Augustus 1983).

Machineries	Number of units
hand tractors	2 102
axial pumps	3 073
transplanters	66
threshers	1 475
dryers	1 091
others (weeders)	2 402

Agencies which cooperate with this programme are the Department of Industry, Bank, Central Research Institute for Food Crop Agriculture (CRIFA), etc.

At farm level utilization of farm machinery

Priority need for utilization of pre- and post-harvest farm machinery is focused on intensification areas, transmigration areas and tidal land for water management by using water pumps. Tractors, sprayers, weeders, seeders and transplanters are types of machinery needed in the pre-harvest activity. Tractors and sprayers are specially needed for the existing intensification areas and transmigration areas, while transplanter machines will be introduced for the areas where the labour is highly needed, for planting.

It is estimated that 20-24 % of the rice production falls in the wet season, when the amount of rainfall is more than 200 mm/month. To solve this problem, small and simple dryers are needed to minimize product losses at farm level. Simple drying machines had already been made by the Sub-Directorate of Agriculture Mechanization and will be broadly introduced at farm level. Rice threshers are also needed in the intensification areas in order to minimize product losses and to increase labour productivity.

Experiences gained in the development of agricultural mechanization in Indonesia, especialy for food crop production, show that some critical points need to be solved soon. Those critical points are:

- research and development on agricultural engineering, especially in design of appropriate farm machinery, testing and modification;
- training and education for agricultural engineers;
- hard ware facilities (workshop, testing laboratory, etc.) to support designing, testing and modification activities.

Foreign aid for technical assistance (software either hardware) in development of agricultural mechanization seems needed to accelerate the mechanization programme in Indonesia.

FUTURE OUTLOOK OF AGRICULTURAL MECHANIZATION

Realizing the transformation of the agro-industrial welfare in the fourth Five-Year Development Plan (1984-1988), the industrial sector will be accelarated. However, the agricultural sector will still be the focuss of economic development to back the agro-industrial programme. Special effort to minimize production losses and expansion of newly developed land integrated with transmigration programmes as well as the development of new rice fields are activities to sustain the growth of the domestic food supply.

Therefore the post-harvest technology will become a more important programme implemented in the intensification area, and pre-harvest machineries will be widely extended in the dry land located in transmigration schemes. All of those activities lead to the need for additional numbers of machineries in line to food crop production programmes in the coming fourth Five-Year Development Plan. Table 2 presents an indication of the number of farm machineries required.

The machinery requirement in Table 2 is an estimation to refer the future food crop farmers model, where fragmented and small land holdings are regarded as main variables. Therefore future machines should meet the small farm requirements: simple in design, usage and maintenance, locally available raw material, effective enough, and low price. Small-scale manufacturers may have the opportunity to benefit from those design criteria. Finally, government policy will be directed to favour the generation of market for these small-scale manufacturers and strengthen their manufacturing capability for better quality product. According to the inventory of the Department of Industry in 1982, and other references, a number of manufacturers are potentially able to meet farm machinery demands, such as simple tractors, hand sprayers, and some parts of rice milling machines (Table 3). Moreover, many simple tools and equipment made by artisans and blacksmiths are widely marketed, but are not formally registered.

Table 2. Expected needed additional number of farm machineries in Indonesia.

Farm machinery	1984	1985	1986	1987	1988
tractors	19 200	23 040	27 640	33 200	39 840
sprayers	63 000	72 000	83 300	95 800	110 180
water pumps	3 300	4 290	5 280	6 270	7 260
threshers	36 600	38 100	39 500	40 920	42 350
winnowers	1 916	4 035	4 318	6 739	5 073
rice milling units	6 600	5 888	6 100	6 300	6 520
dryers	5 500	5 720	5 940	6 160	6 380
transplanters	127	382	449	770	1 027
reapers	1 209	2 077	2 780	4 179	5 546

Table 3. Number of farm machinery manufacturers and their production capacity.

Type of machinery	Number of manufacturers	Production capacity (units per year)
hand tractors (6-8 hp)	18	16 060
rice milling machines	9	24 300
hand sprayers	13	304 000
rice threshers	8	3 600
corn shellers	2	3 000

Status of agricultural mechanization in India

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INTRODUCTION

General

India is located in the northern hemisphere on the world map. The country lies between 68° and 98° longitude and 37° and 70° latitude. Northern parts of the country experience extreme temperature variations, ranging from sub-zero to high temperature up to 47 °C, whereas the southern parts exhibit a warm and humid climate throughout the year. The country comprises 22 States and 9 Union Territories. According to the 1981 Census the population of India was 683.8 million, out of which more than 75 % were reported to be living in the villages. Thus, India is the second most populous country in the world with an average population density of 208 persons per km^2.

The total geographical area of the country is 328 million ha, of which nearly 55 % is under agriculture including pastures and plantations. The total net cropped area is 145 million ha, of which 70 % is rainfed and the remaining irrigated by different sources, such as canals, tube wells, ponds, open wells, etc.

Size of farm-holdings

There exists vast variation in the size of farm-holdings. Over 70 % of the holdings are under 2 ha in size. Table 1 gives the size, distribution and the total number of holdings.

Table 1. Size of farm-holdings in India (Ojha, 1983).

Category	Area (million ha)	Area percentage	Holdings number (million)	Holdings percentage
below 1 ha	17.5	10.7	44.5	54.6
1-2 ha	20.9	12.8	14.7	18.0
2-4 ha	32.4	19.8	11.6	14.3
4-10 ha	49.6	30.4	8.2	10.1
over 10 ha	42.9	26.3	2.4	3.0
total	163.3	100.0	81.4	100.00

Crop types and rotations

The important crop types grown in India and the area covered by them are shown in Table 2. The prominent crop rotations are: paddy-wheat, maize-wheat, groundnut-wheat, cotton-wheat, sorghum-wheat, paddy-paddy, paddy-pulses, paddy-oilseed, sugarcane, etc.

Relevance of farm mechanization in Indian agriculture

A significant step towards the development of Indian agriculture after the country's independence in 1947, was the consolidation of farm-holdings. Next, came the augmentation of irrigational facilities. Both these steps led to marginal increase in agricultural production. However, the real break-through in agricultural production was effected in the mid-sixties through the introduction of high yielding dwarf varieties of wheat and paddy, which could sustain higher doses of fertilizer without lodging and yielded 2-3 times more than the indigenous strains. Consequently, a new agricultural strategy was evolved in the country, which revolved around the use of a package of inputs, namely improved seeds, chemical fertilizers, water, pesticides, and improved sources of power and farm equipment. This strategy paid rich dividends in terms of higher production and productivity and ushered in the 'Green Revolution' in certain parts of the country, notably Punjab, Haryana and western Uttar Pradesh.

Improved farm implements and better sources of power were also recognized, in this process, for the first time, as an important component in the package of inputs vital for increasing agricultural production and productivity. The western concept of mechanization implying use of tractors and large farm machines to make up for the labour shortages, was, however, not accepted in India. Farm mechanization in India was adopted as a means of increasing the productivity of land and labour through timeliness of operations, precision placement and efficient utilization of inputs, and reduction of losses at different stages. The Indian model sought to integrate

Table 2. Distribution of the net cropped area under various crops (Verma, 1981).

Crop types	Area (million ha)
cereals (rice, wheat and millets)	82
pulses (black gram, red gram, gram, etc.)	24
oilseeds	21
fibre crops	9
sugarcane	33
vegetables (including potato)	3
condiments and spices	1.6
fruit crops (citrus, mango, grapes, banana, apple, pineapple, stone fruits, etc.)	1.4
total	145.0

the use of available human labour and animal power with mechanical sources of power.

There have been frequent debates about the desirability of farm mechanization or otherwise in India. These debates have, however, not served any useful purpose. It is, now, widely believed that in an intensive crop husbandry, as being developed in the agriculturally advanced areas of India, selective use of simple and low-cost farm machines, not only increases the agricultural productivity, but also generates greater employment opportunities. A recent study conducted by the National Council of Applied and Economic Research in 85 villages, selected from 28 blocks of 7 different states in India, has revealed that the cropping intensity and average yields were significantly higher on the farms using tractors. Similarly, more human labour was used on these farms compared to the animal farms. These results are apparent from Tables 3 through 5.

On the basis of extensive studies carried out in different parts of the country, it has been found that use of selective farm mechanization results in 7.5-40 % increase in agricultural productivity (Table 6).

It is apparent from Table 7 that the growth rate of the spread in the high yielding varieties is clearly on the decline. However, the growth rate in terms of irrigated areas and fertilizer consumption exhibits an upward trend. Thus the trend in the spread of new farm technology presents a mixed scenario and does not permit a clear-cut inference regarding the future demand of tractors and farm machines.

Table 3. Cropping intensity on tractor and animal farms (Verma, 1981).

States	Cropping intensity (%)	
	tractor farms	animal farms
North India		
Punjab	193	184
(index)	(105)	(100)
Haryana	167	164
(index)	(101)	(100)
Uttar Pradesh	193	184
(index)	(105)	(100)
Central India		
Maharashtra	175	143
(index)	(122)	(100)
Gujarat	119	104
(index)	(114)	(100)
Paddy areas		
Andhra Pradesh	123	122
(index)	(101)	(100)
Tamil Nadu	157	134
(index)	(117)	(100)
total	163	145
	(112)	(100)

Table 4. Average yields on tractor and animal farms (tonne/ha) (Verma, 1981).

Crops	Tractor owners	Tractor users	Animal farms
sorghum	1.456	1.069	0.845
(index)	(172)	(172)	(100)
sugarcane	89.9	79.4	74.4
(index)	(120)	(106)	(100)
paddy	2.92	2.568	2.445
(index)	(120)	(108)	(100)
wheat	2.169	2.070	1.819
(index)	(119)	(114)	(100)
millet	1.327	1.327	1.230
(index)	(114)	(108)	(100)
gram	1.033	0.703	3.917
(index)	(113)	(77)	(100)
cotton	0.106	0.870	0.842
(index)	(107)	(107)	(100)
others	1.537	1.506	1.356
(index)	(113)	(111)	(100)

Table 5. Human labour used on tractor and animal farms for different operations (man-days per hectare) (Verma, 1981).

Operation	Tractor owners	Tractor users	Tractor farms
ploughing	4.6	6.9	14.4
sowing	15.9	15.4	13.7
fertilizing	5.4	3.9	3.4
interculture	25.3	24.2	19.5
harvesting	30.2	27.2	24.1
irrigation and others	29.1	28.0	28.7
total	110.5	105.6	104.8

Table 6. Agricultural mechanization versus productivity (Ojha, 1983).

Mechanized operations	Percent increase in productivity	
	range	average
mechanized seeding and planting	10-20	15
weeding	10-20	15
plant protection application	10-30	20
harvesting and threshing	5-10	7.5
water application	10-50	40

Table 7. Spread of new farm technology in India (Datar, 1982).

Period	Average annual growth rate (%)		
	area under HYV[1]	area under irrigation	consumption of fertilizers
1966-1967 to 1970-1971	178.32	3.0[2]	16.4
1970-1971 to 1975-1976	21.48	3.8[2]	5.66
1975-1976 to 1980-1981	8.33	4.0[3]	12.53

[1] HYV = high yielding varieties.
[2] Relates to 1968-1969 tot 1970-1971.
[3] Relates to 1975-1976 to 1979-1980.

GROWTH OF FARM MECHANIZATION

During the first 15 years after India's independence in 1947 emphasis was placed in the manufacture and introduction of simple hand-tools and animal-drawn implements, such as soil turning ploughs, cultivators, water lifting pumps, threshers, winnowing fans, etc. A Central Tractor Organization (CTO), established in the 50's to promote mechanical farming by using imported tractors and farm equipments, dit not make much impact and was eventually wound up. The major break-through in the farm mechanization technology, as mentioned earlier, was effected in the 60's through the introduction of low horse-power diesel engines and electric motors for water pumping and other stationary operations, such as crop threshing, followed by animal and tractor-drawn ploughs, disc harrow, cultivators, seed drills, sprayers and dusters, etc.

The indigenous manufacture of tractors started in 1961 and their number at present stands at about 650 000. Tractor-operated and self-propelled combines for harvesting wheat and paddy were also introduced on a selective basis in the northern states of Punjab and Haryana by the early 70's. The tractor industry is today one of the major agro-machinery industry in the organized sector. The 13 licensed firms have an annual production capacity of 145 000 tractors. Table 8 shows the indigenous production and import of tractors in India. Table 9 shows the distribution of tractors, diesel engines and electric motors in different states of India. It is note-worthy that no imports of tractors have been effected after 1977-1978.

Apart from the tractors, five organizations were also licensed to manufacture power tillers in the 5-12 horse-power range with a licensed capacity of 31 000 per year. The installed capacity at present, however, is about 16 000 only. As shown in Table 10 there has also been progresssive increase in the production of diesel engines and electric motors, which are being extensively used for water lifting and other stationary operations. Table 11 shows the growth in the irrigation pumps. Their present population is estimated to be about 7 million units. Table 12 shows a progressive increase in the plant protection equipment.

Table 8. Indigenous production and import of tractors in India (Datar, 1982).

Year	Tractor production (number)	Tractor imports (number)	Total
1961-1962	880	2 997	3 867
1962-1963	1 414	2 616	4 056
1963-1964	1 983	2 346	4 329
1964-1965	4 323	2 323	6 646
1965-1966	5 714	1 989	7 703
1966-1967	8 816	2 591	11 407
1967-1968	11 394	4 038	15 432
1968-1969	15 437	12 397	27 834
1969-1970	16 120	12 701	29 802
1970-1971	20 009	16 465	36 000
1971-1972	18 109	16 679	33 429
1972-1973	20 802	4 482	25 184
1973-1974	24 425	3 202	27 627
1974 1975	31 088	1 261	32 349
1975-1976	33 252	646	33 898
1976-1977	33 146	4 363	37 509
1977-1978	38 680	nil	38 680
1978-1979	55 863	nil	55 863
1979-1980	58 863	nil	58 863
Jan.-Nov. 1981	76 200	nil	76 200

Table 9. State-wise distribution of inanimate sources of power in 1981 (figures in thousands) (Datar, 1982).

States	Diesel engine	Electric motors	Tractors
Punjab	209.8	244.8	139.0
Tamil Nadu	544.3	949.1	15.8
Haryana	29.8	199.2	76.0
Uttar Pradesh	851.8	326.8	107.0
Gujarat	683.3	202.8	27.5
Himachal Pradesh	3.4	2.0	1.5
Andhra Pradesh	351.1	403.0	20.5
Bihar	30.1	212.5	19.6
Orissa	194.7	131.3	3.4
Kerala	48.6	87.0	3.2
Jammu and Kashmir	1.6	1.2	1.9
Karnataka	143.2	330.0	14.2
Madhya Pradesh	304.8	329.8	24.7
West Bengal	338.6	60.4	3.8
Maharashtra	176.1	624.3	25.2
Assam	2.9	1.6	2.5
Rajasthan	210.1	168.3	37.0
Union territories/ other states	4 400.0	4 600.0	523.2

There has been a phenomenal growth in the harvesting and post-harvesting machines as well. The innovation of a power wheat thresher, which not only threshes the grain, but also converts the long straw into a finally bruised material suitable for cattle feed, has led to a widespread use of threshers throughout the country, In the state of Punjab, which grows wheat in an

Table 10. Production of electric motors and number of diesel engines (Datar, 1982).

Year	Electric motors (x 1 000 hp)	Diesel engine* (x 1 000)
1970	3 010	71.4
1975	3 648	141.3
1976	3 499	110.1
1977	4 020	139.2
1978	3 945	143.5
1979	3 732	145.7
1980	3 827	157.0
Jan.-Nov. 1980	3 470	160.5
Jan.-Nov. 1981	3 960	157.8

* Data relate to stationary type diesel engines alone.

Table 11. Growth of irrigation pumps in India (Verma and Singh, 1979).

Year	Number of pumps (both engine driven and electrically operated)
1951	108 651
1956	168 441
1961	390 139
1966	869 594
1972	3 246 000
1974	2 441 045*
1980	7 000 000**

* Only electrically operated pumps.
** Estimated.

Table 12. Growth and requirement of plant protection equipment (x 1 000) (Verma & Singh, 1979).

Type of plant protection equipment	Present availability	1964-1965	1965-1976	1976-1977	1977-1978	1978-1979
manually operated						
estimated population	500	600	720	840	960	1 080
estimated annual new addition	-	100	220	220	220	220
low-volume power operated						
estimated population	80	100	120	140	160	180
estimated annual new addition	-	20	26	36	36	36

area of 2.9 million ha, all the crop except about 3 % which is harvested by combine harvesters, is now threshed by these machines. The age-old system of animal treading is nowhere to be seen. Similarly threshing of wheat, sorghum and soyabean as well as other cereals and millets is being mechanized in other states of the country. The threshers are being manufactured by a few hundred small-scale units with a major concentration in the states of

Punjab and Haryana.

The manufacture of tractor-operated combine harvester was started by Vicon Limited in 1971, but today there are as many as eight other units which have developed similar tractor-operated combine harvesters. All these units have been introduced during the last 10-12 years. Use of large-size self-propelled combine harvesters through custom hiring has also been adopted in a big way. Recently two manufacturers have started the production of these combines also. Thus, there has been a tremendous growth in the agricultural mechanization technology in the country during the last two decades. This trend is likely to escalate further.

PRESENT STATUS, TRENDS AND DEVELOPMENTS OF MECHANIZATION

Farm power

The main sources of farm power on the Indian farms include human beings, animals, tractors, power tillers, diesel engines and electric motors. The respective contribution of all these sources towards the total power availability is indicated in Table 13. It is evident from this table that animate power still constitutes to be one of the main sources of power on the Indian farms. The average power availability from all sources, at present, is roughly 0.45 hp/ha. However, the National Commission on Agriculture has recommended that a minimum of 0.3 hp/ha would be required to attain optimum yield levels. With the projected net cropped area of 155 million ha in the year 2001, the power requirement is estimated at 100 million hp. The number of draught-animals is not likely to increase much in the future. However, induction of another about 20 million agricultural workers may furnish another about 2 million hp. In order to archieve the targeted 100 million hp for intensive farming, the additional power is likely to be provided by inanimate sources like engines, electric motors, power tillers, tractors, etc.

Table 13. Existing power availability to Indian agriculture (Verma, 1981).

	Numbers (million)	hp per unit	total hp (million)	hp/ha	percentage of total
human					
male	69.70	0.07	4.90	0.033 7	7.58
female	17.70	0.05	0.90	0.006 2	1.39
animal	63.30	0.40	25.30	0.174 5	39.16
tractor	0.65	25.00	16.25	0.112 1	25.15
power tiller	0.02	7.00	0.10	0.000 7	0.16
diesel engine	2.45	7.00	17.15	0.118 3	18.97
total power			64.60	0.445 5	100.00

Increase in cropping intensity

As much as 70 % of the total cultivated area in India is still rainfed. All efforts are being made under the All-India Coordinated Project on Dryland Agriculture to increase the cropping intensity through appropriate soil and water management practices and cropping patterns. The suitable varieties are being developed for the arid and semi-arid areas with a view to increase the agricultural productivity in these areas. There is a considerable emphasis on the development and introduction of appropriate animal and power-operated farm equipment for seedbed preparation, sowing and planting, as well as other farming operations. This trend is likely to continue during the coming decade also.

Increasing farm-holdings and decreasing farm size

The age-old social system in India leads to division of the farms and increases the number and decreases in the size of holdings year after year. Thus, there is a growing demand for simple and low-cost farm equipment as well as for low cost and low hp prime-movers including engines and tractors. A reasonably priced four-wheeled tractor of about 15 hp is likely to find a great demand in the country.

Selective demand for large-hp tractors

There is a growing demand for large-hp tractors also, especially for earth-moving operations and crop harvesting. The tractor side-mounted 'Vicon' type combines of 4-4.6 m width are being manufactured by 8-9 companies now and becoming extremely popular in the wheat-paddy belt of the northern states of Punjab, Haryana and western Uttar Pradesh. Thus, the demand for relatively large-hp tractors (50 hp and above) has suddenly sprung up during the last two to three years. The area under mechanical harvesting is only under 3 % even in states like Punjab and Haryana. The labour shortages are being experienced in these areas year after year, and considerable losses occcur due to bad weather and storms. As such, the use of combine harvesters and that of the tractors of 50 hp and higher size is likely to increase in the years to come.

Development of specialized equipment

During the recent past, there is a growing trend to manufacture specialized equipment. This is particularly true for the tractors. Several tractor manufacturers are now manufacturing rice and sugarcane special tractors with appropriate features for using them for rice cultivation and intercultivation in tall crops like cotton and sugurcane. With the increasing use of weedicides and pesticides in the standing crops demand for specialized tractor models is likely to escalate further.

Recent trends in research and development in farm machinery

During recent years, there has been a perceptible change in the research and development efforts for new farm machines. Unlike in the sixties and seventies, there is a growing trend to develop combination equipment which can perform more than one operation in a single pass. Some examples are till-planting machines, combination tillage machines, multi-crop seeding and planting machines, and multi-crop threshers, developed by the Research Centres under the Indian Council of Agricultural Research (ICAR) Coordinated Project on Farm Machinery. There is also a growing trend for development of machines for post-planting operations, especially for weed and pest control. As mentioned earlier the use of weedicides and pesticides is continuously on the increase, resulting in perpetual demand for the application equipment, ranging from simple manually operated sprayers to power-operated equipment. There is also need to develop more efficient harvesting and threshing machines.

Emphasis on animate and renewable sources of energy

Due to the prevailing energy crisis, the government of India has established a Department of Renewable Sources of Energy. Research is underway to develop dual-fuel engines, which can be run on bio-gas and producer-gas in conjuction with diesel. Some research regarding the use of plant oils in engines is also being conducted in India. New projects are being launched to develop simple and efficient tools and gadgets to use the available human and animal resources. The Indian Council of Agricultural Research (ICAR) has recently decided to launch an All-India Co-ordinated Research Project on Draught-Animal Power (DAP) with the main objective of augmenting the system efficiency. There is, thus, an increasing emphasis on the use of power and renewable sources of energy to meet the growing energy needs of Indian agriculture. A research project on the use of a gasifier with tractor is going to be started in French collaboration at the Punjab Agricultural University, Ludhiana within next few months.

INFRASTRUCTURAL FACILITIES FOR TRAINING, RESEARCH AND EXTENSION EDUCATION

The first Agricultural Engineering educational programme in India was started in 1942 at the Allahabad Agricultural Institute, Allahabad, Uttar Pradesh. The Indian Institute of Technology, Kharagpur, West Bengal, was the second institute to start a bachelor's programme in agricultural engineering in 1952. There has been a welcome development in the training, research and extension education facilities in India beginning 1960, when the first Agricultural University was set-up at Pantnagar (Uttar Pradesh). Today, there are 22 State Agricultural Universities in the country. As many as 10 institutions are now offering the undergraduate and postgraduate programmes.

In order to support the agricultural mechanization programmes, a three-tier system has been developed. Table 14 gives the technical man-power training capacity directly related to the area of farm power and machinery in the country. The country has developed adequate infrastructure to train man-power at various levels and in adequate number to launch and man the mechanization programmes. Some of the existing institutions are comparable to well-known international agricultural engineering institutions. Many of these institutions have received generous support from international agencies, like FAO, Rockefeller Foundation, USAID, UNESCO, UNDP, etc.

Research and development in the field of farm power and machinery is being carried out by the following organizations:

- Agricultural Engineering Colleges and Departments in State Agricultural Universities as well as other educational institutions.
- Commodity Institutes of Indian Council of Agricultural Research (ICAR), numbering more than two dozens, Council of Scientific and Industrial Research (CSIR), International Crop Research Institute for Semi-Arid Tropics (ICRISAT), etc.
- Private Organizations including tractor, engine, pump and other farm machinery manufacturers.
- State Governments: Directorates of Agricultural Engineering and Engineering Sections of the State Directorates of Agriculture.
- State Corporations: Agro-Industries Corporation, Khadi and Village Industry Corporation, State Farm Corporation, National Seed Corporation, etc.
- Voluntary organizations.

However, the major role in farm mechanization research is being played by the Public Research Institutes and Agricultural Universities. The Indian Council of Agricultural Research (ICAR) has several coordinated research schemes on farm implements, pumps and tube wells, dryland agriculture, as well as for energy studies in the agricultural sector. In the State Agricultural Universities, farm mechanization research and development programmes are also being financed through State funds.

The Government of India has established three tractor training and testing stations to train the farmers in the use of tractors and farm

Table 14. Man-power training for agricultural engineering discipline (Ojha, 1983).

Type of training	Number of institutions	Intake capacity	Annual out-turn
Ph.D.	4	10	6
M.Tech.	10	100	60
B.Tech.	10	400	325
Diploma agricultural engineering	10	400	350
(Mechanical engineering)	(400)	(10 000)	(10 000)
ITI (mech.)	360	20 000	20 000
Vocational cources	250	20 000	20 000

equipment. Out of these, two stations test the tractors to be marketed in the country. Some of the agricultural engineering colleges in the Agricultural Universities also have farm machinery testing facilities. However, only the college of agricultural engineering of the Punjab Agricultural University, Ludhiana, has a full-fledged farm machinery testing centre to test commercial equipment and thus provides a valuable help to the manufacturers, farmers and quality marking agencies.

The extension education work is being carried out by the subject matter specialist and agricultural engineering extension engineers in different agricultural universities, State Departments of Agriculture, and Directorates of Agricultural Engineering. Private manufacturers and their dealers as well as extension training centres are also helping in these programmes. The Indian Council of Agricultural Research has set-up the Central Institute of Agricultural Engineering (CIAE) at Bhopal during the Fifth Five-Year Plan to intensify research development, testing and extension education programmes relating to farm mechanization. Considering the size of the country, the extension education programmes relating to farm mechanization have not grown in size and number. As such, these programmes continued to be a weak link in the chain. Consequently, there exists ample scope for helping in the speedy transfer of technology for village artisans, petty manufacturers, working mechanics, as well as for the estimated 80 million farming families in the country.

Huge amount of money can be saved by launching extension programmes for farmers for proper operation, maintenance and up-keep of pumps, tube wells, engines, tractors, and other farm equipment. With the increasing number of machines, human accidents are also increasing. For instance, about 1 000 persons get injured on power threshers each year (Verma & Bhatia, 1981). There is also need to promote awareness about the safety aspects of farm machines. Studies carried out in the state of Gujarat and Punjab reveal that the overall efficiency of pumps and tube wells is only about 40 %. A recent survey conducted in the college of agricultural engineering of the Punjab Agricultural University, Ludhiana, has revealed that the average specific fuel consumption of a 5 hp diesel engine is about 30 % higher than the optimum fuel consumption of a standard engine. To promote awareness about all these aspects, a need is felt to establish additional infrastructural facilities to strengthen the farm mechanization programmes.

It is worthwhile to mention here that India has made a good progress in the area of standardization of farm equipment. The Indian Standards Institution has formulated more than 200 standards and test codes on human, animal and power-operated equipment and prime-movers.

In order to provide necessary support to farm mechanization programmes, more than 3 000 Agro-Service Centres have also been set-up in the country. These centres provide custom-hire services, apart from marketing various agricultural inputs. Agro-Industries Corporations have also been set-up in seventeen states in the country. These corporations also provide custom-hire services by renting tractors and other costly equipment for seedbed preparation, land levelling and grain harvesting.

Promotion of farm mechanization technology for the benefit of the farmers is being effected by the following agencies:

- Central and State Ministries of Agriculture and Rural Development.
- Ministry of Science and Technology.
- Central and State Ministries of Industries.
- Research and development organizations with their operational research programmes.
- Voluntary organizations.
- Farm machinery manufacturers.
- Rural polytechnics.
- Farmers training centres.
- National Research and Development Corporation of India.
- Indian Standards Institution.
- Tractor testing and training centres.

GOVERNMENT POLICIES FOR FARM MECHANIZATION

More than 70 % of the farm-holdings are of 2 ha size. The government provides incentives in the form of subsidy up to 25-33 percent to encourage small land marginal farmers whose holding size is smaller than 2 ha, to adopt small implements and machines. These incentives are being granted under the Integrated Rural Development Programme (IRDP) of the Ministry of Agriculture. Government's policy for selective and need-based farm mechanization is essentially aimed at modernizing the Indian agriculture, rather than saturating it with tractors and more sophisticated equipment. Introduction of manual and animal-operated tools and implements is considered more beneficial for the Indian farmers, as these help to increase the agricultural productivity without displacing the labour. The improved tools and implements can also be easily fabricated, repaired and serviced by the village artisans and small workshops. Thus, these help towards generating gainful employment for the rural poor and landless.

Incentives are also being provided by the government for adoption of pump sets, threshers and power sprayers in such areas where these equipment have not become popular as yet. The government also provides institutional loans to the farmers owning large and medium holdings to purchase tractors. The preferential rate of interest ranges from 10.5 to 11 %. Instructions have been issued to all commercial banks to reserve 11 % of total credit for the agricultural sector. This is likely to be raised to 16 % by the year 1984-1985. In order to help the small farmers, artisans and landless labourers, the government has established the National Bank for Agricultural and Rural Development (NABARD). The government policy of granting loans on easy terms to the farmers for buying tractors and other costly machines has provided a big boost to farm mechanization in the country. It is note-worthy that 90 % of the tractors in India are purchased against bank credit. Even a few months credit squeeze by the Reserve Bank of India during 1982 had caused big hue and cry in the tractor industry: the demands had dropped down and the stocks began piling up in most of the tractor factories.

The manufacture of farm machine and implements comes under the purview of the Ministry of Heavy Industries. However, necessary help to the manufacturers is provided by the Ministry of Agriculture through the existing research, development and testing infrastructure. The manufacturing of tractors, combine harvesters and power tillers is now being done in the organized sector. However, simple machinery, including tractor-operated combine harvesters and most of the agricultural implements used with human, animal and tractor power, is manufactured in the small-scale sector. The Ministry of Industries exercises control on quality through issue of licences for manufacture of sophisticated machinery like tractors, combines and power tillers. The Indian Standards Institution formulates standards regarding performance and testing of agricultural machinery based on the research results of various R & D organizations in the country. ISI also operates a voluntary Quality Certification Marking Scheme to promote quality consciousness among the users and manufacturers. The Indian Council of Agricultural Research and the National Research and Development Corporation (NRDC) also provide incentives for development and invention of new farm equipment.

As mentioned earlier no import of tractors took place in India after 1977-1978. The country is thus more or less self-sufficient in agricultural machinery. However, import of specialized sophisticated agricultural machines and spare parts for some machines is allowed to the collaborative manufacturers and actual consumers. An import duty of 40 % and countervailing duty of 10 % is levied on all imported agricultural machines and spare parts.

In order to help the farmers the prices of diesel oil are kept low by relaxing the major portion of the excise duty. The rate of electricity for agriculture is also approximately 50 % of that charged for industrial and domestic use.

An amount of about Rs. 138.0 million was spent by the Agriculture Refinance and Development Corporation of India during the period 1968-1981. This does not include the loans and credits granted by commercial banks. Thus, availability of credit has boosted the sale and consequently the production of engines, pumps and tractors in the country, The demand of tractors in India is thus highly elastic depending upon bank credit.

BOTTLENECKS IN FARM MECHANIZATION

In spite of the impressive growth of farm machinery industry, numbering more than 3 500 small-scale units, over 100 000 vilages artisans, 18 tractor and power-tiller manufacturers and more pump and engine manufacturers, farm mechanization programmes in India are not free from constraints. The major bottlenecks in the farm mechanization programme in India can be summarized as follows:

- Lack of a national farm mechanization policy to help plan for further manufacture, sale and distribution of various types of prime-movers and farm machines.
- Inadequate number of R & D organizations and farm machinery testing centres to cope with a multitude of problems.
- Scant and weak infrastructural facilities to promote extension education about different aspects of agricultural machinery use, maintenance and up-keep.
- Inadequate supply of graded raw material and high cost of raw material, leading to high initial cost of implements and poor quality of farm machines.
- Lack of adequate infrastructure for proper quality control and inspection to promote manufacture of standard equipment with high reliability.
- Inadequate credit facilities and promotional subsidies for new farm machines.
- Lack of industrial extension programmes to educate village artisans, small-scale industries and entrepreneurs.
- Inadequate facilities for repair, maintenance and after-sale service of prime-movers and farm machines.
- Non-availability of genuine spare parts.
- Lack of standardization of interchangeable and fast-wearing spares of critical components of farm equipment.
- Lack of adequate training avenues and infrastructure to train farmers and working mechanics.
- Inadequate safety regulations for dangerous agricultural machines.

If the aforementioned bottlenecks could be removed, farm mechanization programmes will receive a further boost in the country.

FUTURE PROSPECTS AND SUGGESTIONS

In order to sustain and strengthen the agricultural mechanization programmes in India, following suggestions can be offered:

1. The farm mechanization technology in India can still be considered in a state of transition. As discussed earlier, lot of ground remains to be covered in the area of research and development for low cost, simple and efficient farm implements for animal power to meet the needs of vast areas

of arid and semi-arid agriculture. Further improvements in the quality, standardization and reliability of existing farm equipment should be effected. R & D and testing facilities need to be furher strengthened and expanded. It appears to be unlikely in India that farm machinery research and development activities will be carried out solely by the farm machinery manufacturing concerns as in the western countries. As such, the existing model, in which almost all the farm machines operated by human, animal and tractor power are produced by the small-scale industries and village artisans, will have to continue for many more years to come. The small-scale industries lack R & D as well as testing facilities on the one hand and skilled man-power on the other. Investment capacity and physical facilities of these units are also limited. In view of all these constraints, it is generally agreed that the public organizations, including State Agricultural Universities and Central Government organizations, have to play a dominant role in the design, development, testing and improvisation of various types of farm machines. During the next decade emphasis will be placed on improving the production technology and manufacturing methods to better the quality of farm equipment in India.

2. The present policy of granting loans and credits for the purchase of tractors and other costly farm machines needs to be continued. In view of the vast magnitude of these programmes it is desirable to establish Directorates of Agricultural Engineering in different states. Presently, only two or three states in the country have these directorates. It would be necessary to have a post of Chief Engineer (Agriculture) or Director of Agricultural Engineering to help the farmers and industries, as well as to check the haphazard growth of farm mechanization in the states.

3. The future research and development needs for farm equipment can be enumerated as follows:

- equipment for arid and semi-arid areas;
- equipment for cereal and root crop harvesting;
- equipment for mechanization of special crops such as cotton, sugarcane, fruit, etc.;
- equipment for precise application of chemicals (fertilizer, pesticides, herbicides, etc.);
- multi-crop and multi-purpose machines for threshing, seeding and planting, tillage, etc.;
- equipment for small and marginal farmers;
- development of low-weight, low-cost, low horsepower engines and tractors;
- emphasis on safety and ergonomic aspects in farm machinery design and manufacture;
- strenghtening of production-oriented of farm machines.

CONCLUSIONS

Considering the various aspects, agricultural mechanization in India has to be need-based, selective, low cost, appropriate, input-oriented and labour-intensive. It is unlikely that there will be replacement of any particular source of power in the years to come. The number of inanimate sources is bound to escalate. This increase is expected to raise the agriculture productivity and cropping intensity of various crops. Hence the demand for additional human and animal labour will also escalate. The mechanization research in India will have to be devoted to the development and improvisation of implements and machines for all the three sources of power. Further R & D programmes will have to follow a dynamic approach to respond to the growing needs of new crops and farm situations. This is only one of the numerous examples where the research and development programme in farm machinery will have to be developed to respond to the new needs and situations to sustain the growth and tempo of Indian agriculture. The farm mechanization programme will have to be geared to sustain the growth and to meet the projected demands of food, feed and fibre for the fast expanding population of the country.

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Agricultural mechanization in Malaysia

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ABSTRACT

The agricultural sector plays a very important role in Malaysia's economy. However, because of rapid growth taking place in the other sectors of the economy, the agricultural sector is facing problems of labour shortage. It is generally acknowledged that the continuing success of this sector would depend on the adoption of mechanization and other labour saving technologies.

While efforts in the adoption of mechanization technology in Malaysia have been successful for certain agricultural operations, for others it has not been so, due to the non-availability of suitable machinery.

The farm machinery manufacturing industry in Malaysia is still small. A survey of the current status and possible future development of this industry is outlined in the paper, together with the current research and training activities in this discipline.

INTRODUCTION

In 1980 the agricultural sector contributed 22 % of the Gross Domestic Product, and 35 % of the total export, while providing 40 % of the total employment in the country (Anonymous, 1981).

Labour shortages are being experienced with increasing intensity in the agricultural sector over the recent years. This is particularly so for agricultural operations that require high labour hours such as planting and harvesting. The shortage of agricultural labour has mainly been due to competition from the other sectors of the economy which are experiencing rapid rate of growth, and is affecting the production of all major agricultural commodities. So it is generally acknowledged in the industry and in government administration that the adoption of labour saving technology is vital to the continued good performance of these sectors. Consequently, considerable attention is being given towards this endeavour.

The following features of Malaysian agriculture influence the development of mechanization in the country:

1. Malaysian agriculture is dominated by perennial tree crops, comprising rubber, oil palm, coconut, and cocoa. In peninsular Malaysia these crops occupy about 80 % of the cultivated area, whereas rice, the major annual crop, occupies only 13 % (Selvadurai, 1979). A large portion of the tree crops are grown on 'rolling' and steep terrains. Mechanization technology for these crops has not been developed. The perennial nature of these crops also affect the size of the overall local machinery market.

2. Agriculture in Malaysia is predominantly by small-holder farmers. In peninsular Malaysia the estate or plantation sector represents only a third of the cultivated hectareage (Selvadurai, 1979).

3. The existence of 'soft soil' condition in some agricultural areas limits the use of conventional 'heavy' machinery. These are mainly in the lowland rice and tropical peat soil areas.

4. Malaysia has a humid tropical climate, with mean annual rainfall of between 2 286 and above 3 556 mm. Dry period, which is usually short, occurs only in a few localities.

UTILIZATION OF MACHINERY

Land preparation and off-field transportation are the most mechanized agricultural operations in Malaysia. Mechanization of harvesting is currently only being done for rice. Mechanical crop spraying and weed control are also done to a considerable extent.

In the production of perennial tree crops, mechanization is employed in the initial land clearing and preparation, and subsequently in farm road transportation and field maintenance (chemical and mechanical weed control). Medium sized four-wheeled tractors are usually used for the latter operations. All other operations are currently done manually. These include the tapping and the collection of rubber, harvesting and in-field handling of oil palm fruit bunches, harvesting and dehusking of coconut, harvesting and splitting of cocoa pods, and fertilizer application. Suitable labour saving technology for these high labour demanding operations still need to be developed.

In the case of rice production, mechanization is employed largely in land preparation, harvesting and crop spraying operations. Other operations, such as transplanting, fertilization, and in-field transportation are done by manual methods. About 60 % of total rice area in peninsular Malaysia is tilled mechanically. However, the extent is as high as 90-100 % for the main rice areas. Four-wheeled tractors (22 to 45 kW) and two-wheeled tractors (7.5 kW) are used to prepare the land using rotary tillers. For harvesting western and Japanese types of rice combine harvesters are being used. Threshers and reapers are being introduced to areas where these combines are either not workable or not viable to operate. An estimated 40 % of the total rice areas in peninsular Malaysia is harvested mechanically. However the extent is as high as 90 % for the main 'rice bowl' of the country. Crop spraying in rice is presently done by using knapsack sprayers, which are either operated manually or are engine-powered.

Mechanization is used to some extent in the production of annual crops, such as sugarcane, groundnut, tapioca, maize, and vegetables. This is limited to land preparation, and in a few cases, also to planting or seeding and fertilization. Mechanical crop spraying is also used for vegetables.

A considerable portion of agricultural machinery in the country is also used in land development projects and also in forestry. These machines are mainly of the bigger sized tracked tractors/bulldozers, excavators and draglines. Tractors are also used in the tin mining and construction industries.

NEED FOR SUITABLE TECHNOLOGY

In spite of the immediate need and demand for mechanization within the agricultural sector, the progress of its adoption is currently seriously restricted by the non-availability of suitable machinery. 'Suitability' here is defined in terms of functional ability.and economic viability within the constraints of local agricultural environment. Local research and development efforts are currently being geared towards the solution of some of these problems. Nevertheless, the interest of foreign agricultural machinery companies is drawn towards these investment and market opportunities. These mechanization problem areas, where technological innovations are in urgent need, are listed according to crop commodities in Table 1.

MACHINERY POPULATION AND OWNERSHIP PATTERN

Comprehensive statistics on agricultural machinery existing in the country are not readily available. The range of farm machinery currently known to be in use in the country is listed in Table 2. The current population of the agricultural four-wheeled tractors in peninsular Malaysia is estimated to be 5 000-6 000 units. The annual market volume on these tractors has been estimated to be 1 000 - 1 300 units (Ujang, 1979). An estimated 50 % of the tractor population is used in the plantation estate sector, while the balance are owned by contractors and government agencies or departments. Only a very small percentage of four-wheeled tractors is owned by individual farmers: on the other hand, the bulk of the two-wheeled tractors is owned by this group (Dept. Agric., 1979). Rice combine harvesters are mainly owned and operated by contractors. In the small-holder sector farm machinery services are provided to the farmers by private contractors as well as by the Farmer Organization Authority.

Table 1. Major problem areas requiring suitable mechanization technology.

Crops*	Problem areas
rubber (2 002 000 ha)	tapping of rubber tree collection and in-field transportation of latex fertilization and weed control (in large scale)
oil palm (1 130 000 ha)	harvesting and in-field transportation of fruit bunches fertilization and weed control (in large scale)
rice (738 500 ha)	harvesting of wet crop in soft soil condition in-field transportation during wet harvest transplanting, deep water and soft soil, cost direct seeding in dry and in flooded puddled soil land preparation in very soft soil, and in dry hard soils. drying of wet season harvest
coconut (345 876 ha)	in-field handling and dehusking
cocoa (72 130 ha)	harvesting and spliting of pods
tobacco (12 753 ha)	transplanting and seedling technique curing-cost and efficiency
crops grown on peat** (eg. pineapples, oil palm, vegetables, cassava)	prime mover (tractor) for soft peat soil all cultural operations (e.g. harvesting, fertilization, planting, weed control), transportation and land development
pepper (13 405 ha)	harvesting of berries
groundnut (5 197 ha)	harvesting and threshing
cassava (12 512 ha)	harvesting and planting

* Figures in brackets represent the total planted hectareage of respective crop.
** There are about 2.4 million ha of peat soil in Malaysia, the bulk of which is still undeveloped. An estimated less than one percent of peat soil in Malaysia is currently utilized (Anonymous 1979).

Table 2. Range of farm machinery currently used in Malaysia.

tractor, 4-wheeled, 15-67 kW
   implements: disc ploughs, harrows, rotary tiller, rotary slasher, sprayers, fertilizer applicator, graders (rear and mid-mounted), front end loader, rear end bucker scraper, trailers, post-hole digger, ridgers, ditcher, mowers/cutter, lifter (root crop), seeder, planter (sugarcane), subsoiler, tines
tractor, 2-wheeled, 3-12 kW
   implements: trailer, rotary tillers, water pump, ridgers
combine harvester (rice)
threshers (rice, groundnuts), reapers (rice), shellers (maize, groundnut), cleaners (grains), tapioca chipper, dryers, transplanters
knapsack sprayer (manual)
springkler irrigation, mist sprayer, water pumps
knapsack motorized sprayers/dusters/fogging machine
lawn mower, forage harvester
hand-tools and implements
crawler bulldozer, motorized graders
digger shovel, hydraulic excavator

RESEARCH AND TRAINING

Research in agricultural mechanization is undertaken at government research institutes, particularly at the Malaysian Agricultural Research and Development Institute (MARDI), the Palm Oil Research Institute Malaysia (PORIM), and the Rubber Research Institute Malaysia (RRIM); further, also at the Agricultural University Malaysia. Mechanization research activities currently being undertaken are mainly on evaluation and design development of machinery, and on field studies (functional as well as socio-economic aspects). Currently there is no standard testing and reporting on agricultural machinery sold in the country.

Training in the field of mechanization at degree and diploma levels is being undertaken at the Agricultural University Malaysia. The Department of Agriculture undertakes training programmes for tractor operators and machinery service supervisors. There are several trades training institutes giving training programmes for motor and heavy machinery mechanics. Currently there is no special training programme for technicians in agricultural mechanization. Generally there is shortage of man-power suitably trained or skilled in agricultural mechanization. This is especially so in the categories of subprofessional, technician and agricultural mechanics.

AGRICULTURAL MACHINERY MANUFACTURING

Agricultural machinery used in the country are mainly imported. Local manufacture of farm machinery is taking place at a modest rate, and this is currently limited to tractor implements, small-powered machinery, and hand-tools. These are produced with varying degrees of local content. The range of machinery and tools known to be produced locally are listed in Table 3. Statistics on the local farm machinery manufacturing industrie are not readily available. There are two types of companies producing farm machinery:

- medium-sized companies specializing in making agricultural implements and hand-tools on a fixed production basis;

Table 3. Range of farm machinery produced in Malaysia.

implements for 4-wheeled tractors: rotary slasher, rotary tillers, mid-mounted grader, rear-mounted bucker scraper, front-mounted loader/shovels, disc plough, trailers, woodern strakes (traction aid), seeder, cage wheels (traction aid)
small machines (motorized): thresher, cleaner, water pumps, sheller, dryer, lawn mower, tapioca chipper, garden tiller
knapsack sprayer (manual operation)
hand-tools and equipment (eg. knives, hoes, rakes, threshing tub, cleaning pan, sickle, planting aids, wheel barrow)
small engines (diesel)
assembly CKD 2-wheeled tractor, small engines
SKD 4-wheeled tractor

- small mechanical engineering workshop and foundries making farm implements, tools, and replacement parts on order by order basis.

Four-wheeled tractors are imported on SKD or CBU basis, while two-wheeled tractors are brought in as SKD or CKD units. Local assembly is done by the tractor companies concerned.

Some of the problems faced by the agricultural machinery industry in its future development are:

- small size of the local market. This is particularly so for the expansive high-technology machinery. However, this could also be considered in a regional (S.E. Asia) basis, where close similarity in agricultural conditions exists;
- competition from imports, especially for 'standard' agricultural machinery. It may not be so for machinery that is especially developed for local conditions;
- market attitude towards locally produced machinery. Efforts need to be made to ensure good quality and reliability, and to increase promotions;
- shortage of skilled man-power, and the relatively high cost of skilled labour;
- the industry need to be organized so that close association is possible between it and agencies for research, extension, marketing, credit, and export promotion.

On the positive side, the need for the country to reduce imports and to conserve foreign exchange might prove helpful towards the development of local farm manufacturing industry. This industry also is expected to grow in the future in accordance to the overall industrialization efforts taking place in the country.

MECHANIZATION-RELATED POLICIES

A 'general' guideline exists in the country encouraging mechanization for cost reduction, where labour shortage and timeliness present a significant obstacle to the efforts of increasing food and agriculture production. Such guidelines relate to the overall government objectives of agricultural diversification, import substitution, and raising the farmer's income. They cover also machinery utilization aspects, i.e. credit facilities for farmers and encouraging joint ownership through farmer's associations. Credit facilities are available for dealers to help make farm machinery readily available to farmers.

Farm machinery manufacturing is covered by the manufacturing sector guidelines, which provide a variety of incentives for potential foreign investors to establish manufacturing concerns in the country. Manufacturing of agricultural machinery and equipment is listed as one of the priority industries for which the incentive scheme is available (Fed. Ind. Dev. Authority, 1976). These incentive schemes are in the form of tax relief or a tax holiday period, the extent of which depends on the individual project's fixed capital expenditure, whether the factory is sited in designated development areas, the priority of the product or industry, the number of employees engaged, and the percentage of Malaysian content.

Other measures or assistance granted by the government include selective tariff protection, import licensing, and exemption from import duty and surtax on raw materials or component parts and machines.

CONCLUSIONS

Presently, the demand for agricultural mechanization and labour saving technology in Malaysia is considerable. To a small extent this demand has been met. A major portion of it is still not being satisfied because of the lack of suitable machinery, and these problem areas have been outlined.

The local farm machinery manufacturing industry is presently still in its infancy. However, it is expected to grow rapidly in the near future, even though there are problems to be overcomed.

ACKNOWLEDGEMENT

The author would like to express his appreciation and gratitude to the Director General of MARDI for his permission to present this paper.

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Agricultural mechanization in Turkey

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INTRODUCTION

As any other industrializing country, Turkey is primarily an agricultural country, where the agricultural sector is the main source of the economy. Therefore, the increase in agricultural product is not only the main factor for motivation of the rural development process, but it is also a must for the over-all economic development. In the meantime, agricultural production supplies the foodstuff and fibre for the local demand as well as for exports of Turkey.

Cultivable land in Turkey has reached its limits. Ever increasing demands for agriculture products, in terms of local consumption and the exports, can only be met by improving agricultural production. This objective can only be achieved by intensification of land use and increased yields.

Within the last 30 years governments in Turkey displayed a great concern in introducing enough modern technology into agriculture. With this policy, Turkey is now one of the few countries of the world, in producing more than enough food and fibre for her own demand.

Among the technologies such as land and water resources development, fertilizing, crop protection and irrigation, agricultural mechanization is usually the most visible and easily recognized forms of technological changes observed in the rural areas of developing countries. It is in fact a vital tool, in applying the agricultural production technologies. Successful agricultural mechanization needs well-defined policy and strategies to avoid unforeseen effects of national development policies on mechanization. There are so many examples, in nearly every developing country, related to misadvised or misapplied mechanization in the agricultural and rural development process.

In this paper the agricultural mechanization in Turkish agriculture has been reviewed and future development policies have been discussed.

THE GENERAL OUTLOOK OF THE TURKISH AGRICULTURE

Turkey is a Middle East country, lying both in Europe and Asia. About 3 % of the country coocupies the easternmost tip of the southern Europe, a region called Thrace. To the east the rest of Turkey covers a large, mountainous peninsula, called Anatolia or Asia Monor. Europe meets Asia across the Turkish Straits, the Bosporus, the sea of Marmara, and the Dardanelles. The continuous interplay of the East and the West has been a central feature of the Turkish history, culture and politics.

Turkey has a population of 46 million, living on an area of approximately 780 000 km^2. About 55 % of her population lives in rural areas and 61 % of the labour force is employed in the agricultural sector. Although share of agriculture in GNP has been decreasing in the recent years, it is still around 20 % (40 % if the agro-industry is included). Agricultural exports constitute nearly 50 % of the total national export.

From the 1960's until 1974, the economical growth rate was between 6-7 % in real terms. This was one of the highest continuous growth rates, among OECD countries. From 1974 to the early 1980's a combination of both external and internal factors led to a serious deterioration in the national economy. But after 1980, the government took serious actions which caused dramatic improvements in the economy.

Arable land under cultivation in Turkey has reached around 28.5 million ha, whereas it was 16.5 million ha in the 1950's. Of this area 10 % is under irrigation. The irrigated area is aimed to be increased up to 8.5 million ha from the current figure of 3 million ha. In most places of Turkey rainfall is scarce during the growing season, even in normal years. Considerable fluctuations in rainfall also occur from year to year. Therefore, irrigation is assumed to be a major factor in increasing and stabilizing the agricultural production.

One of the main structural characteristics of Turkish agriculture is that agricultural holdings mainly consist of very small ones: 59 % of the holdings have 0-5 ha. These small-holdings create difficulties in the application of agricultural mechanization.

Turkey has a great deal of potential to produce a great number of continental crops (i.e. cereals, cotton, tobacco) and Mediterranean crops (fruits and vegetables). The variety of soils and agroclimatic zones in Turkey create a favourable condition to grow such diversified crops as tea, citrus, cotton, soyabeans, potatoes, and bananas.

Arable land is destined to a variety of crops, depending on the agroecological zones. Cereals and pulses are grown mainly in the Central Anatolia, as in sea coast regions main cash crops are industrial crops, vegetables and fruits. In 1980, 71 % of the total cultivated area, was destined to cereals and pulses, of which wheat and barley accounted for 85 %. According to the same year's records industrial crops, such as cotton, sunflower, tobacco, sugarbeet, and oilseeds, account for 9 % of the cultivated area.

Dry land farming is the main agricultural practice in the Central Anatolia, where 8.5 million ha is fallowed every year. There are now new government projects which lead to introduce winter pulse production into fallowed areas. In irrigated areas in southern coasts, two or even three crops can be grown in one year. Maize, peanut, and soyabean are the most promising crops in that respect. The total yield per hectare has even increased during the last twenty years, due to the broad application of production technologies. However, it is quite clear that the production potential has not yet been used up to its full extent. Especially with the application of more irrigation the most of potential can be utilized in the future. Irrigation is assumed as a leading technology, which invites the others. For this reason the highest proportion of government investments in agriculture has been and will be spent to irrigation projects.

THE AGRICULTURE MECHANIZATION AND ITS RELATIONS TO AGRICULTURE

Agricultural mechanization, has been defined by many institutions and individuals in different ways. FAO has recently described the agricultural mechanization more broadly, and this description has been accepted internationally: "Agricultural mechanization embraces the manufacture, distribution and operation of all types of tools, implements and equipment for agricultural land development, farm production, crop harvesting and primary processing".

This includes three main power sources: human, animal, and mechanical. Design, development, marketing, extension and training should also be included in the above definition. The followings are the main factors of agricultural mechanization that should be taken into consideration:

- Mechanization is a production technology which assists and supports the application of other technologies.
- Mechanization replaces the man-power, but in certain cases without mechanization, man-power is not able to produce agricultural products.
- Mechanization should be applied and planned selectively in order to meet specific requests in accordance with technical, economic, social and political considerations.
- Mechanization needs a great deal of capacity investment. The lack of capital is the main problem existing in small-holdings in agriculture. Special measures are needed to be taken to introduce mechanization, such as enough credit and multifarm use.
- Mechanical power mainly relays on petrol energy sources. Therefore, there is a close relation between mechanization and energy sources.
- Mechanization should be planned with agricultural production projects especially for introduction of new crop patterns. Without suitable mecha-

nization, production objectives can not be achieved.
- Mechanization programmes should be closely combined with effective extension and training activities.
- Without organizing the local manufacturing, application of mechanization sometimes leads to be dependent on foreign currency.
- Implements should be designed and developed according to the prevailing local conditions. The soil type and crop requirements are the main factors to select the appropriate type of equipment.

Generally, increased land productivity (i.e. greater yield per unit area) depends on the application of intensive levels of technology (i.e. improved or increased physical inputs) as well as on a higher level of knowledge and management ability. However, it should be stressed that:
1. emphasis is on 'application', however. Just introducing the 'hardware' or technology without concomitant introduction of support arrangements, training and farmer motivation, or incentives, will have little chance for achieving succes;
2. a single technological input will seldom stand alone as an output increaser;
3. interdependence of inputs and management and interrelationships between inputs are such that a 'package' approach is essential to attain success.

Agricultural mechanization is an instrument of farm management. Changes in mechanization levels or types can have an increasing effect on yield. This can only be achieved by a suitable combination of agricultural mechanization and related technologies. Therefore, mechanization cannot be assumed as a single element in the input package determining land output. It is also not possible to isolate the impact of mechanization on the output and defining it in quantitative terms.

Although mechanization (i.e. agricultural tractors) is sometimes assumed to mean the application of mechanical power into agriculture, this assumption causes some misleadings. Without any doubts mechanical power technology, accompanied by other advanced technological inputs, knowledge and managerial ability, has helped to develop the agricultural yield. However, even in developed countries, there are some areas where man and animal-power are still feasible. Without introducing mechanical power mechanization can also be applied successfully by man or animal-power in small-holdings.

In many cases, tractors are solely introduced without a good judgement on suitable type and capacity of equipment. In such cases annual use is limited to 300-400 hours. This causes, in fact, the higher fixed cost per hour. Thus the farmers face serious problems of compensating the capital investment.

THE MECHANIZATION IN TURKISH AGRICULTURE

Agricultural mechanization was first introduced in Turkey in the 1860's in order to promote cotton production. After the declaration of the new Turkish Republic in 1923 by Kemal Atatürk, like any other social and economical reforms in different fields, many realistic attempts were made to introduce modern technologies into agriculture. In these years the government encouraged mechanization through import of tractors and implements. But due to the Second World War, this was limited. According to official records in 1948, only 3 000 tractors were being used. After 1950 much more tractors were introduced and the number of tractors reached to 42 000 in 1960, having a 150 different make and models.

After 1960's, with the aid of 5-year plans, agricultural mechanization was developed very fast. The number of tractors reached to 480 000 in 1982. During this period of the development the tractor industry first started with assembling and then turned to manufacturing. Today Turkey has the following indices for agricultural mechanization:

- energy sources used in agriculture consist of man-power (4 %), animal-power (13.2 %), and mechanical power (82.8 %);
- tractor intensity is 0.81 hp/ha (i.e. 16.4 tractors/1 000 ha or 61 ha/tractor;
- average hp per tractor is 49.3.

In 1960 the above indices were:

- 0.06 hp/ha;
- 2.0 tractors/1 000 ha or 503 ha/tractor;
- 33.0 hp/tractor.

The above indices show that Turkey is comperatively highly mechanized among developing countries.

According to recent estimates based on agricultural development potential, tractor requirement of Turkish agriculture will amount to 580 000 field and 156 000 orchard tractors, which totals 736 000 tractors. When this target is reached, tractor intensity will be 1.47 hp/ha. During the coming 5 years (1984-1988) 260 250 tractors will be needed to meet the demand in the agricultural sector.

Agricultural machinery industry

Turkey has succeeded to establish an agricultural machinery industry. Today there are 9 factories, having a theoretical production capacity of 100 000 and an actual production capacity of 70 000 tractors per year. These factories are producing different agricultural tractors up to 75 hp; the local content has increased to 70 %. Agricultural machinery and implements are essentially produced in Turkey, such as combines, balers, movers, ploughs, and other tillage equipment, such as drills, sprayers, dusters, farm trailers, etc.

Within the last three years, agricultural machinery export has gone up to US$ 50 million annually. Export is mainly oriented to the Middle East countries.

PROBLEMS AND FUTURE DEVELOPMENTS

As explained in the above chapters, Turkish agriculture is almost highly mechanized. During the process of mechanization within the last thirthy years, many problems have been faced. The lack of appropriate government body as adequately staffed and authorized to guide mechanization planning was counted among the most important problems encountered. In 1978 a special Advisory Committee was established in the Ministry of Agriculture and Forestry. This committee is responsible for:

- collection of data, defining objectives, establishing goals and targets;
- formulation of policies and determination of strategies;
- developing programmes and designing projects.

The Advisory Committee comprises members coming from Ministries and universities as well as from other sectors, such as manufacturers and credit organizations. The committee directly advises the minister of agriculture on solutions. It has played an important role within the last 4 years in formulating the agricultural mechanization policies and programmes, such as the establisment of a rational and realistic national mechanization park, a feasible combination of mechanical technology which best meets requirements for production, credit and subsidies, research programmes, training facilities, test procedures and extension activities.

The following general policies were set up by the advisory committee which were accepted as general rule for further developments:

1. Mechanization devices to be supplied and combined to produce both qualitative and quantitative yield according to the modern methods and technologies.
2. Mechanization devices to be developed and designed according to the local conditions and manufactured in accordance with the recent technologies.
3. In marketing, necessary credit facilities should be made available for farmers. Government should encourage both industrial and agricultural sectors to create appropriate mechanization through incentive measures.
4. Research, extension and training to be organized and encouraged in order to establish the necessary man-power on all levels of management and technical skills.

According to the above-mentioned policies, the followings will be taken into considerations for the future developments:

- special measures should be taken for mechanization of small farms;
- mechanization planning should be included in new crop production and especially in irrigation projects;
- application of new methods and technologies should be combined with appropriate mechanization systems;
- multifarm use of agriculture machinery should be established and organized especially for small farms;

- in allocation of commercial energy to different sectors of the economy, the amount of energy to be needed for increased agricultural production should be considered;
- training activities in different levels should be strengthened and the training centres should be enlarged;
- testing facilities should be reorganized to improve the quality of locally manufactured equipment;
- efforts for research and development should be combined and cooperate in universities, government institutions and industry;
- credit and other incentives should be reviewed to improve levels of mechanization;
- agricultural machinery industry should be supported and reorganized, not for only to meet the local market demand, but also for the exports to foreign market.

CONCLUSION

Agricultural mechanization is a vital tool in the agricultural development process. It not only encompasses technical problems, but also social and economic issues. Thus, it is rather difficult to establish general rules for the development of mechanization. Furthermore, each situation, both national and regional, should be examined carefully.

Agricultural mechanization should be considered as a multidiciplinary process which must be carefully planned and carried out in every country. Failure in this respect will be reflected as high cost in terms of money and time. Furthermore, it will not enable mechanization to make the contribution to increased agricultural productivity and rural development for which it is capable. The most important point as applicable to every country, is the establisment of an appropriate government body that is well staffed and authorized to guide planning properly.

Promoting factors and constraints in the development of farm machinery industry in Sri Lanka

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INTRODUCTION

Sri Lanka has a population of 15 million people and covers an area of 25 000 square miles. The majority are farmers of small-holdings having up to 3 acres. They are mainly engaged in rice cultivation. Most of the farmers still depend on traditional techniques and on draught power.

Economic development policies in Sri Lanka, as in most of the developing countries, are largely governed by a common set of problems and crises: a population growth of 2 % per year and the majority of the population living at subsistence levels that make it necessary to increase food supplies. In 1982, basic foods items already accounted for 28 % of the country's import bill, with the overall balance of trade in heavy deficit. Yet, Sri Lanka is in many respects comparatively well endowed: the sparsely populated Dry Zone (Fig. 1) offers abundant land for agricultural expansion, has sunshine throughout the year, and a rainfall of an overall average of 1 020-3 940 mm per year. The literacy rate is 79 %, the highest in the region.

AGRICULTURE PRODUCE

The main agricultural produce in the country encompasses: rice, tea, rubber, coconut, cinnamon, cardamon, cloves, pepper, nutmeg, maize, coffee, areacanut, sesame seed, cocoa, tobacco, betel leaves, papain, cinnamon leaf oil, cinnamon bark oil, and citronella oil.

In this paper only the rice cultivation is discussed in detail as this is the only sector where farm mechanization is possible on a large scala.

Rice cultivation

In Sri Lanka there are altogether 1.6 million acres (0.65 million ha) of asweddumized land (land prepared for cultivation). There are two seasons for cultivation: the Maha and the Yala. September to March is the Maha season, and April to August is the Yala season. 65 % of the land is cultivated during the Maha season and 35 % during the Yala season. In terms of acres,

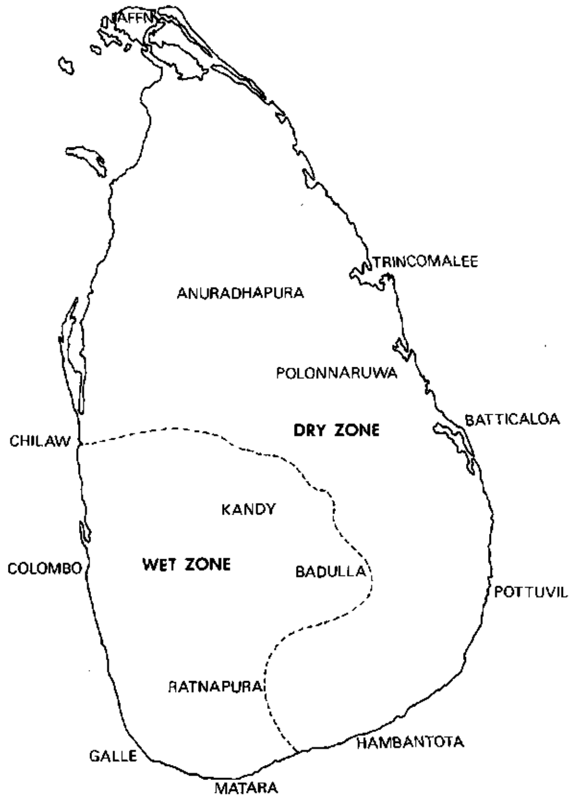

Fig. 1. Map of Sri Lanka showing climatic zones.

this is equivalent to 1 040 000 and 560 000 acres, respectively. After the completion of the Mahaweli Development Scheme, which is a diversion of the river Mahaweli, the land available for cultivation will be increased by 600 000 acres.

The majority are farmers of small-holdings having up to 3 acres. There is a land ceiling, imposed by statutory regulations in Sri Lanka, whereby only 50 acres could be owned by an individual. Out of the 50 acres only 25 acres could be rice lands. Table 1 gives the breakdown by size of holdings together with their percentages. The rice lands are sub-divided into small bunded plots for flooding before cultivation.

Table 1. Land-holdings.

	Size of holding (acres)						Total
	Up to 3	3-5	5-10	10-15	15-20	Over 20	
number	671 749	53 977	5 467	1 607	847	957	734 622
percentage	91.44	7.34	0.75	0.22	0.12	0.12	100

Traditionally the lands are tilled by farmers using mammoties or by animal-drawn ploughs, depending on the extent of the land. This is followed by flooding the field, protected by the surrounding bunds, until the soil is water-logged and the weeds are decomposed. The land is tilled again and levelled and kept in readiness for sowing. The earliest records of the use of domestic buffaloes and cattle in rice cultivation in Sri Lanka date as far back as the fourth century B.C. Since the advent of imported tractors in the post war period and the introduction of new seed varieties and chemical inputs, farmers have become heavily dependent on tractors for land preparation.

Majority of the farmers sow germinated rice seeds by hand while walking about in the field. Very few use row seeders. Transplanting is done by hand. Mechanized transplanters are not available in the country at present.

Harvesting is done manually by means of sickles. An attempt is being made now to introduce small two-wheeled harvesters into the country. Large harvesters cannot be used because of the terrain and the sub-divided bunded plots.

Unlike most of the developing countries threshing in Sri Lanka is not done by hand. Rice, after harvesting is threshed by buffaloes or cattle. However, the tractors are also widely used. Use of cattle in threshing is generally preferred where the objective is to obtain seed rice. Farmers believe that least damage is caused to rice when threshed by buffaloes or cattle. Mechanical threshers are also used and they are becoming increasingly popular.

FARM POWER IN SRI LANKA

Sri Lanka possesses one of the most mechanized rural sectors in the developing world. This indeed is a curious situation considering the average Gross National Product per capita which was US$ 254 in 1980 (Central Bank Report). This may be due to the high level of literacy in the country and the technical competence which make people more adaptable to modern concepts. Most widely used farm power source is the tractor. Along with the increasing volume of tractor usage, there has been a corresponding growth in the proportion of land cultivation annually by mechanical means. Current estimates suggest that about 45 % of rice land in the country is cultivated by tractor, with the remainder falling to buffaloes and mammoty tillage (Table 2).

The smaller land-holdings and higher buffalo and labour densities in the Wet Zone account for the low use of tractors in tillage. According to the Registrar of Motor Vehicles, there were 42 795 registered tractors as at 31.12.1982. The number of tractors licensed in 1982 districtwise is not available, nor the breakdown of the types. In 1981 however, there were 24 985 four-wheeled tractors and 15 696 two-wheeled tractors, totalling

Table 2. Percentage of annual rice acreage ploughed by power source. Source: Department of Agriculture, Peradeniya. Calculated as an average over four seasons, i.e. Maha and Yala in 1977/1978 and 1978/1979.

Zone	Mammoty (%)	Animal (%)	Tractor (%)
wet	48	42	10
intermediate	7	63	30
dry	4	26	70
Sri Lanka	18	37	45

40 681, registered with the Registrar of Motor Vehicles, i.e. 61 % and 39 %, respectively.

According to the Sri Lanka Tractor Corporation and the Agriculture Department sources, the two-wheeled tractor registration was on the increase since about 1978. This is largely due to the high price and high cost of maintenance compared to the two-wheeled tractor.

Four-wheeled tractors are mostly used for tilling operations, whilst some prefer these for threshing as well. The cost of land preparation and threshing by draught power is far less expensive to the national economy than tractorized ploughing, but mechanized farming has entered Sri Lanka and it is going to stay. As the figures in Table 2 indicate, tractorized land preparation is a distinct feature in the Dry Zone, and this covers almost 70 % of the cultivated acreage.

There are approximately 665 000 domesticated buffaloes, excluding calves, available for agricultural operations. Buffaloes are widely used in the Wet Zone. This is mainly because the rainfed tillage is not difficult, also the wet zone farmers have small-holdings, where tractor tillage is not possible due to the small bunded plots.

There are three methods of threshing in Sri Lanka. Most widely used method is the use of the 4-wheeled tractor. However, as in the case of tilling, power-driven threshers are used in the Dry Zone and the Intermediate Zone. In addition, in some areas threshing by men is practised, but only on a very small scale.

The power thresher was introduced into the country around the same time as the two-wheeled tractor. This was in the early 1970's. Within the last decade the two-wheeled tractor became popular by leaps and bounds, but the power thresher is still a novelty to the farmer. The studies undertaken by the Agrarian Research and Training Institute of Sri Lanka, show the following distribution of the percentage of threshing outputs by different methods between 1979/1980 (these could be taken as benchmarks in determining the demand for power threshers for the ensuing years):

tractor (4-wheeled mainly): 75 %;
buffalo : 24 %;
other (thresher and men) : 1 %.

In 1982 the recorded production of rice was over one billion bushels. This production is expected to increase further over the years, as more land is coming under rice cultivation, due to the implementation of the accelerated Mahaweli Development Scheme. Considering the increasing income levels of farmers and the general shift towards agricultural mechanization in the country, the power thresher will replace the tractor within the next 5-8 years as the principal method of threshing.

By the end of 1982, approximately 750 threshers of different makes and models were sold by the local manufacturers. These 750 threshers accounted for 3 % of the total rice threshed in 1982. Table 3 shows the projected demand for power threshers the next 5 years.

Reapers are not used in the country at present. There is a growing awareness for the need of a power-driven reaper, particularly a model that could be coupled to a two-wheeled tractor. Normally reaping is done by hand, and requires a much higher labour strength than the other field operations for rice cultivation. As this has to be done at the right time, when the moisture level of the crop is approximately at 23 % in order to avoid shattering losses, organizing the additional labour is always a problem. In the Wet and Intermediate Zones however, there is a certain amount of cooperation among the farmers at village level. Therefore, mustering a sufficient number of hands for the reaping operation was not an acute problem in these zones. These trends are gradually changing even at village levels, due to the rapid urbanization and the transmigration of the educated youth to the cities, looking for greener pastures.

The majority of the farmers in the Dry Zone are in the settlement schemes of colonization projects and are strangers to the area. As a result of this, the same amount of cooperation among the farmers as in the case of Wet Zone cannot be expected. Furthermore, the land-holdings are also much larger. The net result of this is the high dependence on paid labour in these areas. Therefore, difficulties of finding adequate labour during the harvesting season have to be expected. This is further aggravated by the fact that the crops of a large extent of the land will mature more or less at the same time, as sowing is done in time for the availability of the tankfed water for all the fields. Thus, the need for a power-driven reaper is acute, as the shattering losses increase if not harvested in time with consequential loss to the national economy. Few companies in the country have realized the potential of the reaper and are attempting to develop a

Table 3. Market potential for threshers. Source: Market Survey by Samuel, Sons & Co. Ltd. (1983; unpublished).

	1982	1983	1984	1985	1986
percentage	3	8	15	25	30
number of units	750	2 000	3 750	6 250	7 500

model based on a design by the International Rice Research Institute in Phillippines.

Transplanting is done by hand, mostly by women at present. This is not very popular, due to the labour intensiveness of the operation. There are a few mechanical transplanters in the country, but they are mainly used for experimentation purposes. The small size of the 'liyaddes' or the prepared fields impose constraints on the manoeuvrability of the machines. However, the agricultural authorities feel that there is a need for a mechanical transplanter, but without power-driven attachments.

Lift irrigation by large pumps is not common in Sri Lanka. However, the 2 inch self-priming agricultural pumps are very popular among the farmers. These are popular because of their portability. The pumps are generally coupled to 2 hp petrol-kerosine engines. These pumps have a capacity of approximately 6 000 gallons per hour. Larger pumps with higher output are also used, but are comparatively few in number.

Many authorities have recognized water as the most important element in the achievement of the full potential of vast tracts of both irrigated and non-irrigated lands. The pumps are mostly used in the fields where it is not possible to obtain water through irrigation channels; due to the higher elevation of the land. In the Wet and Intermediate Zones it is quite common to pump water from shallow wells dug by the side of the fields.

It is on the development of the Dry Zone by expansion of the gravity-irrigation systems that successive Governments depended on for their food drive programmes. But there are many who doubt to what extent it is administratively and economically feasible to reduce the high consumption of water per acre, and spread more widely the potential benefits of the scarce resource. They also feel that the use of pumps should be encouraged wherever it is feasible.

The government has launched a programme to encourage the use of windmills through a subsidized scheme. This scheme, however, was not successful, as the subsidized price of a wind-mill is approximately 3 times the price of an engine-driven 2 inch agricultural pump, giving a much higher capacity.

Hand-operated sprayers are widely used and has become an indispensable tool for an average farmer. The engine-driven knapsack type power sprayers are also common, and are popular among the farmers who own more than 5 acres of land.

MECHANIZATION OF FARMS

Agriculture authorities differ widely over the advantages and disadvantages of the mechanization of farms in Sri Lanka. There are many who argue that the tractors have not realized their full production potential: cropping intensity has not arisen as a result of their introduction, nor have the yields. Again, the total number of tractors (both 4-wheeled and

Table 4. Farm power implements available at the beginning of the season Maha 1981-1982.
Source: Agriculture Department, Peradeniya.

Equipment	Number of units
4-wheeled tractors	8 460
2-wheeled tractors	6 571
power threshers	750
water pumps	27 985
hand dusters	4 497
hand sprayers	28 689
power sprayers	4 162
seeders	2 527
rotary weeders	9 849
mammoties	1 084 838

2-wheeled) is not available for agricultural purposes (Table 4). This is because the owners find it more profitable to use tractors for road haulage.

Some authorities also argue that the displaced labour by mechanization may increase the burden of social cost involved in further impoverishment of those who are already poor, and also the cost to the national economy by the use of fossil fuel and the imports of machinery. This is encountered by the argument that the yield outweighs the displacement of labour from mechanized operations.

Whilst this may be true, the socio-economic considerations cannot be overlooked. There is a reluctance on the part of the educated youth to cultivate because of the labour-intensive traditional techniques practised in the fields. When the modern living patterns and implements are brought to their thresholds by mass media such as television etc., the exodus to the cities in search of an easy living with modern trappings cannot be avoided. Farm mechanization will be an inducement to discourage the transmigration of the youth to the cities.

MANUFACTURING FACILITIES

There are several engineering firms of repute with a large number of experienced and well-trained professional mechanical engineers in the country. These firms own and operate well-equipped machine shops, ferrous and non-ferrous foundries, heat treatment facilities, and electric deposition plants. However, as an inherited industry from the colonial past, tea, coconut and rubber sectors were the prima donna of the leading engineering firms since independence. The farming sector, including the rice cultivation, was totally neglected by the local engineering industry. This was because the traditional techniques employed by the farmers were not conducive to the engineering trade. The farmers in turn did not see any reason in changing their techniques in view of the abundantly available, labour and other resources. It was the rapid industrialization and the urbanization, together with the population explosion, which required a radical change in the outlook for the need for mechanization.

All tractors are imported, whilst the other implements are manufactured locally. The limited market in Sri Lanka inhibits the total manufacture of 2-wheeled tractors, which have wide applications for the small farmers, as it can be used as a prime mover for other implements.

CONSTRAINTS IN DEVELOPMENT

The main constraints in the development of farm machinery are: a limited market, governed by the socio-economic conditions of the country, the engineering of raw materials, which are totally imported, and the lack of infrastructure in the engineering industry for specialized services, which again is a reflection of the limited market.

According to Table 1 91.44 % of the land-holdings are up to 3 acres. The maximum production, under the most favourable conditions and with high chemical inputs during both the seasons, never exceed 360 bushels. This is a yield of 60 bushels per acre. Therefore the annual turnover of an average farmer is US$ 840.00, based on a floor price of US$ 2.40 per bushel. The cost of an imported Japanese two-wheeled tractor, including the rotavator, is US$ 1 400.00. Thus it would appear that this is beyond the capacity of our average farmer. This explains the limitations in the market potential. However this also reveals the need for a cheaper power source.

Before the imports were liberalized by the present government in 1977, there was a number of organizations who manufactured 2-wheeled tractors. Though they were comparatively cheap, they were not popular among the farmers, mainly due to one malady, namely the lack of a reverse gear. These tractors were simple belt-driven models, based on an International Rice Research Institute (Phillippines) design, with slight modifications. Ironically, most of the features available in a Japanese 2-wheeled tractor are not required by the farmer. What is required is a 5-7 hp tractor with a maximum of 3 forward speeds and a reverse gear. It must be emphasized here that in Sri Lanka, the 2-wheeled tractor is extensively used for road transport of people in very remote areas: therefore a high-speed transmission is desirable. This is why the available tractors for agricultural operations are less than the actual number (Table 4).

There is a tendency by various technological institutions in the developed countries to advocate appropriate technology in the developing countries. However, what is professed as appropriate technology is very often far below the expectations and aspirations of the developing countries in view of rising consumerism and the increasing exposure to modern technology. What is appropriate in a country by way of appropriate technology may not be appropriate in another country. For instance, pedal-operated machines are no longer popular in Sri Lanka. Farmers are more fastidious and discerning in their selections of plant and machinery, and pay attention to the appearance as well. What is required are selective mechanization systems to suit the technological, social and economic conditions of the country.

Sri Lanka is dependent on imported steel, ferrous and non-ferrous ingots and prime movers in the manufacture of power-driven agricultural implements. In view of the limited market, there are very few trading houses offering specialized items and materials for the industry. This could be very frustrating at times, as the design and development of a machine require a greater effort considering the non-availability of special materials and components, even though technical skills and competence are available in the country. These range from special alloy steels to springs and fasteners. In ferrous and non-ferrous foundries, scrap-cast iron, brass and aluminium are used, resulting in poor finishes where complicated sections are required. The import of ingots make the products prohibitively expensive, compared with imported machinery, particularly these from far eastern countries, which are used to 'dumping' under the present liberalized import policies.

Whilst manufacturing facilities and the skills required to produce a product to international standard, are freely available in the country, the most important requirement in the development of an engineering industry is prominently felt by its absence: a die and tool making industry.

Successive governments have encouraged the development of various sectors of engineering by the establishment of Statutory Boards. However, there had been only investments on man-power, but what is required is a modern workshop with trained personnel for the production of dies and tools in order to produce quality plant and equipment up to international standard. This is an area where the investment is prohibitively high for the private sector participation in view of the sophisticated precision machines required and this could be handled only by a state sector organization.

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Aspect général de la mécanization de l'agriculture ivoirienne, Afrique de l'ouest

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INTRODUCTION

La mécanization agricole a toujours été mené dans les pays en développement et en particulier en Côte d'Ivoire, en suivant consciemment ou non, des axes précis recouvrant des intentions à priori qui ne sont pas toujours compatibles entre elles. On peut rechercher soit la mécanisation par le paysannat, pour le paysannat, et sans le paysan.

MÉCANISATION PAR LE PAYSANNAT

La mécanisation agricole se concrétise le plus souvent par la mise en oeuvre de matériels à traction animale, et correspond dans de nombreux pays africains (surtout ceux de zone sèche) a une forme remarquable de mécanisation adaptée, appropriée aux moyens et aux besoins des petits agriculteurs. Cette situation se retrouve à des degrés divers dans les pays suivants: Mali, Sénégal, Niger, Bénin, Côte d'Ivoire, Ghana, Nord Nigéria, Cameroun, etc.

Les avantages de cette technologie douce sont appréciables:

- Appropriation individuelle des matériels, ce qui est favorable à la prise de conscience de la responsabilité des propriétaires.
- Adéquation de la taille, coût et performance des machines à la taille des exploitations.
- Simplicité de mise en oeuvre, correspondant bien aux connaissances techniques des utilisateurs.
- Facilité relative de création d'un réseau rapproché de maintenance, pouvant faire appel aux artisans locaux.
- Transferts de technologie assez aisés pour permettre l'implantation locale d'industries du machinisme agricole (ABI en Côte d'Ivoire, SISCOMA au Sénégal, SNECMA au Mali, TROPIC au Cameroun), même si, en réalité, la part d'intégration et de valeur ajoutée restent faibles.

Les inconvénients et limites de la formule sont connus:

- C'est un système limité, car la culture attelée ne peut pas tout mécaniser; elle reste une mécanisation sectorielle; elle déplace plus qu'elle ne les résorbe les goulots d'étranglement; la part de main-d'oeuvre dans le bilan de travail reste importante. En fait ce besoin de main-d'oeuvre tend à rendre la culture attelée seulement performante dans les grandes familles. Elle ne constitue pas un remède au manque de main-d'oeuvre et donc à sa cause qui est l'exode rural.

Le cheptel bovin de trait doit être acquis, entretenu, soigné. C'est là une contrainte importante, d'autant plus que les prix augmentent au moins aussi vite que les produits manufacturés. La valorisation de la viande de boucherie a été fatale à bien des attelages. On constate que les animaux soint moins disponibles, ce qui freine certaines opérations de culture attelée.

- Les prix des matériels montent rapidement malgré la fabrication locale, surtout si les subventions précédemment consenties deviennent moins importantes (FAC), ou sélectives (Sénégal), ou sont supprimées (Mali).

MÉCANISATION POUR LE PAYSANNAT

C'est le modèle le plus généralement proposé, celui qui fait appel à des matériels et équipments existant dans les pays développés, celui qui convient a priori aux organismes de financement. On transpose en conditions tropicales des matériels et des méthodes connus par ailleurs. Il y a des avantages:

- Solution logique et programmable permettant en principe une mise en valeur progressive au niveau d'une micro-région ou d'une région.
- Solution qui permet d'utiliser la motorisation conventionnelle à une échelle compatible avec ses caractéristiques de base. En d'autres termes, les superficies mécanisées sont définies pour satisfaire aux règles d'amortissement classiques des matériels utilisés, y compris pour la motorisation lourde. Il en découle que les coûts 'prévisionnels' de mécanisation sont raisonnables et théoriquement comparables aux charges admises dans des pays développés.
- Les paysans individuels sont 'approchés par l'amont' et leur formation peut être assurée graduellement, puisque, à l'origine du projet, toute la technicité est assurée par l'encadrement, le transfert des connaissances vers l'aval (le paysan) se faisant peu à peu.
- La regroupement du terroir motorisé (blocs de Côte d'Ivoire) correspond à un véritable remembrement qui est très favorable à la motorisation: les contraintes de temps s'en trouvent atténuées.
- Des techniques 'intensives' peuvent être mises en oeuvre: labour profond, semis de précision à la bonne date, pulvérisations répétées.

Les inconvénients sont:

- Il n'en existe qu'un, mais rédhibitoire: le paysan n'est pas concerné.

(a) La guestion du parc lui échappe. S'il paie des redevances, il n'a pourtant pratiquement aucun droit de regard sur le matériel, et, bien entendu, il ne s'en sent pas responsable. (b) Il n'est pas consulté pour l'organisation du travail. Il possède certes des terres (ou il en a l'usufruit), mais souvent il ignore quand elles seront labourées, hersées, semées. Tout le planning relève de l'autorité de la Société de Développement.

- Du fait de cette situation de dépendance, le paysan a tendance à considérer que cette agriculture motorisée est l'affaire des autres, et, en conséquence, il maintient en parallèle, son système traditionnel, qui concurrence en fait le système motorisé. Rien d'étonnant alors qu'il accorde plus de prix et qu'il donne plus de soins à ses propres cultures, allant parfois jusqu'à négliger les travaux qui lui incombent sur le bloc moderne (exemple du Yabra à Yamoussokro, et des blocs modernes de l'AVB autour de Béoumi).
- De ce fait, les rendements de la culture motorisée sont moins élevés que prévus, ou vont en décroissant au fil des ans. Le coût relatif de la motorisation augmente d'autant surtout si l'organisation a des faiblesses dans le domaine de la maintenance, de l'approvisionnement et de l'organisation des chantiers. A la limite on va à l'échec.

MÉCANISATION SANS LE PAYSAN

Cette formule est intéressante et couramment appliquée, même si elle ne concerne encore qu'une faible part de la production agricole. C'est souvent le seul moyen d'aborder le niveau des agro-industries, donc des cultures industrielles liées aux plantes perennes (palmiers à huile, café, avocatiers) ou aux cultures annuelles à technologie bien maîtrisée, et correspondant, au moins initialement, à des marchés existants, comme pour la canne à sucre, la tomate, l'ananas, le soja. C'est ainsi que toutes les opérations sucrières (Sodesucre), deux opérations de maraîchage (Sodefel), des opérations d'ananas (Socabo, Salci, Tiassalé), manioc à Toumodi (Sodepalm) relèvent de cette formule.

Les avantages de cette formule sont:

- Maîtrise totale de tous les facteurs agronomiques machinisme, organisation du travail, gestion.
- Création d'emplois à travers le salariat agricole (environ 3 000 emplois permanents et temporaires au niveau de chacun des 6 complexes sucriers).
- Création d'un pôle de développement nouveau par rapport à la situation antérieure.

Il y a aussi des inconvénients:

- Coûts de production, qui peuvent devenir très lourds, et recherche aléatoire d'un équilibre entre ce qui peut être mécanisé et ce qui ne peut pas l'être pour des raisons techniques, économiques ou sociales (récolte mécanisée de la canne à sucre, du coton).
- Aspect social parfois délicat du fait de la création d'un véritable prolétariat agricole, coupé de ses bases et privé de ses cultures tradi-

tionnelles, ce qui provoque une rupture brutale dans le mode de vie.

- Risque important lié au caractère même de la production agricole, qui limite le système à certaines cultures seulement, à performances régulières et élevées. Ceci exclut pratiquement les cultures annuelles vivrières.

TECHNOLOGIE ET ÉBAUCHES DE SOLUTIONS

Les tendances actuelles

Ce qui précède constitue un rappel succinct de la situation présente ou passée. Retenons que, si la mécanisation par la traction animale a progressé sans arrêt depuis un demi-siècle et qu'elle n'a pas atteint encore son développement maximum, les aléas de la motorisation ont été plus flagrants. D'abord, elle n'a démarré qu'après 1945, avec des formules lourdes et coûteuses, sans qu'aient été maîtrisé les problèmes agronomiques, économiques et humains qui l'accompagnaient. Les échecs ont été à la dimension des projets entrepris, c'est-à-dire spectaculaires. A partir de 1955 on a alors constaté partout en Afrique tropicale un fort courant d'opinion contre toute forme de motorisation, et ce n'est guère que depuis 1965 environ que l'on ose regarder en face les véritables problèmes posés et que l'on tente de les résoudre. Aujourd'hui on assiste à une éclosion d'idées nouvelles qui concernent tout les secteurs de la mécanisation et on peut espérer que des solutions originales vont s'affirmer, certaines d'entre elles étant spécifiquement africaines.

Tendances actuelles du point de vue technique

- Développement de matériels post-culture motorisés d'intérieur de ferme qui répondent à des demandes prioritaires des agriculteurs. Citons par exemple:

a. les moulins, broyeurs pour la transformation des céréales;

b. les batteuses à riz, sorgho, blé, déjà connues auparavant, mais peu répandues encore;

c. les batteuses à mil, qui n'existaient pas du tout auparavant et qui sont à usage collectif (Sénégal/Siscoma) ou même individuel;

d. les égreneuses à maïs;

e. les matériels d'épluchage et de broyage du manioc.

- Innovation dans les matériels de culture:

a. étude du no-tillage et du minimum tillage;

b. introduction de matériel à dents pour le travail du sol en remplacement du labour. Ceci a des conséquences sur le calendrier cultural, débloque des goulots d'étranglement, facilite l'utilisation des tracteurs modernes qui s'accommodent mieux de vitesses rapides pour une bonne utilisation de leur puissance, réduit la consommation d'énergie.

c. introduction des herbicides à bas et très bas volume pour différents degrés de mécanisation, depuis la culture manuelle jusqu'à la motorisation.

C'est là un des domaines où la technique appliquée en Afrique devance celle communément employée en Europe.
d. introduction, plus ancienne, des pesticides à très bas volume, avec la même remarque que ci-dessus.

Tendances actuelles du point de vue de l'appropriation du matériel

On a redécouvert récemment que la solution réelle à l'accroissement de la production reposait surtout sur le travail et la productivité du petit et moyen agriculteur. Compte tenu des structures agraires en Afrique et de la très grande importance des petites exploitations (2-20 ha), on a enfin compris la nécessité de favoriser la mécanisation/motorisation au niveau de l'exploitation familiale. Par voie de conséquence, on a alors admis qu'il fallait effectuer des travaux de recherche, adaptation et mise au point de matériels nouveaux et originaux, dérivés peut-être, mais différents des matériels conventionnels, américains ou européens. Enfin on est devenu conscient que ces matériels nouveaux devaient être conçus de façon à permettre leur fabrication sur place, au moins partiellement. Ce phénomène a émergé lentement car il se manifestait à l'encontre des idées reçues à savoir que:

- les agriculteurs africains devaient s'adapter aux matériels importés classiques et non l'inverse;
- les économies d'échelle au niveau industriel imposaient des matériels de grande série, de grande puissance, de forte complexité;
- les petits tracteurs étaient 'trop coûteux au cheval' et ne pouvaient pas réaliser les travaux indispensables.

Toutes ces 'idées reçues', et bien d'autres allant dans le même sens, ont pu être corrigées ou réfutées progressivement, non pas par des raisonnements théoriques. mais par la réalisation de prototypes, puis de préséries testés et expérimentés sur le terrain. Une fois franchi le stade de la mise au point technique, il a fallu aborder l'étude économique in situ pour trouver la viabilité des formules proposées, en les comparant à des témoins culture attelée ou motorisation classique.

Le projet de motorisation des exploitations paysannes

La question posée par les autorités Ivoiriennes chargées du développement rural est celle de la mécanisation de l'agriculture paysannale dans la perspective d'un accroissement nécessaire de la productivité du travail. L'expérience passée, axée principalement sur la grosse motorisation, a montré les limites de cette solution.

Outre les prix élevés à l'investissement et sans doute de plus en plus élevés au functionnement hausse du prix de l'énergie, les coûts de réparation et d'entretien apparaissent eux aussi prohibitifs. Devant l'échec partiel de la grosse motorisation, il convient, pour l'avenir de s'entourer d'un maximum de précaution avant de généraliser certaines formules. Dès lors le projet motorisation paysannale va élaborer sa méthodologie sur trois approches essentielles:

- Compléter les possibilités de la motorisation conventionnelle, en étudiant des matériels spécifiques pour la mécanisation intégrale du manioc, de l'igname, du soja.
- Progresser dans la voie d'une mécanisation appropriée aux besoins des petites exploitations selon les principaux axes ci-après.

a. no-tillage ou minimum tillage;

b. équipements de récolte ou d'aide à la récolte (strippers, récolteuse à coton);

c. application de sources d'énergie renouvelables aux besoins des petits agriculteurs (methane, gas pauvre);

d. études sur les minima énergetiques requis pour la mécanisation intégrale ou sectorielle;

e. mise au point de matériels à usage collectif limité, par exemple pour aider à promouvoir une corporation de petits entrepreneurs de travaux agricoles;

f. amélioration des matériels de technologie après récolte.

- Former un reseaux d'artisans ruraux susceptibles d'assumer la maintenance de type de mécanisation.

CONCLUSION

Que ce soit en Côte d'Ivoire ou partout ailleurs en Afrique, les exploitations agricoles sont diversifiées, de tailles différentes, avec des spéculations nombreuses et correspondant à des niveaux techniques et économiques multiples. Il ne peut donc pas y avoir une seule solution et un seul type de mécanisation. Seulement une approche multidisciplinaire, peut être couronnée de succès. C'est ainsi qu'une étude économique doit précéder, accompagner et suivre toute réalisation technique. C'est le non-respect de cette règle qui a entrainé tant d'échecs et qui a conduit à la conclusion erronée que toute motorisation agricole en Afrique était vouée à l'échec au niveau des petits exploitants.

plus généralement, toute étude de machinisme doit passer par une étude des systèmes de production, car il y évidemment interaction permanente entre le système de production agricole et le système de mécanisation qu'on y introduit. Il faut donc trouver un équilibre au niveau de la recherche de façon à harmoniser l'action des spécialistes en mécanisation avec celle des agronomes, économistes, et sociologues.

Politique actuelle du gouvernement ivoirien pour la motorisation des exploitations paysannes. Le Project de Promotion de la Mécanisation Paysanne

C. Assemien

Centre Ivoirien du Machinisme Agricole (CIMA), Mankono, Côte d'Ivoire

L'ACQUIS EN MATIÈRE DE MOTORISATION

Cet acquis est très important mais il concerne essentiellement la motorisation conventionnelle (avec des tracteurs à roues classiques à des niveaux de puissance élevés: même processus que dans les pays industriels quant à l'augmentation de puissance). Le parc matériel était, jusqu'à présent, presque exclusivement geré par des Sociétés de Développement (SODE). Deux secteurs d'intervention étaient touchés: (1) les défrichements et la première mise en culture effectués avec des engins à chenille de forte puissance (défrichements sociaux MOTORAGRI; AVB; CIDT) sur des blocs de culture où les paysans pratiquent une ou deux cultures conseillées par la SODE sans intégration aucune aux systèmes de productions traditionnels, et (2) la motorisation des opérations culturales exécutée avec des tracteurs à roues conventionnels. Sans toucher toutes les techniques, ce type de motorisation concernait la préparation des terres, l'entretien, et, dans certains cas, la récolte (moissonnage, battage du riz: AVB, USOP, SODEFEL). Sa mise en oeuvre était essentiellement faite par les SODE.

Des expériences de motorisation conventionnelles plus proches du paysan ont été tentées grâce à la formule GVC (Groupements Villageois Coopératifs); ce fût le cas pour le développement de la culture du riz dans le Nord-Ouest (cas des entrepreneurs de travaux, labours récolte, d'Odienné).

Quelques expériences de motorisation à des niveaux de puissance plus faibles peuvent être signalées: c'est le cas de la riziculture de bas-fond, conduite dans le Sud-Ouest (ARSO; SODEPALM; SAN-PEDRO).

A un niveau de puissance plus élevé que le précédent (motoculteur) la CIDT s'est lancée avec succès dans la motorisation intermédiaire par la vulgarisation du tracteur BOUYER TE (427 exemplaires en place à ce jour).

Le bilan des expériences passées fait apparaître que, si les solutions proposées ont joué un rôle certain dans le développement de la Côte d'Ivoire dans un contexte économique plus favorable qu'aujourd'hui, elles ne sont plus guère satisfaisantes, tant sur les plans technique qu'économique.

La dynamique de développement semble sinon bloquée, du moins freinée, en raison de la conjoncture économique actuelle. Des propositions nouvelles doivent être faites très rapidement en matière d'équipement du monde rural avec pour objectifs:

- Une diminution progressive des charges de l'état (ce qui ne veut pas dire désengagement, les mêmes moyens étant consacrés à d'autres tâches: résolution des contraintes externes aux unités de production).
- Une prise en charge, progressive, par les paysans de leur propre développement.
- Une meilleure intégration des machines et surtout des techniques mises en oeuvre dans le milieu rural.

LES OBJECTIFS DU PROJET MOTORISATION PAYSANNE

Les objectifs du projet sont grossièrement au nombre de quatre, il s'agit:

1. D'amener les responsables techniques ivoiriens à une nouvelle approche de la motorisation dans l'optique d'une véritable prise en charge par le milieu rural.
2. De mettre à l'épreuve (ou d'expérimenter) non seulement des matériels, mais aussi et surtout des ensembles de techniques (package) susceptibles de lever les goulots d'étranglement de l'exploitation agricole.
3. De définir pour chaque zone pédo-climatique homogène des systèmes de production équilibrés, tant sur les plans technique qu'économique: (a) adaptés aux moyens de production initiaux des exploitations agricoles; (b) permettant d'assurer une bonne conservation du capital sol, et (c) économiquement viables, donc incitatifs, au niveau des unités de production (notamment par l'augmentation de la productivité globale du travail).
4. De tenir le plus grand compte des problèmes de formation et de maintenance qui constituent actuellement les freins les plus importants au développement de la motorisation.

Ainsi le 'Projet Motorisation Paysanne' est en accord avec les grandes orientations du plan de développement de la Côte d'Ivoire, qui sont:

- Freiner l'exode rural par une meilleure rémunération du travail en zone traditionnelle de départ, en évitant l'émigration vers les zones de forêt.
- Moderniser les exploitations paysannes dans le sens d'un mieux être et d'une diminution de la pénibilité du travail.
- Augmenter les productions vivrières afin (a) d'éviter les importations provoquant des hémorragies de devises inutiles, et (b) d'assurer un surplus de production utilisable en période défavorable.
- Assurer la conservation du capital sol (diminution de l'érosion, mise en place d'une agriculture fixée).

LA CONCEPTION GÉNÉRALE DU PROJET

Le projet comporte des expérimentations de matériels et un suivi-évaluation des résultats. Il ne s'agit nullement de faire des recherches en machinisme agricole, au contraire, le problème de la mécanisation des exploitations paysannes doit être étudié dans tout son environnement:

1. Agronomique: maintien du potentiel productif du sol, modes de défrichement, types de successions culturales, techniques de culture, amélioration de la production à l'unité de surface).
2. Economique: evaluation des rendements (output) et des coûts (input). Evaluation de la rentabilité de la motorisation. Analyse des contraintes externes à l'exploitation agricole: prix des productions, commercialisation, transport, stockage crédit au monde rural, régime des taxes sur les matériels, etc.
3. Social: incidence des régimes fonciers sur l'utilisation du facteur 'terre'. Modes d'utilisation de la main d'oeuvre. Formation des paysans. Propositions de travail en commun à différents niveaux: famille restreinte, étendue, GVC, etc.

Sur un plan plus technique

Aucune conception de prototype n'est envisagée dans le projet, il s'agit simplement de sélectionner et d'introduire des machines déjà au point (grande ou petite série ou à défaut présérie).

Le projet tiendra le plus grand compte des connaissances existantes en matière de techniques agronomiques mobilisées au niveau des centres de recherches avec lesquels une collaboration très étroite est envisagée (MRS).

Afin de permettre une diffusion plus rapide et plus éfficace des inovations introduites par le projet, on privilégiera l'experimentation directe en milieu paysan, ainsi la mise à l'épreuve des matériels se fera en trois phases:

1. En milieu rigoureusement contrôlé indépendamment des contraintes socio-économiques (correspondant à une station).
2. En milieu paysan contrôlé par le projet, sans participation financière des paysans (aboutissement à une primière évaluation de l'incidence des contraintes socio-économiques sur le mode de mécanisation chosi).
3. En milieu paysan sensu-stricto (afin de cerner complètement les contraintes socio-économiques).

La troisième phase doit normalement déboucher sur des microprojets de développement (développement expérimental) proposant l'utilisation de chaînes motorisées complètes ou de portions de chaînes (battages par exemple). La durée des trois premières phases est de 3 ans, les microprojets peuvent porter la durée totale du projet à 5 ans.

LES THÈMES D'ACTION DU PROJET

Le but initial du projet était très ambitieux, puisqu'il s'agissait de traiter tous les problèmes de mécanisation qui se posent en Côte d'Ivoire.

La concertation avec les SODE lors des études de factibilité et d'évaluation a permis de concentrer les efforts du projet sur sept thèmes prioritaires:

1. Expérimentation sur les cellules énergétiques. L'accent est mis à ce niveau sur la motorisation intermédiaire, c'est-à-dire sur un niveau de puissance de 15-30 cv. Si la motorisation intermédiaire a été jugée la mieux adaptée, les autres niveaux de puissance n'en sont pas moins pris en considération:

- motorisation légère de type motoculture;
- motorisation conventionnelle qui peut présenter un intérêt pour les travaux à l'entreprise.

Des variantes technologiques doivent également être mises à l'preuve dans le projet:

- types de transmission (mécanique ou hydrostatique);
- sources d'énergie (diesel, essence, etc.).

2. Expérimentation d'équipements. La gamme d'équipements proposée en Côte d'Ivoire a été jugée beaucoup trop restreinte. L'équipement proposé doit permettre de lever progressivement les goulots d'étranglement. Un accent particulier sera mis sur:

- la préparation des terres et l'implantation des cultures;
- le contrôle de l'enherbement;
- les récoltes et le traitement des récoltes.

3. Expérimentation de techniques culturales. L'expérimentation en matière de techniques culturales a deux buts essentiels: (1) assurer la conservation de la fertilité du sol, et (2) étaler le calendrier de travail en réduisant les pointes de travail et partant les coûts de production.

L'essentiel du travail en ce domaine doit porter sur:

- le mode de défrichement: blocs de culture, ilots, défrichement diffus, bandes, bocage, etc. (expérimentation de méthodes 'douces' et moins onéreuses que le défrichement au chenillard);
- la préparation du sol: comparaison travail avec retournement (labour classique) travail sans retournement (dents, etc.) non travail.

4. Expérimentation de motorisation sectorielle. L'expérimentation concerne en priorité les cultures vivrières (riz, igname, manioc, etc.). Un accent particulier est mis sur la riziculture, pour laquelle il est nécessaire d'augmenter rapidement la production, ce qui implique des conditions de prix particulièrement favorables au paysan. Les cultures pérennes (café, cacao, etc.) sont également prises en compte, notamment au niveau des travaux d'entretien et de transport sous plantation.

5. Tentative d'installation d'Artisans Ruraux. Le projet prévoit la formation et l'installation d'artisans mécaniciens, regroupés en un réseau, articulé sur une Centrale d'Approvisionnement et de Fabrication (CAF). Il s'agit de mettre en place un petit atelier de fabrication concernant des outillages divers et des équipements simples, permettant de rentabiliser

l'activité principale de réparation. Les ateliers ruraux peuvent en outre servir de support à la formation technique des paysans.

6. Mise au point d'un système de suivi évaluation. Des enquêtes socio-économiques sont intégrées au dispositif expérimental du projet. Ces enquêtes sont conduites sous la direction d'un agro-économiste, assisté d'un socio-économiste à plein temps travaillant à la fois sur les zones Centre et Nord du projet. Elles doivent permettre le recueil de la plupart des données à caractère économique: temps de travaux, périodes de travaux, évaluation des contraintes de travail, fonctionnement des unités de production, évaluation des échanges de travail entre les différents groupes sociaux etc. L'élaboration en cours d'étude du système de suivi évaluation doit déboucher très rapidement sur la mise au point d'un système de suivi 'passe partout' utilisable par d'autres structures, notamment au niveau des SODE.

7. Formation. La formation occupe une place très importante dans le projet. En dehors de la formation sur le tas et à tous les niveaux des personnels ivoiriens du projet et de celle des paysans et artisans, une action de formation est prévue pour deux niveaux d'ingénieurs:

- A l'IAB (Institut Agricole de Bouaké) formation de six élèves par an au niveau de la troisième année: création d'une spécialisation en machinisme agricole.
- A l'ENSA quatre élèves par an seront formés selon le même processus qu'à l'IAB.

ORGANISATION DU PROJET

Le projet est dirigé par le Directeur du Centre Ivoirien du Machinisme Agricole, assisté dans cette tâche par un Chef de Projet, qui est aussi son Adjoint au sein du CIMA et du COMACI. Les moyens du CIMA en personnel qualifié sont nettement renforcés, puisque le projet compte 17 expatriés, dont cinq ingénieurs et 12 techniciens supérieurs spécialisés en machinisme agricole (B.T.S. du Chesnoys).

Le personnel est réparti géographiquement en trois zones dont les deux premières sont nettement plus importantes quant au volume des expérimentations mises en place (Fig. 1):

- Nord: Base Korhogo,
- Centre: Base Bouaké,
- Sud: Base Gagnoa.

Toutes les SODE (CIDT, SODEFEL; SODEPALM; SATMACI) sont directement concernées par le projet qui réalise la majeure partie de ses expérimentations au sein de leurs structures.

Les programmes sont définis chaque année, séparement, avec les représentants de chaque SODE. Les résultats sont diffusés globalement au niveau de toutes les SODE.

Un Comité de suivi placé sous l'autorité du MINAGRI participera une ou

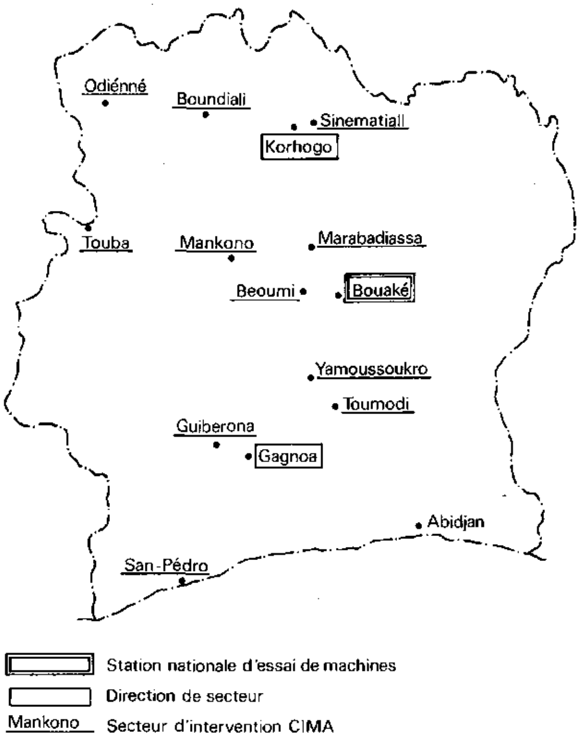

Figure 1. Implantation du CIMA.

deux fois par an à l'exploitation des résultats et à l'orientation du projet. Il est composé de représentants des ministères concernés et d'experts extérieurs spécialisés dans les principales disciplines spécifiques au projet: agronomie, machinisme agricole, socio-économie, développement rural, formation, etc.

Financement du projet

Le projet est financé par l'Etat Ivoirien, qui bénéficie d'un prêt de la Caisse Centrale de Coopératio Economique Française pour un peu plus de la moitié, l'autre partie étant financée sur Budget Général de Fonctionnement.

Le machinisme agricole en Algerie

Benzaghou Mouradi

ONAMA, Birkhadem, Alger

SITUATION ACTUELLE DE LA MÉCANISATION

Rétrospective

Depuis plus d'une décennie, l'Algérie s'est engagée dans un processus de modernisation de l'agriculture et des techniques de production, à travers la mise en oeuvre d'un plan d'équipement ambitieux en matière de matériel agricole. Cependant et malgré les efforts consentis dans ce domaine, le niveau de mécanisation demeure encore relativement faible face aux mutations que connait le secteur agricole et surtout aux exigences nouvelles induites par la croissance économique du pays.

Une analyse rétrospective permet de situer les différentes étapes de la mécanisation et les principales caractéristiques de ce facteur de production. A l'indépendance de l'Algérie, la mécanisation de l'agriculture était faible et concernait uniquement le secteur colonial. Le parc hérité était de l'ordre de 5 000 tracteurs, dont 40 % avaient plus de cinq ans d'âge. L'indice de mécanisation était très faible et se situait autour de 1 300 ha de SAU par tracteur et 6 500 ha de céréales pour une moissonneuse-batteuse (M-B).

Après l'indépendance et dans une première étape, la mécanisation n'a pas connu une évolution importante. Jusqu'en 1970, à la veille du premier plan quadriennal, le volume des équipements acquis a permis une légère amélioration de l'indice de mécanisation par rapport à son état de 1962. Ainsi, l'indice de mécanisation a évolué (Tableau 1).

Au cours de la décennie 1970-1980, la mécanisation a connu un progrès notable grâce à l'effort d'investissement engagé en agriculture. Ce développement de la mécanisation était dicté par les impératifs de l'augmentation de la production face aux exigences croissantes de la consommation et au déficit de plus en plus important de la main d'oeuvre disponible en agriculture (Tableaux 2 et 3).

Niveau d'équipement actuel

Les acquisitions pour les années 1981-1983 sont les suivantes:

- tracteurs: 35 000;

Tableau 1. Evolution de l'indice de mécanisation jusqu'à 1970.

Periode	Nombre d'ha de sau/tracteur	Nombre de cv/ha de sau	Nombre d'ha de céréales/M-B
1962	1 300	0,04	6 500
1970	300	0,13	1 700

Tableau 2. Acquisitions au cours de la décennie 1970-1980.

Periode	Tracteurs	Moisonneuses-batteuses	Semis et et épandage
1970-1973	10 852	1 163	9 220
1974-1977	13 295	3 330	7 100
1978-1980	20 304	1 877	2 300
Total	44 451	6 370	18 620

Tableau 3. L'évolution de l'indice de mécanisation jusqu'à 1980.

Periode	Nombre d'ha de sau/tracteur	Nombre de cv pour 1 ha/sau	Nombre d'ha de céréales/M-B
1977	250	0,16	777
1980	225	0,22	549

- moissonneuses-batteuses: 1 400.

L'évaluation du parc encore en fonctionnement dans le secteur agricole fait ressortir, déduction faite du parc réformé et du parc non utilisé dans l'agriculture, une disponibilité réelle de 42 000 tracteurs environ et 4 800 moissonneuses-batteuses. Ce qui donne les ratios suivants: 0,32 cv par ha de SAU ou 154 ha par tracteur, respectivement 730 ha par moissonneuse-batteuse.

L'état actuel de la motorisation de l'agriculture place l'Algérie á un niveau appréciable, si l'on se réfère à la moyenne mondiale ou à celle des régions telles que l'Afrique, l'Asie ou l'Amérique latine. Outre le matériel automoteur, l'équipement agricole tel que le matériel aratoire, de semis et fertilisation, de traitement, de récolte et conditionnement des fourrages, est livré dans des quantités suffisantes pour permettre la réalisation correcte du plan de production.

Par ailleurs, en matière d'équipement de petite hydraulique (moto-pompes, pompes et autres accessoires), les réalisations ont été très importantes et l'équipement distribué au cours de la période 1972-1983 est de l'ordre de:

- 80 000 groupes moto-pompes de différentes puissances;
- 47 000 moteurs fixes d'irrigation de différentes puissances;
- 25 000 pompes de différents types.

Les efforts réalisés dans la petite hydraulique permettent de suppléer à la faiblesse relative et temporaire de la grande hydraulique.

Situation actuelle de la production de machines agricoles

Les progrés de la mécanisation de l'agriculture ont été possibles grâce, d'une part, aux importations massives réalisées par le pays, mais aussi grâce à la production nationale. Cette dernière bien que marginale existait déjà pour le matériel aratoire, et les équipements de pompage. Mais la véritable production de machines agricoles a été initiée dès les années 1969, date à laquelle a été lancé la réalisation du complexe moteurs tracteurs de Constantine (Est du pays) et en 1972, la réalisation du complexe machines agricoles de Sidi-Bel-Abbès (Ouest du pays). Ces deux complexes sont entrés en production; le premier en 1974 et le second en 1975.

La capacité de production installée du complexe moteurs tracteurs est la suivante:

- 8 300 moteurs diesels en ligne (2-6 cylindres);
- 1 200 moteurs diesels en ligne (6-8 cylindres);
- 4 000 tracteurs à roues (licence Deutz);
- 1 000 tracteurs à chenilles.

A l'heure actuelle, la capacité nominale du complexe est de 10 000 moteurs en ligne et 6 000 tracteurs à roues. La fabrication des tracteurs à chenilles a été abandonné. Quant au complexe de Sidi-Bel-Abbès, sa capacité de production est de:

- 500 moissonneuses-batteuses (licence Claas);
- 2 000 presses ramasseuses;
- appareils de traitement:

a. pulvérisateurs (1 000 l): 500
b. atomiseurs (1 000 l): 500

- appareils de fenaisons:

a. rateaux faneurs: 2 600
b. faucheuses: 2 200

- matériel de semis et fertilisation: 1 300.

Compte tenu du nombre élevé des types d'engins à produire et des difficultés induites par une intégration aussi poussée du complexe, l'entreprise de production du matériel agricole a décidé de réduire la gamme aux équipements de moissons-battages, de fenaison et de traitement.

Outre ces deux complexes, la production de machines agricoles est assurée par d'autres unités situées au centre du pays. Ces unités assurent la couverture des besoins de l'agriculture en:

- remorques agraires: 100 % des besoins;
- citernes d'irrigation: 100 % des besoins;
- matériel aratoire: 80 % des besoins.

PROBLÈMES LIÉS À LA MÉCANISATION DE L'AGRICULTURE

Si l'indice de mécanisation de l'agriculture algérienne apparait relativement satisfaisant par rapport à la moyenne mondiale, il n'en demeure pas moins que ce niveau de mécanisation n'a pas eu encore d'impact déterminant sur l'évolution des rendements. Ceci s'explique par différentes raisons parmi lesquelles nous pouvons citer:

- l'accroissement important du parc reste relativement récent, les acquisitions antérieures n'assurant même pas le renouvellement du parc réformé;
- l'immobilisation d'une partie importante du parc a toujours constitué un handicap majeure à la mobilisation totale de l'ensemble du potentiel. Ceci découlait de l'insuffisance de la maîtrise de la fonction maintenance et distribution de pièces de rechange;
- insuffisance de la qualification des utilisateurs et faiblesse de la vulgarisation, sources de sous utilisation de l'équipement disponible;
- faiblesse de la recherche et de l'expérimentation destinées à assurer une meilleure répartition de l'équipement et des choix techniques adaptés;
- inadaptation relative des équipements de préparation du sol, de semis et fertilisation;
- insuffisance du réseau de distribution de pièces de rechange et de maintenance.

PERSPECTIVES DE LA MÉCANISATION DE L'AGRICULTURE

Dans le cadre des plans de développement futurs, l'Algérie a opté pour un renforcement de la mécanisation de l'agriculture. Cette orientation s'intègre dans un plan général de redressement et de restructuration du secteur agricole et de son environnement technique et économique.

Objectifs de mécanisation:

Pour le futur plan quinquennal 1985-1989, les objectifs de mécanisation arrêtés, visent à pourvoir le secteur agricole d'un tracteur pour 73 ha et d'une moissonneuse batteuse pour 300 ha. Cet objectif se traduira par:

1. une acquisition nouvelle de 50 610 tracteurs, dont 30 430 sont destinés au renouvellement, et 20 180 à l'extension du potentiel;
2. une disponibilité totale d'un parc de 88 000 tracteurs à l'échéance 1989.

Le rythme d'équipement annuel prévu au cours du plan est de 10 100 tracteurs. En ce qui concerne les moissonneuses-batteuses, les acquisitions annuelles seront de l'ordre de 1 300 unités et permettront une acquisition globale de l'ordre de 6 500 moissonneuses-batteuses supplémentaires, dont 3 150 sont destinées au renouvellement, et 3 350 à l'extension du potentiel.

Le parc de moissonneuses-batteuses opérationnelles au terme du plan sera de 9 500 engins. En ce qui concerne les autres équipements, le parc disponible en 1989 sera le suivant:

- presses ramasseuses: 7 400 engins, soit une machine pour 80 ha;
- semoirs: 25 000 semoirs soit une machine pour 160 ha;
- épandeurs d'engrais: 28 000 épandeurs, soit une machine pour 150 ha;
- appareils de traitement: 18 000 pulvérisateurs et atomiseurs;
- matériel aratoire: 266 000 engins environ;
- mini-tracteurs: 4 200 acquisitions nouvelles.

Pour le matériel d'irrigation, il est prévu l'acquisition de:

- 100 000 groupes moto-pompes;
- 20 000 moteurs d'irrigation;
- 20 000 pompes horizontales;
- 20 000 pompes verticales;
- 10 000 pompes immergées.

Actions sur l'environnement

Parallèlement aux actions d'équipement, le plan de redressement de l'agriculture axe les efforts sur les mesures suivantes:

1. Renforcement du réseau de maintenance de l'ONAMA. A cet égard, l'Office doit redéployer son réseau pour le rendre plus dense. C'est ainsi qu'il est prévu dès l'année 1985 de disposer d'une centaine d'antennes dotées d'un magasin de vente de pièces de rechange et d'un atelier de maintenance du niveau II. L'ONAMA ne disposait jusqu'à l'année 1982, que de 40 antennes. Au cours de l'année 1983, vingt-cinq nouvelles antennes ont été créées. Un réseau de véhicules ateliers a été mis en place au niveau de chaque daïra.
2. Maîtrise de la gestion des stocks et des ateliers de réparation. Dans cet optique, l'Office mène une action d'information de la gestion des stocks et de la gestion des ateliers. La formation et le perfectionnement du personnel technique de l'entreprise (mécaniciens, gestionnaires de stocks, responsables du service après vente, etc.), constituent un axe d'effort important pour les années à venir.
3. Encadrement et équipement des exploitations agricoles. Les exploitations agricoles disposant d'un parc important seront dotées, au cours du plan, de petits ateliers de maintenance. De même, l'affectation de chefs de parcs aux exploitations a été engagée et se poursuivra progressivement.
4. Recherche et expérimentation. L'expérimentation du matériel agricole sera renforcée au niveau des fermes pilotes relevant des instituts de recherche-développement. Il est prévu la création de plus de 120 fermes pilotes, dans lesquelles l'étude des équipements sera réalisée en fonction des spécificités régionales et selon les orientations culturales. D'ores et déjà, 80 fermes pilotes ont été créées et réalisent des essais sur une gamme de plus de 100 machines de différents types. Une coordination étroite existe entre l'agriculture et l'industrie pour la détermination commune des types d'équipement à produire par les complexes nationaux, ainsi que les modifications et adaptations à apporter à la production actuelle.

5. Vulgarisation. La vulgarisation a constitué par le passé une faiblesse majeure dans le cadre de la promotion des techniques agricoles adaptées. Cette faiblesse est caractérisée dans le domaine du machinisme. L'organisation des services de vulgarisation a été réétudiée pour permettre un plus grand dynamisme en la matière. Le secteur de production socialiste est encadré par des SDA (ou secteurs de développement agricole), composés de cadres chargés du développement et de la vulgarisation. Le secteur de production privé sera encadré par des délégués agricoles chargés plus particulièrement de la vulgarisation. Ces services sont en liaison étroite et permanente avec les instituts de recherche-développement. En matière de machinisme agricole, l'ONAMA est chargé d'élaborer les documents de vulgarisation en relation avec les instituts.

Perspectives de la production de machines agricoles

Compte tenu des besoins croissants de l'agriculture en machines agricoles, les projections de la production nationale ont été étudiées dans la perspective d'un accroissement des capacités de production nationale. L'entreprise nationale du machinisme agricole prévoit:

- l'accroissement de la production de tracteurs à 8 000 unités par an, dans les modèles de puissance allant du 65 cv (6 000 unités) à 100 cv (2 000 unités);
- l'accroissement de la production de moissonneuses-batteuses à 800 unités par an;
- la fabrication de motoculteurs et mini-tracteurs.

Les études sont en cours pour déterminer les types et la capacité de production. Pour les équipements de semis, de fenaison et de traitement, l'entreprise de production du machinisme agricole étudie les possibilités de reconversion de la production pour répondre de manière plus satisfaisante aux besoins des utilisateurs. Pour l'ensemble des autres équipements, les études sont en cours pour réaliser l'extension des chaînes de fabrication en vue d'atteindre l'autosatisfaction des besoins. Seuls les tracteurs à chenilles, dont les besoins annuels sont de l'ordre de 2 000 tracteurs, continueront à être importés.

Le niveau de mécanisation agricole au Cameroun

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INTRODUCTION

Le Cameroun est un pays en développement dont les activités sont essentiellement agricoles. En effet, 8,5 millions d'habitants que forme la population vivent d'agriculture. Ce qui justifie l'importance que les pouvoirs publics donnent à ce secteur.

Il nous sera donc possible de voir dans cet exposé la situation actuelle de l'agriculture camerounaise, ainsi que ses différents niveaux de mécanisation, la place de la recherche et de la formation dans la problématique de l'insertion de la mécanisation de l'agriculture traditionelle, qui est la situation de base. Nous nous attarderont ensuite sur les efforts de constructions locale de machines agricoles avant de terminer avec la position du gouvernement face au problème de la mécanisation de notre agriculture.

PHOTOGRAPHIE ACTUELLE DE L'AGRICULTURE CAMEROUNAISE

L'agriculture camerounaise, bien que largement traditionnelle, n'est pas monolithique. Trois classes d'exploitants la partagent: le petit paysannat, les agro-industries, et les agriculteurs modernes.

Le petit paysannat

Il forme plus de 90 % tant de population agricole que des activités agricoles. Toutes les cultures qui caractérisent le Cameroun s'y retrouvent: cultures vivrières (maïs, arachide, riz, mil, sorgho, plantain, manioc, macabo, ignames, etc.), cultures pérennes ou de grande exportation (cacao, café, coton, etc.).

Les superficies des exploitations de cette classe sont toujours petites (moins d'1 ha à 2-3 ha). La main d'oeuvre quant à elle est toujours familiale. Tandis que les techniques culturales sont en cours de modernisation.

Le petit paysannat est encadré soit par les Services traditionnels du Ministère de l'Agriculture (encadrement plus lâche et classique) soit par les Sociétés de Développement (encadrement plus serré, techniques culturales et équipements plus modernes; ce deuxième type de structure se développe de plus en plus).

L'équipement agricole employé par le petit paysannat est généralement individuel, rustique, manuel. S'il couvre la préparation sommaire du sol (sémis et buttage à la houe), il n'intervient que fort rarement à la récolte et encore plus rarement à la transformation (en dehors du mortier et du pilon et de la pierre à meuler les grains). En fait, le paysan traditionnel a un outil agricole de base qui intervient dans toutes les activités agricoles et même dans la défense de l'individu contre les agressions extérieures. Suivant les secteurs, il s'agit de la matchette ou de la houe (elle-même pouvant avoir plusieurs dessins).

Dans les zones où la traction animale a cours (savane herbeuse et steppe), deux activités en bénéficient particulièrement: le travail du sol (ouverture du sol avec des charrues en bois, pas très sourante) et le transport (produits et actifs agricoles).

La modernisation des techniques culturales et de l'équipement agricole utilisé par le petit paysannat s'accélère particulièrement dans les zones encadrées par les Sociétés de Développement: introduction du labour au tracteur ou à la culture atteleée (WADA, MIDO, SODERIM, SEMRY, SODECOTON, etc.*), de l'utilisation des engrais et semences sélectionnées, du travail en équipes (ce qui rend disponibles des superficies plus grandes, d'où la possibilité d'utilisation de machines plus performantes).

Les agro-industries

Ce secteur représente 7-8 % des activités agricoles du pays. Il s'agit de la mobilisation de très grandes superficies par spéculation retenue (milliers ou dizaines de milliers d'hectares). Les techniques culturales aussi bien que les équipements agricoles sont généralement des plus modernes (SOSUCAM, CAMSUCO, SOCAPALM, HEVECAM, SODEBLE, etc.). Les équipements agricoles sont généralement de grande puissance (tracteurs agricoles, moissonneuses-batteuses, séchoirs, etc. en rapport avec les superficies à exploiter et la quantité de produit à manutentionner.

* WADA: Wum Area Development Authority à Wum
MIDO: Mission de Développement des Cultures Vivrières d'Ombessa
SODERIM: Société de Développement Rizicole des Mbos près Dschang
SEMRY: Secteur de Modernisation Rizicole de Yagoua
SODECOTON: Société de Développement du Coton, Garoua.
SOCUCAM: Société Sucrière du Cameroun
CAMSUCO: Cameroon Sugar Compagny
SOCAPALM: Société Camerounaise des Palmeraies
HEVECAM: Société Hevea Cameroun
SODEBLE: Société de Développement de la Culture du Blé

Les agriculteurs modernes

Cette catégorie d'exploitants, dont l'importance et le nombre sont grandissants, représente la couche intermédiaire entre les deux premières citées plus haut. Il s'agit de fonctionnaires et d'hommes d'affaires investissant dans l'agriculture au même titre qu'ils le feraient dans l'immobilier. Ce sont donc essentiellement des agriculteurs à temps partiel et une partie du capital investi vient du FONADER (Fonds National du Développement Rural), notre Crédit Agricole.

La superficie des exploitations concernées est moyenne de 10-100 ha, et les cultures qu'on y trouve ne sont pas particulières (vivrier, cultures pérennes), pourvu qu'elles puissent être commercialisées localement ou par l'exportation.

Les équipements agricoles utilisés sont modernes avec une puissance et une performance correspondant au rendement exigé. Il faut reconnaître néanmoins que le travail de formation en machinisme agricole déjà entamé comme nous le verrons plus loin devrait encore se poursuivre en profondeur chez cette jeune catégorie d'exploitants agricoles.

RECHERCHE ET FORMATION EN MACHINISME AGRICOLE

La recherche et la formation en matière de mécanisation de l'agriculture trouvent leurs activités au sein du Centre National d'Études et D'Experimentation du Machinisme Agricole (CENEEMA). S'agissant d'abord de la recherche, le CENEEMA a pour objectif de trouver pour le Cameroun des machines adaptées à ses différentes cultures, ses écologies et aux niveaux techniques des utilisateurs. Pour ce qui est de la grosse motorisation et de la motorisation conventionnelle il s'agit surtout d'un tri, de retrouver de part le monde, chez les différents constructeurs, la machine répondante à ces exigences précises. Dans le cas des petits exploitants agricoles, le problème devient plus complexe, car il faut trouver une machine rustique, efficiente et peu chère. Or ce type de machine qui correspond à une époque déjà dépassée pour l'Occident, ne se retrouve plus chez les constructeurs. Car il s'agit de petites séries et d'obsolescence. Il nous reste donc à nous tourner vers des pays ayant des problèmes similaires aux nôtres, d'y trouver un modèle à adapter à notre cas, ou alors dans le dernier cas, à mettre au point un prototype correspondant aux exigences locales.

Dans ce dernier contexte, le CENEEMA teste dans les conditions camerounaises tout le matériel agricole pouvant correspondre à ces besoins. C'est dans ce même esprit qu'il a développé une série de prototypes correspondants aux conditions du petit paysan (batteuses de riz, décortiqueuses d'arachides, semoirs, dépulpeuses de noix de palme, moulins, tarares, râpes, etc.). L'introduction en milieu rural de ces différents prototypes est en cours d'étude.

Concernant la formation en machinisme agricole, cette tâche qui revient au CENEEMA est très importante; l'assimilation de la mécanisation agricole par le monde paysan en dépend. Il est formé ainsi des conducteurs de tracteurs et de machines agricoles et des mécaniciens agricoles, à la demande des privés, coopératives ou complexes agro-industriels, et cette demande est sans cesse croissante.

Actuellement une cinquantaine de ce type de personnel est formé par an. De même le Centre offre une occasion d'imprégnation ou d'initiation à travers des sessions qu'il organise pour les ingénieurs et techniciens du ministère de l'agriculture et des organismes de développement rural. D'autre part, dans le but d'initier et de susciter l'intérêt, le CENEEMA accueille pendant les vacances universitaires pour les stages, des étudients de l'ENSA (École Nationale Superieure Agronomique) de Yaounde et de l'Etsher (École Inter-États des Techniciens Superieurs de l'Hydraulique et de l'Équipement Rural) de Ouagadougou en Haute Volta. Des stagiaires des pays voisins sont également acceptés au sein du Centre.

CONSTRUCTION DES MACHINES AGRICOLES AU CAMEROUN

La construction de machines agricoles est encore une industrie naissante. Elle se divise en deux volets: une usine de construction et de montage de machines agricoles (La Société des Forges Tropicales: TROPIC) et un ensemble d'artisans ruraux ou urbains. TROPIC est une Société privée où l'État n'a qu'une faible part (16 %). Elle fabrique des outils manuels (matchettes, charrettes, butteuses, etc.). De même un montage de pulvérisateurs est fait sur place. Le marché de cette Société couvre tout l'UDEAC (Union Douanière Économique d'Afrique Centrale).

Une extension des ces activités industrielles est possible avec la naissance récente d'une fonderie SOLADO au sein du Groupe TROPIC.

Pour ce qui est des artisans, leurs fabrications répondent à des besoins locaux. Leurs formations comme leurs activités sont généralement héréditaires. Les problèmes auxquels ils font face sont une manque d'approvisionnement efficace en matières premières de bonne qualité (acier) et une bonne infrastructure technique pour l'extension du marché.

POLITIQUE DU GOUVERNEMENT FACE A LA MÉCANISATION

L'agriculture est une priorité pour le Cameroun. Le gouvernement insiste donc pour une augmentation de la production tant en quantité qu'en qualité. Les raisons justifiant cette politique sont le maintien de l'autosuffisance alimentaire du Cameroun et la continuation de son rôle de grenier de l'Afrique Centrale.

L'introduction de la mécanisation agricole est un élément important de la politique du gouvernement et c'est pour cette raison qu'il a été crée le Centre National d'Études et d'Experimentation du Machinisme Agricole pour faciliter l'utilisation des machines par le paysan. De même l'acquisition du matériel agricole sur crédit FONADER a été facilitée. D'autre part, il a été prévu dans le cadre du cinquième plan quinquennal la mise en place par le CENEEMA d'un réseau de jeunes artisans rurauxe formés à cet effet. Enfin, ce faisceau d'activités se complète par une vigoureuse politique d'installation de jeunes agriculteurs dont la perméabilité aux techniques culturales et équipements modernes est bien connue.

Situation actuelle de l'expérience sénégalaise de mécanisation agricole

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SURVOL DE L'ÉVOLUTION DE LA MÉCANISATION AGRICOLE

Une politique d'équipement de l'agriculture au Sénégal a été esquissée pour la première fois dans les années 1930, sous l'impulsion des sociétés de prévoyance, puis des sociétés mutualistes de développement rural. En fait la mécanisation agricole s'est effectuée graduellement à partir de la mise en place du programme agricole en 1958. Aux outils manuels a succédé la traction animale. On compte actuellement 200 000 attelages en service, faisant du Sénégal un des pays les mieux équipés d'Afrique Occidentale. La motorisation a également fait son apparition principalement pour la préparation des sols labours et pour les opérations post-culturales. Cette motorisation progresse actuellement sous l'impulsion des sociétés de développement, et aussi il faut le dire, de l'agressivité commerciale et les dépositaires et importateurs privés qui entraîne un développement anarchique de ce marché.

Le niveau technologique de l'équipement est en effet très variable suivant le système de production, les régions et la culture dominante. Le bassin arachidier a atteint un niveau d'équipement satisfaisant, alors que les régions périphériques, dont le potentiel agricole est considérable, ont été délaissées pour des raisons diverses: faible capacité d'endettement des paysans céréaculteurs, sols lourds à forte densité de souches, parcellaire très spécifique de la riziculture traditionnelle, introduction récente de culture dont la mécanisation a été peu étudiée, etc. En ce qui concerne le matériel de récolte et de post-récolte, la demande est importante: la récolte du coton, le battage de l'arachide et du riz, l'égrenage du maïs se font avec le concours saisonnier d'une main-d'oeuvre étrangère de plus en plus rare et chère.

PROBLÈMES ACTUELS DE LA MÉCANISATION AGRICOLE

L'équipement des cultivateurs est lié, pour une grande part, au progrès de la traction bovine, qui implique la mise au point et la diffusion d'une gamme de matériels en général plus élaborée et plus dispencieux que l'équipement léger qui constitue encore la plus grande partie du parc. Par ailleurs, les sociétés de développement sont confrontées à des problèmes à ce jour encore irrésolus: labours d'enfouissement, récolte en sol dur, goulots d'étranglements du calendrier agricole.

Le recours à la mécanisation est alors envisagé; l'engouement que l'on note chez les cultivateurs s'explique par l'amélioration considérable du rendement de leur effort et de la réduction concomitante de la pénibilité des travaux culturaux, grâce au moteur. Ils s'interrongent sur leur possibilités d'accès à ces moyens de production, et attendent des autorités qu'ils soient mis à leur dispositions dans le cadre des structures qui restent à mettre au point, si l'on veut éviter que ce marché soit exploité anarchiquement au bénéfice des fabricants étrangers et des gros constructeurs.

Role du Comité National

Le Comité National pour la Mécanisation Agricole doit avoir pour rôle principal de contrôler et de coordonner, sur le plan technique, la diffusion des matériels agricoles mis à la disposition des cultivateurs après essai, homologation et agrément officiel de ces matériels. Il ne s'agira en aucun cas d'un organisme de promotion des ventes, ni d'incitation systématique à la motorisation; il s'agira bien plutôt de maîtriser la prolifération désordonnée des équipements: il n'y a pas moins d'une dizaine de marque de tracteurs agricoles au Sénégal, représentées par autant de concessionnaires, alors que le parc est encore dérisoire. Cette profusion de matériels pose des problèmes évidents de service après vente et de formation. Une certaine standardisation du parc contribuerait à faciliter la coordination et le contrôle des constructeurs, importateurs et sociétés de développement. L'action à mener se situe donc sur trois plans:

- formation des utilisateurs et de l'encadrement;
- identification et choix des modèles;
- mise en place des structures de maintenance.

La mise en oeuvre d'un tel programme justifie que soit mise sur pied une structure spécifique d'impulsion, de contrôle et de coordination, qui soit aussi opérationnelle que polyvalente. C'est le rôle du Comité National pour la Mécanisation Agricole.

POLITIQUE DE RECHERCHE DÉVELOPPEMENT

La situation du Sénégal par rapport à la plupart des pays de la sous-Région en matière d'acquis agronomiques est la conséquence d'une longue tradition de recherche-développement.

Dès l'origine la stratégie était à la décentralisation en relation avec les opérations de développement agricole lancée dans le temps à travers le pays depuis 1920. Le centre de Bambey dans le centre du Sénégal polarisait les centres secondaires de Richard-Toll dans le nord, de Sefa en moyenne Casamance. D'autrec centres complémentaires à Synthiou Maleme dans le Sénégal Oriental à Nioro du Rip (Sine Saloum) à Djibolor en basse Casamance et des points d'essai à Boudoum barrage dans le Delta, avaient en charge la recherce-développement. Plus tard la mise en place de plusieurs points d'appui et d'expérimentation multilocale des unités expérimentales devaient permettre de descendre la recherche vers le terrain opérationnel pour les applications de développement qui se prolongent jusqu'au réseau paysan, correspondants de recherche.

La création de l'Institut Sénégalais de Recherche Agricole (ISRA) a constitué en 1977, la dernière réorganisation structurelle de la recherche-développement. Cette importante expérience de recherche-développement a donné des résultats appréciables dans les différents domaines de l'agronomie. Car au Sénégal la recherche agricole s'est conçue dans un cadre multidisciplinaire pour tenir compte des interéactions et interdépendance des disciplines agronomiques et à priori sans rapport entre elles, comme par exemple la génétique de la machinisme. C'est l'un des grands avantages de la centralisation en matière de formulation des programmes de recherche. La pratique a mis en évidence qu'il était impossible, ni même souhaitable, d'isoler un aspect particulier de la recherche en particulier le machinisme, et de l'étudier indépendemment des autres considérations agronomiques. De là a écoulé la notion d'agro-machinisme mieux appropriée que la conception strictement 'mécanicienne' du machinisme agricole.

LES ACQUIS DE LA RECHERCHE ET LES AXES DE DÉVELOPPEMENT

Les principaux acquis de la recherche en matière de machinisme agricole peuvent être résumés sommairement comme suit:

Les techniques culturales. Progressivement mis au point à travers le dispositif structure de recherche définis ci-dessus, les différents travaux réalisés; ont parmi tôt de dégager les méthodes et techniques les plus appropriées assurant au niveau de la vulgarisation d'abord ensuite du paysan lui même la maîtrise des façons culturales mécanisées grâce à la traction animale, des principales productions traditionnelles sénégalaises: sorgho, arachide, mil, niébé, etc.

Le contenu de ces techniques culturales englobe les composantes machinismes, agronomiques et socio-économique notamment:

- les densités de semis;
- les variétés de semences;
- les types de fumure;
- les différentes opérations (travaux);
- les rotations culturales;
- la gamme des matériels et outillage nécessaires;

- les techniques d'attelage;
- les types de traction (asine équine, bovin);
- les réglages et l'emploi des machines;
- les normes d'équipement;
- les temps de travaux;
- les effets économiques;
- les études de système.

La combinaison de ces différents résultats a permi d'imprimer une dynamique remarquable dans le développement du machinisme agricole et de l'industrie qui en a la charge sur les plans:

- de l'amélioration des équipements existants;
- de l'identification des blocs de travaux agricoles ouvrant ainsi la voie:

à la création d'outils complémentaires;

à la récréation de machines nouvelles tel le polyculteur à grand rendement et le semoir à coton, etc.;

- de la correction et de la réalisation des normes d'équipement;
- de la lutte contre l'aridité et l'utilisation efficiente des réserves hydriques par la pratique des labours et de la diffusion de la charrue.

Axes de recherche-développement en machinisme. L'importance relative au développement et de l'évolution du machinisme agricole au Sénégal se vérifie à travers:

1. La tendance à créer au sein de certaines grandes sociétés de développement (SAED, SODEVA, et SODEFITEX) de section machinisme, ayant pour objectif d'intégrer certaines préoccupations dans les actions concrètes de développement en vue de résoudre des problèmes spécifiques et immédiats.
2. La poursuite des recherches en mécanisation attelée pour remplir quelques créneaux non encore mécanisés ou dont les solutions existantes ne sont pas satisfaisantes par exemple labour d'enfouissement en Casamance.
3. Les expériences de motorisation intermédiaires et de développement des matériels d'intérieur de ferme (moulin, décortiqueuse, etc.).
4. Les études en motorisation classique appropriée dans le cadre d'utilisation collective.
5. La volonté du gouvernement de créer des structures d'accompagnement et de rationalisation des préoccupations machinismes (Comité National du Machinisme Agricole, Centre National, d'Expérimentation et de Formation).

SITUATION DE L'INDUSTRIE DU MACHINISME AGRICOLE

L'industrie Sénégalaise du machinisme agricole, qui cumule déjà une expérience de plus de vingt ans, est sans doute la plus ancienne dans la Région Ouest-Africaine, et certainement l'une des plus anciennes dans le continent Africain. Elle a exercé ces activités jusqu'en 1980 sous le nom bien connu de SISCOMA. Depuis, à la faveur d'une transformation liée à des exigences de croissances et de redynamisation la nouvelle Société Industrielle Sahélienne de Matériels Agricoles et de Représentation SISMAR a pris le relais.

LES PROBLÈMES DE CONCEPTION ET DE DÉVELOPPEMENT DES MATÉRIELS ET ÉQUIPEMENTS AGRICOLE EN AFRIQUE

La situation des pays en développement dans laquelle a des degrés quasi comparables se trouvent nos différents pays, est caractérisée d'une manière générale par:

- un manque de spécialistes dans les divers domaines, notamment dans celui du machinisme agricole;
- une insuffisance de moyens financiers;
- la nécessité d'un développement aussi rapide que possible de l'agriculture (principale activité économique) avec l'objectif d'une autossuffisance alimentaire.

Ces simples considérations devraient à elles seules suffire très largement pour justifier une étroite coopération sous-régionale et régionale dans le but de rationaliser au maximum les faibles moyens existants. Au contraire on assiste à:

- une dispersion des efforts;
- une duplication des mêmes efforts ça et là;
- une manque de coopération;
- un défaut grave de circulation des informations techniques et technologiques.

L'étroitesse relative du marché solvable du machinisme agricole dans nos pays individuellement considéré est une réalité due à la faiblesse de la capacité autonome d'investissement du paysannat et à l'insuffisance des crédits pouvant être mobilisés à leur profit compte tenu de l'importance et de la diversité des besoins en équipements. Ces réalités devraient impliquer une stratégie de concentration et de spécialisation dans le développement du machinisme agricole:

- Centralisation localisée: par groupe de pays des moyens de conception et de mise au point de prototypes avec subséquemment développement au niveau national des capacités d'amélioration et d'adaptation aux conditions locales spécifiques.
- Specialisation localisée: sous forme de division du travail. Cette spécialisation des unités de production industrielles couvrant des marchés d'une taille économiquement viable et capable d'assurer un réel développement et une modernisation appropriée de l'industrie, qui autrement resterait encore longtemps à la limite ou juste au-dessus d'un artisanat amélioré.

Donc le développement véritable de l'industrie du machinisme agricole en Afrique se situe à notre avis dans la stratégie ci-avant exposée, car on ne dira pas assez que sur un plan simplement économique la mise en oeuvre de certaines filières technologiques qui permettent d'atteindre un niveau d'intégration relativement intéressant (conséquent), n'est envisageable qu'au niveau d'un marché dont la dimension devrait se situer du niveau d'un groupe ou de la sous-région dans les conditions actuelles et à moyens termes de la réalité de la situation de nos marchés.

De plus il faut souligner que la promotion d'une telle coopération horizontale par cercle concentrique entre groupe de pays en développement ne peut que revigorer la coopération verticale entre ces mêmes pays et les pays développés.

The agricultural mechanization in Egypt

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INTRODUCTION

The current interest among policy makers and planners in speeding the pace of agricultural mechanization, stems in large part, from high concern over the rapidly growing pressure of population among severely limited land resources.

The 1978-82 five-year plan understandably makes 'food security' the centerpiece of national strategy of the agricultural sector (Min. of Planning, 1977). In this plan mechanization is looked to as one of the principal means for furthering food security objectives. Mechanization is seen mainly as a means of avoiding further deterioration in the rate of increase in agricultural production by off setting the effects of labour shortage and rapidly rising wage rates engendered by the heavy external migration of Egyptian workers. Beyond describing the labour shortage problem and pointing to mechanization as a means of ameloirating it, the Ministry of Agriculture has defined specific objectives of agricultural mechanization and charted broad approaches to achieving them.

AN OVERVIEW OF EGYPTIAN AGRICULTURE

Existing cropping system

Egyptian agricultural year extends through the period October 1st till September 30 of the next year. Climatic conditions, as well as availability of irrigation water, permit production of Egyptian field crops all the year round. The agricultural year is commonly divided into three main seasons, namely fall, summer, and nili. Fall crops, such as wheat, berseem (Egyptian clover), horse beans, barley and flax, are sown during autumn, i.e. the period October-November, and harvested during late spring and early summer, April-June. Summer crops, such as corn, rice, cotton, and soya beans, are sown during spring and early summer, i.e. August-October. Nili crops (named after the Nile flood season) are sown by late summer, i.e. July-August, and harvested by late autumn, i.e. October-November. Overlapping, takes place between different seasons, notably summer and nili.

Some crops can be grown within more than one season as well. This is so with respect to truck crops, such as tomatoes, beans, and potatoes, as well as some of the field crops, i.e. rice, corn, and sorghum. The cultivated area, in case of field and truck crops, is used for producing two to three crops per season, which in turn requires arranging their production in a rotating system known as the crop rotation. A given crop rotation is known after the leading crop of that rotation. Cotton and sugar-cane rotations are the most dominant rotations of Egyptian agriculture. Crop rotations, meanwhile, are known after the fraction of the area devoted to production of the leading crop. A two-fold or a three-fold cotton rotation implies that the fraction of cultivated area devoted to cotton production amounts to 50 % in the first case, compared to 33 % for the second one. This pattern of rotating crops implies that cotton production is repeated in the same plot once every two years in the two-fold rotation, and once every three years in the three-fold one.

Farm labour balance

Egyptian farmers, small and large, look to mechanization to overcome their crop production bottlenecks. Wage-rates tripled between late 1973 and mid-1978 after having remained virtually unchanged throughout most of the preceding decade. The demand for seasonal workers has pressed ever harder upon available supplies, until now there are periodic shortages during the summer and fall peak seasons.

Principally responsible for the increasing scarcity of farm workers and the sharply escalating wage-rates is the rapid rise since 1973 in the number of Egyptian workers who have moved to higher-paying employment in construction work abroad, mainly in the Gulf States and Lybia. The 1976 Census reported 1 425 000 Egyptians (including dependents) living abroad. The Arab Federation of agricultural workers, estimates that 1.5 million agricultural workers went abroad or into domestic non-farm employment between late 1973 and mid-1978. The Ministry of Agriculture estimates that an average of 230 000 persons per year left Egyptian farms between 1966 and 1976.

Types of land tenure

Two main types of land tenure, namely private ownership and legal renting, dominate the cultivated area. According to the land tenure type of 'private ownership' farm land is used for agricultural production by the owner or somebody else on his behalf. Tenants, in accordance with the legally rented type of land tenure, are entitled the right to hold and use farm land for agricultural production. They were given such rights in accordance with the Land Reform Act No. 178 dated 1952. Their lease contracts were legally authorized for three consecutive agricultural years. These contracts, afterwards, were extended indefinitely, thereby preventing landlords from substituting the tenants and/or holding their ownerships.

HISTORICAL MECHANIZATION PERSPECTIVE

Prior to the land reforms of 1952 (Min. of Agriculture, 1920-1921) and 1961, mechanization progressed as large land-holders found it advantageous. While large holders represented only 1 % of Egypt's farms in 1960, units of more than 50 feddans comprised 20 % of total cultivated area. Consequently, though the distribution of benefits under the pre-reform land-holding pattern did more than a little violence to any reasonable concept of social justice.

In the mid-1960's, recognizing that Egypt's typically very small farms could not be individually mechanized economically, the government induced a dramatic increase in mechanization through cooperative-based custom service, which blended the goals of technological improvement and social justice. Form a pilot experiment in two governorates in 1965, this innovative system spread rapidly under strong government encouragement to bring the benefits of mechanization within reach of even the smallest farms. With limited built-in capacity for growth, the cooperative-operated system could not keep pace with the effective demand of custom services. Nor has it in fact served all farmers equally well. In spite of the difficulties faced the cooperative-based custom services, it played a vital role in pioneering an approach to agricultural mechanization uniquely adapted to the structure of Egypt's agricultural economy.

During the period from 1952 up to 1965 about 900 000 feddan have been reclaimed. The most up-to-date heavy machinery was used in both land reclamation as well as land utilization. In this period of time complete lines of farm machinery were put into operation under the supervision of the General Organization of Land Utilization. This organization was abolished in 1973, and the responsibility of running this area has been shifted to several agricultural companies. This period is considered the most flourishing period of mechanization in Egypt, where a complete system has been created concerning the research and development of systems and machinery required to fit the Egyptian Agricultural conditions in the newly reclaimed land. In order to strengthen the training system five training centres have been established to prepare the technical staff. A network of service centres has been established to cover the repairs and maintenance of the huge fleet of farm machinery working in the reclaimed area. In fact a strong foundation of mechanization has been founded during that period.

Between 1965 and 1973 private custom operators entered the field in rapidly increasing numbers. Where the cooperative-based custom services built a market for custom operation at the village level.

The 'Open Door Policy' of 1973 already has significantly increased the pace of agricultural mechanization. By its philosophy, this policy has profound implications for further mechanization strategy. In particular, it implies that private enterprise is to be encouraged to take up much of the decision-making burden previously placed upon the government bureaucracy. Evidence of the effectiveness of this policy in achieving its intended results are easily found in farm mechanization field. After resting on a low-level plateau for several years, tractor imports tripled from 1974-1977.

FORMS AND PRESENT STATUS OF MECHANIZATION

With the low productivity of traditional agriculture and high potential of increasing this productivity, the basic problem centres around how to introduce mechanization into an agriculture based on a large number of holdings with many attendant problems. Some of those include:

- small holdings without adequeate access roads;
- fragmentation of holdings into odd-shaped individual farms;
- high cost of farm machinery usually beyond the means of most farmers;
- the problems of adoption of farm machinery to the Egyptian farming conditions, which were designed for different environment and farming systems;
- the practice of mixed cropping in which different types of crops are grown on the same plot;
- poor level of technical education among farmers and lack of technical know-how.

Three stages of mechanization can be identified in Egypt. The use of hand-tools, the use of animal power and the use of standard four-wheel tractors or power tillers.

Hand-tools

The common hand-tools are made locally by blacksmiths with simple equipment. The Egyptian hoe is an excellent digging, weeding and all-purpose tool. The curved blade and the shape of the handle made this tool functionally well designed. The hoe is used mainly for cultivation, ridging and weeding.

Another much used tool is the shovel. Some are made locally, but the imported ones are preferred by the farmers. These shovels are used mainly for shifting earth, cleaning drains and ditches.

The traditional sickles are used extensively for harvesting and moving operations. The Egyptian short-handle sickles are locally made by artisans. The major deficiency is the quality of the metal used. Whatever the efficiency of hand-tools, at best they place heavy demand on human energy, increase work hours and are often responsible for low levels of production.

It was observed that the engagement of hand-tools in the country's agriculture has become a forceful repellent to farmers and will be progressively more repulsive with time. The young generation of farmers who will be school leavers will detest the use of any implements that will make farming entail more difficult manual work than in other jobs (like motor driving, mechanic's work, building and mason's work, etc.), which people of their own comparable education do.

Animal power

Animal power is considered an inevitable stage between hand-operated machines and tractor-operated machines. Cattle and buffaloes are used extensively as draught animals in Egyptian agriculture; animal energy still accounts for some of the major production functions among small farmers. The use of animals is quite common for primary tillage, irrigation, threshing and transport. The total number of animal hours used for various operations are summarized in Table 1. From this table it can be concluded that about 71 % of total animal work on farms is taken up by irrigation practices (operating water wheels).

A considerable area is still cultivated by animals which are also used for water lifting. Draught animals number about 1.3 million; that takes the limited fodder resources of the country. Thus the use of animal power can only be looked upon as a preliminary phase in the introduction of more sophisticated mechanical power in the future.

Engine power farming

It is important to reiterate that a farm machine must meet the economic and social needs of the farmer. It must fit in well with the level of industrial and technological development of the region. There exist two distinct agricultural mechanization technologies that have evolved to suit different sets of agricultural and socio-economic conditions: the approach which emphasizes dry-land farming, using large high-powered equipment with great emphasis on labour savings, and the Japanese type, which emphasizes wet-land farming based on small holdings using relatively small low-power machines.

Table 1. The use of animal in Egyptian agriculture.

	Animal hours/acre			
Crop	non-irrigation	irrigation	total	percentage for irrigation
clover	-	31	31	100
cotton	18	31	49	63
maize	13	37	50	74
wheat	19	26	45	58
total	50	125	175	71

1. Power tillers (single-axle tractors). Pilot trials were carried out since 1962 by the Egyptian Ministry of Agriculture. The objectives of the trials were to find out whether the single-axle tractor could be a substitute for draught-animal power for individual farmers. From 1976 the trials and demonstrations became more extensive. The different kinds of tillers tried included 18 models. They were used for primary and secondary cultivations for cotton and rice, as well as orchard cultivation. The overall results of the trials were varied. The experiences to date show that there are certain limits to the use of these power tillers, these include: (a) inability to till the land when dry; (b) in order to carry out primary cultivation in the Egyptian heavy soils, it requires tillers equipped with at least 14-20 hp units and overall weight of at least 250 kg; (c) prices still too high for individual farmers; (d) low rate of work, and (e) lack of spare parts.

In spite of all reservations expressed above the Egyptian farmers are willing to adopt such equipments to overcome the shortage already existing in agricultural labour. The Ministry of Agriculture in its effort to develop a system suitable to mechanize small holdings need to experiment with these small machines, modify and rebuild as necessary. The tests and studies should be more concerned with problems of equipping the tractors with locally-built suitable implements and the integration of these small-power units into the farming system, rather than with a mere comparison of mechanical efficiencies between different makes of tractors.

2. Tractor-power farming. In 1950 there were only about 5 000 tractors in Egypt. These tractors were mostly located on large farms and not available or well known to the majority of Egyptian small-land holders. Mechanical power for agriculture is therefore relatively new to the present farming population.

Up to 1960 all tractors belonged to the private sector. Today roughly 70 % of all tractors are owned by private individuals and 30 % by cooperatives.

From about 5 000 units in 1950 the tractor inventory for all Egypt rose to about 16 960 in 1965, 24 500 in 1970, 31 352 in 1976, and about 34 600 in 1981. About 40-45 % of the tractors listed in 1976 are obsolete and are fully or partially inoperative. Therefore, the fully operational power at present may be under 19 000 units.

In the early years of tractor introduction their use was limited to power for primary-tillage operations and transport. Later stationary threshers were introduced and the tractors were used as a power-source through the belt pulley. Today much the same tractor-use pattern remains with an estimated 70 % of the total annual tractor use for primary tillage and 30 % for other uses, such as transport, belt power, etc.

Chisel ploughs have been the predominant primary-tillage implement through the years. Today there are 26 030 chisel ploughs in the country and only 1 130 units of all other types of ploughs combined. The reason given for this unusual predominance of chisel ploughs for irrigation farming are: similarity to action of the traditional animal-drawn plough, and therefore ease of introduction to conservative farmers, simplicity of adjustment with relatively low mechanical aptitude or knowledge, and the absence of moving parts and therefore easier to manufacture with locally available materials. Today, however, there is considerable scope for improving primary tillage as one step in the overall goal of increasing crop yields and reducing costs of production, and an orderly change from the use of chisel ploughs to soil inverting ploughs appears timely.

The stationary threshers commonly used in Egypt have nearly all been locally manufactured units of about 300 kg/h capacity, powered by a belt from the tractor pulley and with a threshing cylinder, but without a separating fan. Some hand-operated fan separation units are used in the second operation, as well as the traditional basket/winnowing for separating the grain from the chaff.

One hundred percent of the application of chemicals for plant protection is reported to be mechanized. The 1975 national inventory shows 1 000/30-hp power-sprayers, 13 000/6-hp power-sprayers, 4 000/30-hp back-pack sprayers and 120 000 manually-operated pressure sprayers. In addition in 1972, 500 000 acres of cotton were sprayed by aeroplanes.

All field operations, except rice transplanting and cotton picking, are mechanized in some of the mechanized farms in the 'new lands'.

FARM MECHANIZATION POLICY

The Ministry of Agriculture is beginning to broaden their effort in mechanization reflecting their firm commitment to pursuing some forms of mechanization to relieve what are perceived as real problems. The Ministry of Agriculture took as a basis a five-year period (1980-1985) as the shortest time to span in which reasonable progress could be expected towards establishing a systematical and optimal approach to mechanization. The programme pace and content would maximize the contribution of further mechanization in increasing Egyptian farm output. The Ministry of Agriculture has recently approved an agricultural mechanization programme which concentrates its effort on the following three points:

1. Near-term priorities.

The most promising areas of opportunity for directly increasing production by further mechnizing farms operations are:

- better seed-bed preparation;
- more timely planting;
- increased sub-soiling coverage or precision-levelling operations;
- replacement of animal-drawn sakia with motor-driven pumpsets;

- more diversified use of tractors;
- placing thresher-winnowers and mechanical grain harvesters into general use.

2. Relieving equipment constraints.

In order to optimize the contribution of machines to Egyptian farm production, a significant increase in both the number and types serving Egyptian agriculture is required. Priority needs for addition equipment include:

- tractors to expand custom operations;
- subsoiling and land-levelling equipment to enable to demonstrate the benefits of subsoiling and precision land levelling sufficiently to develop a market for private custom work in this field;
- new types of land preparation, planting and cultivation equipment;
- self-powered thresher-winnowers and mower-binders to reduce grain losses;
- motor-driven pump-sets to free cows and buffaloes from draught work.

3. Improving the support system.

- better management of machines by farmers and custom operators;
- improve repair facilities and availability of spare parts;
- modernize local manufacture capacity for farm equipment;
- expand and improve farm mechanization research and development;
- increase effectiveness of on-going machinery introduction programmes;
- increase the supply of trained mechanics;
- establish a more effective management information system.

INTERNATIONAL COOPERATION

Realizing the importance of international cooperation providing technical and material assistance to mechanize the Egyptian Agriculture, the government approached the different international organizations to give the required support to fulfil the Agricultural Mechanization Programme. The following projects have been approved.

USAID Projects

1. Agricultural mechanization project. US aid to the project amounting to US $ 40 million and Egyptian contribution is US $ 15 million. As stipulated in the plan of operation, the following objectives have been set up for the period of 1980-1985:

- Institutionalize within the Undersecretariate for Engineering Affairs a Planning and Evaluation Unit that would specialize in gathering and analysing data for programme planning, evaluation and policy formulation.
- Institutionalize within the Undersecretariate a research capability to identify research priorities and the effect of mechanization alternatives on yield and cropping intensities. Also, initiate research on the socio-

economic impact of mechanization.
- Assist in the development of a machinery management extension programme, machinery introduction programme and an advisory programme for small, local manufacturers of agricultural implements. Ameliorate small-farmer access to improved water-lifting equipment.
- Improve land productivity, concentrating in Upper Egypt, through land-levelling to better control the application of irrigation water and sub-soiling activities to relieve soil compaction and hard-pan formation problems.
- Assist in the development of the MOA plan for establishing a network of privately owned and operated service centre facilities based on both area and satellite workshop to the degree that funding would permit.
- Organize training programmes that would: (1) upgrade basic skills of existing equipment repair personnel and equipment operators, (2) organize within the government a farm machinery management programme, and (3) develop two types of participant training: short-term observation training in other developing countries with similar mechanization problems, and long-term training to create a mechanization leadership potential.
- Conduct a local manufacturing feasibility study that would: (1) identify current capacities and financial needs for plant modernization, (2) identify types of equipment and parts that could be manufactured locally to meet Egyptian needs, and (3) develop a market analysis study for the manufacture of suitable equipment for the current and intermediate Egyptian market.

2. Small-scale agricultural activities project. USAID contibution US$ 1.7 million and Egyptian contribution amounting L.E. 271 000. The following targets have been set up for the period of 1979-1982
- The project will assist to improve the quality of rural life for rural families.
- To increase the participation by small enterpreneurs in national economic development by:
  . introducing or adapting technologies appropriate to small farmer and rural resident needs;
  . beginning the process of developing an institutional capacity in appropriate technology;
  . increasing rural employment opportunity through expansion of the activities of small, rural-based agribusiness enterprises.

Federal Republic of Germany

The Federal Republic of Germany approved a grant to modernize the Maamoura Training Centre. The project is aiming at, providing training in:
- use and application of farm machinery;
- maintenance of farm machinery;
- repairs of farm machinery.

World Bank Project

The IBRD approved a soft loan amounting US $ 32 million to establish an agricultural development project in Menofia and Sohag Governorates. The project objectives are:

- To initiate a process of restructing and strengthening of agriculture extension, credit and cooperative institutions to enable them to become genuine promoters of ecomonic development and of the interest of small farmers.
- To increase crop and livestock production and productivity and farm incomes through carefully designed farm mechanization for the benefit mostly of small-holder farmers, relieving human drudgery and releasing animals from work, with a minimal adverse impact on employment.
- To carry out machinery testing activities and trials in covered irrigation, to study and demonstrate advanced farm machinery and irrigation systems for future use.
- To evaluate the impact of mechanization of land use, livestock and employment; leading a.o top policy prescriptions and preparation of development projects.

Japanese Internation Cooperation

- The JICA approved a soft loan amounting US $ 13 million to establish farm machinery custom service in Aswan Governorate which will be devoted mainly to improve sugar-cane production.
- JICA approved a grant to establish a Rice Mechanization Project in SAKHA, Kafr El Sheikh Governorate.

FAO Improved Farming Systems

FAO contribution US $ 1 992 720 million.

- To strengthen applied research and introduce economic studies on systems of farm production practices.
- To secure farmer adaptation of improved combination of practices through extension services and related activities on village levels.
- To increase the production of field crops and to equip and put in operation farming systems research centres at Sets and Mallawi stations, and to train national research scientists. The period of systems: 1978-1982.

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Present status, problems and prospects of agricultural mechanization in Sierra Leone

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INTRODUCTION

Sierra Leone, like any developing country, has been aiming at national food self-sufficiency, and, consequently, the nation has been looking at all aspects of the agricultural production system to identify areas which will accelerate the pace of the production effort. The greater proportion of all farms in Sierra Leone are small, often smaller than 5 ha. Low fertility, poor soil structure, poor seed and planting materials, uncertain water availability, extreme temperatures, and lack of access to inputs and markets tend to reduce the productivity of such small farms. However, under conditions where land is limiting, as in parts of Asia, highly productive and energy-efficient systems of farming have been developed and the mechanization of agricultural operations at the appropriate level has featured to some extent in this effort.

Mechanization in our context should be looked at in its widest sense. It is the process of substituting capital in the form of machines in place of human labour and animal power. Simple mechanization, such as improved hand-tools and animal-drawn implements tend to increase the efficiency of human and animal power. A more complete mechanization of agricultural operations will include tractor power and many different types of machines which replace animal power and human effort in the planting, cultivating, harvesting and processing of agricultural commodities.

Sierra Leone is one of the smaller countries of Africa, and its 73 326 km^2, which lie between 6°55' and 10°N and between 10°16' and 13°18'W, represent just under 0.25 percent of the African continent. The tropical climate is characterized by a 7-8 month wet season from May to November, with heavy rains from July to September. Although some rain continues to fall during the predominantly dry season from December to April, and the humidity remains relatively high, the drought is sufficiently severe to leave dead vegetation tinder dry, and to cause bush fires. The rainfall of about 3 000 mm a year on the coastal plain drops to 2 300 mm a year in the north of the country, where the dominant forest regrowth gives way to some savanna woodland.

The 1974 census estimated a population of 2 735 159 persons, with a growth rate of 1.9 % at the time and rising to 2.1 % per year by 1980 (Dow & Benjamin, 1975). Approximately 70 % of the total population is involved in agriculture, i.e. about 70.8 % of the male population and 78 % of the female population, respectively.

There are about 300 000 small-farm holdings in the country, cultivating about 1 300 000 acres of land. In addition, another 20 000 acres are operated by institutional farms and large farms, making a grand total of approximately 1 320 000 acres destined to the growing of crops. This is less than 8 % of the total area of Sierra Leone.

PRESENT STATUS OF MECHANIZATION IN SIERRA LEONE

Mechanization of agriculture in Sierra Leone could be said to have started with the introduction of several small ox-training projects in 1928, and these have demonstrated the potential for using Ndama cattle for crop cultivation and farm transport. In areas of Northern Province, where about 90 % of the nations cattle are found, farmers have continued to use the old Ransome 'Victory' ploughs for over thirty years, despite serious problems in obtaining spare parts.

Mechanization by the use of tractors could be said to have started when the first agriculture tractor, plough and harrow were brought into the country by the Department of Agriculture, in 1946 (Annual Report of the Department of Agriculture, Sierra Leone, 1947). Towards the end of the 1940's tractors were used for experimental cultivation of the northern bolilands and southern riverain grasslands by the Ministry of Agriculture (Spencer, 1974). Two hectares were ploughed mechanically at Subu in the riverain grassland, and 20 ha in the bolis around Batkanu in 1949. The total acreage rose steadily to a peak of about 12 000 in 1956 and 1957, followed by a sharp drop in 1958/59 when the Ministry, it is reported, demanded payments in advance rather than after the harvest. Acreage rose steadily after that to a plateau of 9-10 000 ha in the late sixties and early seventies, with the highest of about 11 600 ha in 1971. Early 1974 the Ministry added a new fleet of 200 tractors to the 100 odd tractors in running condition, making a total of about 300 operational units, which ploughed some 22 900 ha. Nearly all this was planted to rice.

There has been a gradual increase in the importation of tractors and farm machinery with a view to increase the production of the country's staple food, rice. In 1980, the Sierra Leone Produce Marketing Braod (SLPMB) made available to the Ministry of Agriculture and Forestry (MAF) a quantity of agricultural machinery and associated equipment, to form the basis of a 'Crash Rice Programme', which was formulated by the MAF early in 1979 with the main objective of reducing the dependence on foreign sources for the supply of the staple food crop of the country.

The constraining factors in the development of wide-spread mechanical cultivation are daunting and include high capital costs, involving foreign exchange, increasing costs of imported fuel, and very severe organizational problems involved in adequately servicing and repairing complicated mechanical equipment widely dispersed around the country. The long-term national impact of previous mechanical cultivation schemes have never had access to the tractor ploughing schemes, and the limited number of farmers who have at one time benefited, have suffered from the short-term nature of the various projects, which have generally stopped completely when the tractors broke down and were abandoned after a few years.

PROBLEMS OF MECHANIZATION IN SIERRA LEONE

Historically, the evolution of farming tools and equipment has been slow. The first digging sticks were developed over the years into the plough, which was pulled by the farmer or his wife and, later on, by oxen or other draught animals. In Sierra Leone these indigenous methods are still in use. Similarly, harvesting is carried out by hand and the grain crop threshed by flail. Although government desires that its farms be mechanized in order to increase productivity, the mechanization of Sierra Leone farms is hampered by several problems, many of which cannot be solved in this decade. They include the following:

1. Expensive mechanical power source and equipment. The capital investment for even a small farm is quite high, because most mechanized equipment is imported. The non-availability of foreign exchange, coupled with the high prices of these machines, make it impossible for small farmers to avail themselves with these machines.
2. Spare parts and services. Non-availability of foreign exchange similarly affects the provision of spare parts, which in turn affects all mechanization schemes in the country. Also service facilities are limited and often after sales service not available.
3. The cost of fuel and oil. With the high cost of diesel fuel and engine oil it is indeed expensive for an average farmer in Sierra Leone to own a tractor.
4. Inadequacy in design of available equipment. What makes most imported farm equipment all the more expensive is its inefficiency in working under local conditions. Some modifications and redesigning have to be done to make such machines functional. This is due to the absence of a suitable testing and evaluation programme to ascertain the efficiency of the imported equipment.
5. Low level of technology for mechanical operation. Most farmers are illiterate and have little or no experience with mechanical implements. They have little or no exposure to modern machines and are hesitant to even try handling of powered piece of equipment.

6. Lack of trained operators and servicemen. Little or no programmes exist to train operators and servicemen for the various types of machinery and equipment brought into the country. With no training in the use of tractors and equipment machinery is often badly used, resulting in major breakdown and delays in farming operations.
7. Other problems. Other problems include a cumbersome land tenure system, a lack of irrigation facilities where needed, as well as social and political problems.

METHODS OF DEALING WITH THESE PROBLEMS

Cooperatives

A logical answer to one of the many problems of mechanization seems to be the creation of cooperatives, which could institute syndicate farming, machinery pools and joint storage projects. Such arrangements have been successfully introduced in other countries, where previously it was thought difficult to persuade farmers to cooperate. Care should be taken in starting such schemes where there is already an abundance of labour. The use of machinery may lead to a reduced need for labour, though this will be required at a later stage, when more work is done on agricultural processing. In the interim period, employment could be created with the local manufacture of improved hand and animal-operated implements needed for regular cultivation operations in the agricultural cycle. This period could also be used for the education of farmers, and those wives who would be released from the need to work on the land. Educational schemes of this kind should properly be organized and financed by government authorities.

Government action and aid

The government should be accept the necessity of opening up new areas by bush clearing, surveying for corrective soil conservation measures, and introducing group farming. Such schemes require capital and technical assistance contribution could be sought from foreign donors and the United Nations' agencies, supplying capital either as gifts or loans on favourable terms. Such projects may prove highly successful. The clearing of the bush may help to eradicate the black fly that causes river blindness, and consequently improving the health of the people. There would be more permanent settling on the land, and equipment pools could enable farmers to hire machinery for use on their own farms.

However obvious it may seem that machinery is needed, nothing can be done unless the people wish to make use of it. Although there may be initial reluctance to try new tools, great enthusiasm generally evolves on the benefits of mechanization realized. The use of machinery may, nevertheless, produce its own problems. Where land is traditionally inherited and held by families in small holdings, the use of machinery will be difficult. Law of inheritance and subdivision of land can only be changed by government legislation, and feelings of family and traditional right must be dealt with cautiously.

A large amount of capital would be required for assistance in the initial stages of a land-clearance scheme. The heavy equipment necessary for clearing bush would be beyond the reach of a small-scale farmer. Once land is cleared, further capital would be necessary to cover its dividion into settlements, allocating it to group farmers, etc. In addition, the farmers would eiter need loans for buying their initial equipment or the opportunity of hiring government or syndicate-owned machines. For efficiency steps would have to be taken to process and store the crops, i.e. processing machinery and stores would be needed. In addition, effective transport and marketing systems would have to be created.

Planning

The importance of forward planning cannot be overstressed when introducing mechanical methods of cultivation into the agricultural industry, and it seems essential to consider the following factors in order to ultimately achieve successful mechanization: the availability of machinery service and maintenance facilities; increasing the acreage of ploughable land at the expense of that previously used for grazing animals; growing cash crops as well as high-yielding food crops; observing soil-conservation practices; making maximum use of favourable climatic conditions; securing greater output per man per acre; altering the system of land tenure, and establishing training centres for educating farmers in the use and understanding of machinery. The list is long and items are not necessarily given in order of priority.

Many instances can be cited in which countries, eager and enthusiastic to introduce mechanical schemes, have failed through the lack of preparation and planning to make them work, with the result that equipment has prematurely reached the scrap heap.

In areas where it may be dediced to undertake mechanization, planning is essential if the waste of scarce resources is to be avoided. In particular the importance of considering the policy of gradual approach to mechanization should be stressed. In large-scale farming schemes, whether privately or publicly owned, heavy mechanization is necessary if extensive field operations are to be carried out with the minimum cost.

In many cases, there is the tendency to encourage the use of tractors without due consideration of the part that could be played by draught animals. In small-scale farming efficient use could often be made of animal-draught power, though as the farms increase in size the problem of ensuring timely ploughing, cultivating and planting becomes critical.

Machinery pools should be established to serve individual farmers or groups of producers. In this regard, it is necessary to plan administration, supervision and maintenance in such a manner that the overhead costs are kept to a minimum without in any way impairing efficiency. Successful administration is usually the result of accurate survey work in the initial stages, which involves investigation into the needs of the producers and careful selection of equipment to meet these needs.

It is essential for maintenance facilities to include adequate base workshops capable of handling major repair work with connecting depots, where regular preventive maintenance can be performed with efficiency.

Sometimes, the introduction of a large variety of makes and types of tractors and implements increase the problem of maintenance and also causes unnecessarily large amounts of capital to be tied up in spare parts and servicing tools. Therefore, it is necessary for the government to set up a machinery testing station, preferably in the university, to test the equipment according to a standard of procedures under local conditions. Government should restrict the import of machines, by not granting import licence to dealers whose machines do not meet the specifications of the standard required. It must be recognized that some tractor and implement design with conventional equipment is not always ideal for conditions in tropical agriculture and that there is a need for research into adaptation of such equipment to the local conditions that exist in the country. Many technical problems in machinery operations could be solved through research. The formulation of a suitable mechanization programme for the country needs a wealth of technical, economic, social, political, educational and other data.

CONCLUDING REMARKS

There is a number of factors which contribute to the success or failure of a mechanization scheme. Each must be given due consideration, for lack of attention to a single factor can result in technical or economic failure of the entire scheme. One must never loose sight of the fact that a tool or machine must pay for itself through increased returns or decreased operating costs.

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Agricultural mechanization in Nigeria

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INTRODUCTION

Nigeria lies in the tropics and has a land area of 98.3 x 106 ha out of which about 71.2 x 106 ha, i.e. about 71.24 %, is considered agricultural land. As at now, only about 34 x 106 ha, i.e. 47.8 % of the cultivable land, is being cropped. Fig. 1 shows the various ecological zones in Nigeria These ecological zones, which are based on rainfall and consequent environment, are well established. A set of crop pattern has consequently broadly

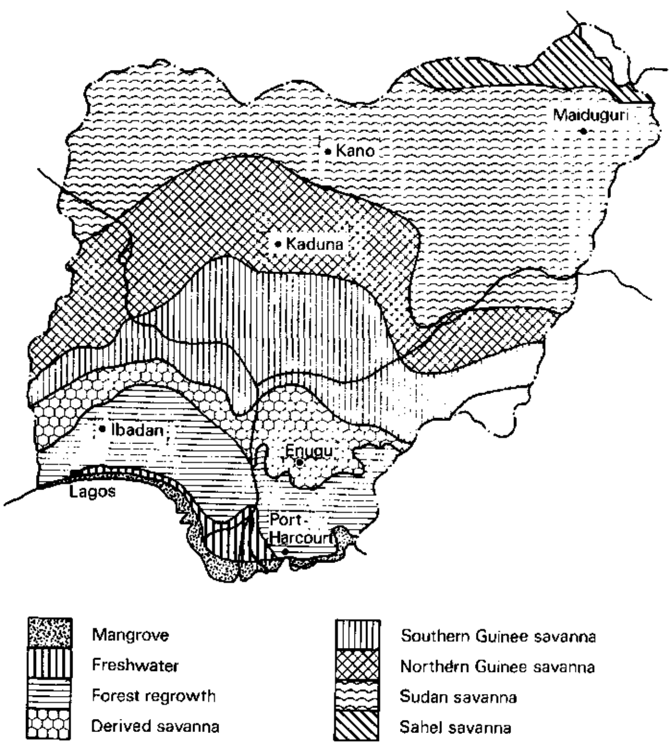

Fig. 1. Vegetation zones of Nigeria.

emerged. For example tree crop farming is restricted to certain ecological zones, so is cattle production.

Farmers constitute the most single important occupational group in Nigeria. The 1952/1953 population census indicated that 78 % of the adult population was engaged in agriculture, forestry and fishing. This participation level was maintained in 1963/1964. Out of the estimated 25.1 million economically active population 20.1 million people were engaged in agriculture. In 1966/1967 and 1970 there was a slight decline in percentage of the population engaged in agriculture to 71.7 % and 62.2 %, respectively (Agboola, 1979).

The main agricultural systems are:

- rotational fallow agriculture;
- semi-permanent or permanent agriculture;
- mixed agriculture.

The major crops include:

- root crops, such as cassava, yam, cocoyam, Irish potatoes, sweet potatoes and cocoyam;
- grains, such as cereals like maize, rice sorghum (guinea corn), wheat and millet; and legumes, such as cowpeas, groundnuts, and soyabean;
- tree crops, such as cocoa, oilpalm, kolanut and rubber;
- fruits, such as citrus, pineapple, pawpaw (papaya), banana, plantains;
- industrial crops, such as cotton, tobacco, sugar-cane, kenaf.

The main types of livestock are: cattle, sheep, goats, and poultry.

PRESENT STATE OF AGRICULTURAL MECHANIZATION

Nigerian agriculture is to be characterized by the following among other factors:

- large numbers of small-holdings scattered over large areas without adequate access roads;
- difficult land tenure system, resulting in fragmentation of holdings into odd-shaped farms;
- mixed cropping in which different types of crops are grown simultaneously on the same plot, thereby making the use of machines on these plots difficult;
- inadequate infrastructural facilities;
- poverty, low levels of production, shortage of capital, and insecurity of income for farmers;
- lack of experience in the use of machinery and lack of technical skills or know-how of farmers;
- high costs of machines, usually beyond the means of the farmers;
- progressively increasing age of the farming population;
- shortage of various grades of personnel in agricultural mechanization, particularly technicians agricultural mechanics and agricultural machine

operators.

A small number of large farms is owned by government agencies and private individuals. Given all this, it will be not surprising that, in general, the overall level of agricultural mechanization in Nigeria is low. Agricultural mechanization in Nigeria involves in the main the use of hand-tools. In the northern states, some animal-drawn implements are used. Conventional tractors and the accompanying range of equipments for land preparation, planting, weeding, harvesting and post-harvest processing are used on the large-scale farms.

The succeeding governments have embarked on a number of schemes aimed at improving agricultural output and increased agricultural mechanization. These include the creation of the River Basin Development Authorities, Agricultural Inputs and Services Units (AISU), Agricultural Development Corporations (ADCS) encouragement of the formation of cooperatives, and establishment of government and private tractor hiring services.

Experiences with cooperative ownership of equipment show that it has difficult problems, particularly those on the human and technical levels. The farmers in most cases do not have the required skills for both the operation and maintenance of the equipment. The close supervision and control, necessary to ensure proper use and maintenance of the equipment, are always interpreted by the farmers as interference. The order of rotation of the equipment among the farmers present some difficulties, as the farmers have need of the equipment at the same time. There is also a shortage of good managers for cooperative projects.

Tractor hiring units have enjoyed some amount of encouraging success. The main constraints militating against the effectiveness of tractor hiring service include:

- distant location of tractor hiring units from the farms they service;
- shortage of good operators and mechanics;
- irregular supply of fuel;
- difficulty of obtaining spare parts, leading to high frequency of breakdown and long periods of equipment downtown;
- improperly stumped fields;
- fragmentation of lands;
- lack of feeder roads to the fragmented farms;
- lack of credit facilities for the tractor hiring unit services;
- poor programming of the tractor hiring services, resulting in inadequate provision of tractors during the peak periods.

LACK OF STANDARDIZATION OF EQUIPMENT AND PROBLEMS OF SPARE PARTS SUPPLY

Prior to the establishment of the two tractor assembly plants, Nigeria imported different types and sizes of tractors and agricultural equipment. For example, in 1976, 95 % of the imported tractors are of medium size

(37 kW) and 2 % are heavy (75-104 kW) (Makanjuola et al., 1977). In the same year, ten companies distributed several types of tractors, like Ford, David Brown Steyr, John Deere, Fiat, Massey Ferguson, and Deutz. The estimated importation in 1976 is 2 000 units. In the same year the total population of tractors is estimated at 10 000 units. Thus, with such a small population and a wide variety of different types and makes, the dealers do not always have in stock all the spare parts required to keep these various types of tractors in operative conditions. The establishment of the two tractor assembly plants is seen as an effort to standardize on the tractors available to Nigerian farmers.

A cursory examination of the types of the other types of agricultural equipment like the combine, threshers, and corn shellers shows that various makes and sizes are still being imported into the country, with the attendant low volumes of sales of each type, poor after-sale service and inadequate spare parts supply.

In order to reduce the problem of scarcity of spare parts, some state ministries of agriculture purchase fast moving parts of agricultural machines up to 10 % of the cost of the machines. Dealers are encouraged to allocate up to 15 % of the initial cost of the machines for spare parts. In addition, state ministries have mobile workshops, which help farmers repair their machines.

RESEARCH IN AGRICULTURAL MECHANIZATION

Nigeria has a number of commodity and specialized agricultural research institutes. Some of these institutes undertake agricultural mechanization research related to their specialities. These institutes are managed by the Federal Ministry of Science and Technology. There are a number of universities, colleges of technology and polytechnics which undertake research in agricultural mechanization. The International Institute for Tropical Agriculture (IITA), Ibadan, is an international organization which undertakes research in all aspects of tropical agriculture.

In addition there is a National Centre for Agricultural Mechanization. Unlike the other agricultural research institutes, that are managed by the Federal Ministry of Science and Technology, the National Centre for Agricultural Mechanization at present operates as an arm of the Engineering Division of the Federal Department of Agriculture. The Centre is sited in Ilorin, Kwara State, within the Southern Guinea Savanna zone. When it is fully operative it will have sub-centres in the other ecological zones of the country.

The National Centre for Agricultural Mechanization was set up about 5 years ago with the following objectives among others:

- provision of up-to-date guidelines on agricultural mechanization strategies;

- provision of guidelines with respect to importation of agricultural machinery;
- encouragement and motivation of local design and manufacture of equipment and machinery for the various local conditions in agricultural production;
- aiding and promoting effective cooperation among various institutions by encouraging multidisciplinary approach to the improvement of the mechanization of agricultural production processes;
- provision of supplementary facilities for man-power training and development in the different fields of agricultural engineering.

In order to meet the above objectives, the Centre is being equipped to undertake the following specific functions:

- testing and certification of agricultural factors and agricultural equipment being imported or fabricated in Nigeria;
- standardization of agricultural machines used in Nigeria;
- undertaking of adaptive and innovative research towards the development of new machines, farm mechanization techniques, control measures for soil erosion, and better utilization of soil and water resources;
- fabrication of prototypes of locally developed agricultural machines for testing in the different ecological zones;
- undertaking of long time and short time training of different categories of workers in agricultural mechanization.

MANUFACTURE OF AGRICULTURAL MACHINES

In Nigeria, three levels of agricultural machinery manufacturers can be identified: (a) modern large-scale tractor assembly plants; (b) medium-scale manufacturers; and (c) hand-tools manufacturers.

Large-scale tractor assembly plants

The Nigeria tractor market, as indicated by sales, during the last eight years is given in Table 1.

The figures do not indicate a continuous demand. On the other hand the fourth 5-Year Development Plan indicates yearly new registration of 15 000 units. However, from the huge agricultural resources of the country, it should be able to maintain a yearly registration of about 5 000 units per year.

There are at present two tractor assembly plants in Nigeria, namely the National Trucks in Kano and Steyr Nigeria Ltd., in Bauchi. The factories were set up to assemble lorries and agricultural tractors. For example, the Steyr plant in Bauchi has an annual capacity for assembling 8 000 lorries and 2 000 agricultural tractors. The total annual production capacity of the two assembly plants is 5 000 tractors. The two plants commenced production in 1980.

Table 1. Sales of tractors in Nigeria.

Year	Units of tractor sold
1975	2 600
1976	2 000
1977	2 400
1978	1 700
1979	600
1980	3 400
1981	5 500
1982	1 850
1983	2 000 (expected)

Table 2 shows the relationship between imported completely built units of tractors and the units of locally assembled tractors. The high sales of 1980 and 1981 result from the Green Revolution campaign efforts of the various governments in Nigeria. Tabel 3 shows the capacity utilization of the assembly plants. From these figures it will be noticed that the capacity utilization of the existing plants is low. Steyr assembles two basic models, the 60 kW (80 hp) two-wheel and four-wheel drive types, and the 82 kW (110 hp) two-wheel and four-wheel drive types. The Fiat Company produces also two basic models of comparable sizes.

In a recent address at the First Quarterly Meeting of the Motor and Air

Table 2. Break-down of tractors sold in Nigeria. Source: Private communication with A. Doru, Sales Manager, Steyr Nigeria Limited, Industrial Estate, Bauchi.

Year	CBU (imported)				Units locally assembled		Total
	M.F.	Ford	J.D.	others	Steyr	Fiat	
1979							600*
1980	500	350	300		900	950	3 400
1981	1 550		150	355	1 822	1 623	5 500
1982	260		570		450	570	1 850
1983			660*		740**	600**	2 000**

* Break-down not available.
** Estimated.

Table 3. Capacity utilization of tractor assembly plants.

Year	Capacity utilization (%)	
	Steyr	Fiat
1980	45.6	31.67
1981	91.1	54.1
1982	22.5	19.0
1983	37.0	19.0

Transport Standing Committee of Lagos Chamber of Commerce, the Honourable Minister of State in the Federal Ministry of Industries stated that two additional companies will be approved to manufacture agricultural tractors and implements in Nigeria. The details of the prospective assembly plants and their capacities are still to be made public.

Medium-scale manufacturers

Apart from the above mentioned two plants, John Holt Agricultural Engineers of Kaduna, in Kaduna State, is the only other manufacturer of agricultural equipment in Nigeria. This factory does not produce tractors, but specializes in producing different types of animal-drawn implements and trailers. There are a number of other plants in Nigeria which can undertake custom production of agricultural products processing equipment.

Hand-tools manufacturers

Hand-tools are produced mainly by local craftsmen and artisans. Their products are, in the main, hoes, cutlasses, and harvesting knives. The needs of the farmers for these categories of hand-tools are met by these manufacturers. The major drawback of this level of manufacture derives mainly from using metals that are not hardwearing and rust-resistant, and from the application of low-level technology.

TRAINING IN AGRICULTURAL MECHANIZATION

The categories of personnel trained for agricultural mechanization in Nigeria are: the engineers, technicians, agricultural mechanics, heavy-equipment operators, agricultural plant operators and farm tractor operators. While the engineers are trained in the universities, technicians in polytechnics and colleges of technology, the artisans and farm machinery operators are trained in the trade centres and special schools.

There are about 8 universities offering degree courses in agricultural engineering. Table 4 shows the dates of establishment and other information on the older departments of agricultural engineering. There are a fewer number of polytechnics and colleges offering technician courses. Training facilities for tractor operators are available in only a limited number of places, like Fashola Agricultural Machinery Training Centre; College of Agriculture, Samaru; Schools of Agriculture in Umudike, Ibadan and Akure; Kaduna Polytechnic; and some agricultural equipment firms. In general the numbers graduating from all of these various institutions are not sufficient to meet the needs of the country.

CONCLUSIONS

The federal and state governments in Nigeria acknowledge the need to

Table 4. Historical development of some departments (Nwa, 1982).

Name of institution	Year of establishment of institution	Year of establishment of Agric. Eng. Dept.	Year of accreditation by COREN	B. Eng B.Sc 1st awarded	M. Eng M.Sc. research started	M. Eng M.Sc. by course work and research established	Ph.D by research established
Ahmadu Bello University, Zaria	1962	1974	1979	1977	1977	1979	1979
University of Ibadan Ibadan	1948	1971	-	1975	-	1978	1979
University of Ife Ile - Ife	1962	1970	1975	1973	-	1979	1979
University of Nigeria Nsukka	1960	1962	1978	1976	-	-	-
University of Maiduguri, Maiduguri	1975	1978*	-	-	-	-	-

* Department not Agric. Engineering, but Agric. Technology.

give priority to the development of agriculture. Various measures concerning the improvement of agricultural mechanization are therefore undertaken. For example:

(a) land tenure systems are being studied, soil and topographical surveys are being undertaken; (b) land clearing is considered a specialized and costly operation; cooperatives are being encouraged to purchase their equipment and train the personnel required to operate the equipment; a pool of private contracting firm specializing in agricultural land clearing is being encouraged; (c) a National Centre for Agricultural Mechanization has been set up to promote the development of all aspects of agricultural mechanization in Nigeria; (d) two tractor assembly plants have been set up; they have a combined yearly capacity of 5 000 units.

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La Société Malienne d'Étude et de Construction de Matériel Agricole (SMECMA)

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INTRODUCTION

Le Mali est un pays continental de l'Afrique de l'Ouest dont l'économie est à prédominance agricole. En effet, dans notre pays, le secteur primaire occupe près de 85 % de la population. Il va sans dire que tout développement harmonieux passe par l'élevation du niveau de vie de la masse paysanne. Or, la mécanisation est un puissant facteur de modernisation de l'agriculture. C'est pourquoi le gouvernement a mis en place en 1974, avec l'aide de la France, une usine de construction de matériel agricole. Cette unité est gérée par une Société mixte, dénommée Société Malienne d'Étude et de Construction de Matériel Agricole (SMECMA). L'objectif majeur de la SMECMA est de pourvoir, aux moindres coûts, à l'équipement du paysannat en matériels agricoles nécessaires au relèvement de la productivité et de la production dans l'agriculture. La capacité théorique de production est d'environ 60 000 appareils par an.

PRÉSENTATION

La SMECMA fabrique toute la gamme de matériels agricoles à traction animale:

- charrues légères, moyennes et lourdes;
- multiculteurs 'CIWARA' avec cinq équipements;
- charrettes de charge utile 1 000 kg;
- semoirs monorang avec différents disques;
- herses à 2 éléments;
- houes 'Falidaba' à traction asine;
- herses à 3 éléments pour tracteurs simplifiés;
- remorques de charge utile 3 tonnes pour tracteurs simplifiés.

De sa création à ce jour, la SMECMA a réalisé un chiffre d'affaires moyen annuel d'environ 2 milliards de francs maliens. Dans le même laps de temps, elle a enregistré un bénéfice annuel moyen de près de 70 millions. L'Entreprise emploie 200 travailleurs permanents. Cependant, elle fait appel en plus, à certaines périodes de l'année, à du personnel temporaire.

Des résultats de la dernière enquête agricole, il ressort qu'environ 35 % des exploitations agricoles du Mali sont équipées en matériels agricoles de la catégorie 2 (Tableau 1). Donc l'effort de modernisation doit être soutenu. Ces matériels donnent entière satisfaction, puisqu'ils ont été testés sur le terrain au préalable avant d'être fabriqués en série.

FABRICATION ET IMPORTATION

Pour assurer sa production la SMECMA importe annuellement près de 4 000 tonnes de matières premières: fers, profilés divers, plats, etc. Actuellement, toutes les pièces forgées sont importées, ainsi que la boulonnerie.

Instruments de la catégorie 1

Les outils de cette catégorie sont actuellement importés par les commerçants privés et les maisons commerciales. Leur importation est faite suivant les besoins du marché.

La SMECMA envisage la contruction locale de certains de ces instruments. Cette production locale intéressera les brouettes et le matériel de jardi-

Tableau 1. Besoins prévisionnels en matériels agricoles pour les cinq prochaines années.

Catégorie de matériels agricoles	Désignation matériels agricoles	Quantité prévue annuellement				
		1983	1984	1985	1986	1987
catégorie 1	délaniéreuses à dâh	120	170	190	230	240
	brouettes	200	250	320	370	400
	divers	5 000	5 500	5 800	6 200	6 500
catégorie 2	charrues	6 500	7 500	8 700	9 800	10 500
	multiculteurs	3 500	4 000	4 300	4 900	6 000
	semoirs	5 500	6 200	7 000	7 800	9 000
	charrettes	5 000	7 000	10 000	10 800	11 500
	herses	1 685	1 800	2 100	2 500	3 200
	houes	2 820	2 920	3 150	4 100	5 500
catégorie 3	tracteurs simplifiés	-	-	-	50	100
	groupes moto-pompes	-	50	150	190	220
	matériels d'accompagnement	100	150	230	250	310
catégorie 4	moyens et gros tracteurs	-	-	-	-	-
	engins automoteurs	-	-	-	10	-
	moissonneuses-batteuses	-	-	-	-	-

nage. Des études ont été faites dans ce sens et seul le financement reste à acquérir.

Équipements de la catégorie 2

Actuellement, notre usine produit les machines rentrant dans cette catégorie (Tableau 1). Nous envisageons de diversifier notre production par la fabrication d'une charrue nouvelle conçue et réalisée avec la collaboration de Rumptstad, une société néerlandaise.

Au niveau du pays, nous disposons des compétences nécessaires pour la conception et la production de ces équipements. Les institutions dont le pays dispose sont:

- le Bureau d'Études au niveau de la SMECMA;
- le Centre d'Études et d'Essais du Machinisme Agricole (CEEMA) et le Bureau d'Études de la Division du Machinisme Agricole;
- les Opérations de Développement Rural avec leurs 'Points d'Essais du Machinisme Agricole' (PEDMA) et les 'Actions forgerons'.

Nous avons sollicité, dans le but d'augmenter la valeur ajoutée de nos productions, un financement hollandais pour la mise en place de certains équipements techniques.

Machines à moteur et équipements spécialisés

Présentement, nous fabriquons le matériel d'accompagnement des tracteurs simplifiés: remorques de charge utile 3 tonnes et herses à 3 éléments. Il est prévu la fabrication, à partir de 1984, d'équipements de la catégorie 3. Quant aux équipements de la catégorie 4, leur production n'est envisagée qu'en 1986. La stratégie arrêtée pour la confection de ces matériels est la suivante:

- fabrication sur place des pièces simples;
- importation des pièces sophistiquées et des sous-ensembles;
- assemblage.

Pour ce faire, nous prévoyons d'agrandir les installations existantes. Il se posera des problèmes relatifs à:

- l'assistance technique au niveau de la production;
- l'investissement;
- l'organisation du service après-vente.

CONCEPTION MISE AU POINT, ADAPTATION, ESSAIS ET ÉVALUATION

La conception de nos matériels se fait en collaboration étroite avec la Division du Machinisme Agricole. Cette institution dispose au Samanko, à 20 km de Bamako, d'installations complètes comprenant:

- un bureau d'études;
- des machines-outils pour la confection de diverses pièces;
- des bancs d'essais pour les essais du matériel agricole;

- d'une gamme complète de matériels agricoles: de l'instrument à main à la moissonneuse-batteuse;
- d'appareil pour mesurer la dureté, les forces de traction, etc.;
- d'un terrain pour les essais comparatifs de travaux;
- de prototypes de matériels agricoles;
- d'une école de spécialisation en machinisme agricole pour les techniciens et les ingénieurs d'agriculture.

ÉTUDES TECHNIQUES ET TECHNIQUES DE FABRICATION

Les institutions actuelles sont capables de fournir l'assistance technique et les conseils nécessaires pour la mise au point des techniques de fabrication des matériels que nous produisons actuellement. Mais une assistance technique sera indispensable pour le lancement de la production des matériels agricoles des catégories 3 et 4.

RÉPARATION ENTRETIEN ET PIÈCES DE RECHANGE

La SMECMA assure le service après-vente du matériel agricole qu'elle produit en mettant à la disposition des utilisateurs que sont les paysans, les pièces de rechange nécessaires. Il existe également au niveau des Opérations de Développement Rural des actions dénommées 'Actions forgerons' qui sont des programmes de formation des artisans locaux.

Au Mali, la solution consiste à utiliser le réseau de forgerons villageois en le rendant capable de réaliser les réparations nécessaires et de fabriquer certaines pièces de rechange. La SMECMA collabore étroitement avec ces artisans locaux par deux voies: la sous-traitance et l'approvisionnement.

Sous-traitance

Nous sous-traitons avec les artisans locaux encadrés, la fabrication de certaines petites pièces de matériel agricole. Cela leur permet d'amortir plus aisément les équipements techniques mis en place. De même, le coût des pièces ainsi confectionnées est moins élevé que si elles devaient être faites à à l'usine.

Approvisionnement

Nous cédons aux forgerons les chutes de nos aciers à des prix très étudiés. Ils peuvent de ce fait, améliorer la qualité des pièces de rechange fabriquées.

POLITIQUES, PLANIFICATION, STRATÉGIES ET COORDINATION

Il existe au Mali un organisme technique chargé de conseiller le gouvernement dans sa politique de machinisme agricole. Cet organisme s'intitule le Comité Consultatif National du Machinisme Agricole. Il regroupe les personnalités suivantes:

- les représentants des départements suivants: Finances, Économie et Plan, Agriculture, Développement Rural et Développement Industriel;
- les responsables des Opérations de Développement Rural;
- les responsables du Génie Rural et de la Division du Machinisme Agricole;
- les constructeurs de matériel agricole;
- les importateurs de matériel agricole.

Bref, cet organisme regroupe tous ceux qui sont intéressés par le devenir du machinisme agricole. Il se réunit tous les deux ans.

CONCLUSION

Notre Société s'occupe d'un secteur vital pour l'économie du Mali, le secteur agro-pastoral. Il joue de ce fait un rôle de premier plan dans le processus de développement économique et social.

Grâce aux mesures prises par le gouvernement, les goulots d'étranglement qui entravent le développement du secteur primaire seront levés; ces mesures concernent notamment:

- les prix des facteurs de production et des produits agricoles;
- la maîtrise progressive de l'eau;
- le fonctionnement adéquat de la Banque Nationale de Développement Agricole (B.N.D.A.).

Agricultural mechanization in Tanzania – Constraints and prospects

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ABSTRACT

A review of past and present efforts in mechanizing Tanzania's agriculture over the past 30 years is presented. It is shown that, despite these efforts, 80 % of the cultivated land in Tanzania is still under the hand-tool technology, 15 % under animal-powered technology, and only 5 % is under mechanically powered technology. These figures have, by and large, remained the same of the past two decades. The potential for increased agricultural production through appropriate mechanization is discussed. With less than 10 % of the total land area of Tanzania being under cultivation, and the remaining 90 % being potential rich agricultural land which has yet to be opened up for agricultural production, it is argued that the traditional green revolution technology packages, viz. intensifying land use by irrigation, high yielding varieties, and fertilizers, are less feasible in such countries.

The major constraint to increased food and crop production, it is argued, has been lack of adequate farm power and the required implements. Problems of increased utilization of mechanically powered technology in both small holder and large-scale agriculture are discussed. The major constraint to success of adoption of mechanically powered technology has been the lack of trained man-power and efforts to relieve this constraint are presented.

Finally a description of existing facilities for manufacture of agricultural machinery and implements for the hand-tool, animal-powered and mechanically powered technologies are presented. Problems afflicting these industries and the potential for future expansion are presented.

INTRODUCTION

Agriculture has contributed on the average, about 50 % of the Gross Domestic Product of Tanzania and 80 % of her exports over the past two decades (IBRD, 1982). In addition, over 80 % of Tanzania's population is engaged in agricultural production, either as small-holder farmers or workers in large-scale farms. Agriculture therefore is the backbone of Tanzania's economy.

Tanzania's agriculture is dominated essentially by small-holder agriculture. Of the cultivated land (5.12 million ha) 86 % is cultivated by small holders and 14 % is cultivated by large-scale farmers (public or private companies). With an exception of a few crops (e.g. tea, sisal, wheat, wattle) most of the food and cash crop production is dominated by small-holder farmers. These small holders depend, by and large, on the hand-tool technology for performing most of the field operations involved in crop production. Most of these small-holder farmers rely on their family labour and simple hand-tools, e.g. hoes, axes, and machetes for performing the field operations.

Farming carried out using this technology, with entire reliance on human energy, rarely exceeds subsistence level. The area which can be cultivated by a family using such technology is-by and large-limited to 2 ha. If cash crops have also to be cultivated, then the area left for food crops is rearely in excess of 1 ha. In most cases, therefore, the entire effort of the family is concentrated on production of subsistence food. Only in exceptionally 'good' years, and these are rare, especially in the semi-arid areas, there is a surplus which can be marketed. For Tanzania about 80 % of the total land area under cultivation is cultivated entirely by means of the hand-tool technology. Of the remaining 20 % about 10-15 % is estimated to be partly under hand-tool technology and partly by animal-powered technology, with only about 5 % under mechanical (tractor) powered technology (Mrema, 1981). This situation has remained more or less the same over the last 15 - 20 years. Further it should also be noted that only 6 % of the total land area of Tanzania is under cultivation (i.e. about 5.14 million ha out of a total land area of 88.6 million ha). The remaining 94 % consist of potentially food agricultural land, which can be opened up for agricultural use. It is also interesting to note that the increase in land use in Tanzania over the last twenty years corresponds to the increase in population, which shows that a significant percentage of the increased land under usage has been opened up by the hand-tool technology (Mrema, 1983). With such a potential for increased food and crop production, Tanzania should therefore be able to feed herself, as well as produce enough cash crops for export to earn enough foreign currency to develop the industrial as well as the service sector of her economy. This paper reviews Tanzania's past efforts to mechanize her agriculture since independence in 1961 up to now. Problems which have confronted past attempts at mechanization are outlined, and proposals for the future are given.

MECHANIZATION ALTERNATIVES AVAILABLE

A number of experts have argued that the use of technologies developed for agriculture in the advanced countries may often fail in the third world countries, and in most cases replace labour and increase unemployment. It is therefore argued that for the developing countries, 'intermediate' or 'appropriate' or 'selective' mechanization should be selected. This view is controversial, as it would seem that a clear definition of this 'appropriate mechanization' can be given. However an examination of the literature on mechanization systems, indicates there are three conflicting groups in the 'appropriate mechanization' camp:

1. Those who would repudiate the use of advanced technologies (mostly mechanical power) in mechanization as entirely inappropriate in all situations in the third world countries. They would argue that mechanization would replace labour, and increase unemployment and rural-urban migration, and hence it is undesirable. They therefore advocate the use of what they call 'improved hand-tools' and animal-powered technology. They therefore see what they call appropriate technology as an alternative to modern technology.

2. The second group comprises those who view the use of 'appropriate technology' in mechanization as an intermediate step. As an intermediate technology, appropriate technology or mechanization acts as an intermediate step between the most rudimentary step of technological development (hand-tool technology) and the advanced (mechanically powered) technology which characterizes the advanced countries. This theory proposes that the course of technological development is evolutionary and it is each countries prerogative to aspire to a higher level. Modernity is a legitimate goal, it is argued, but care should be taken that technological, social and cultural development all work in tandem, to create a well-balanced society. This group therefore opposes any rapid mechanization by use of mechanical power.

3. The third group comprises those who oppose any form of 'intermediate' or 'appropriate' mechanization and advocate the use of modern technology in all mechanization schemes. They argue that alternatives to modern technology do not just exist as a practical matter, or these alternatives would not produce the results claimed of them. They further claim that where modern technology has failed in mechanization in the third world countries, this has been largely due to poor planning, supervision and management.

Numerous research papers have been published concluding with one view or the other of the above view for Tanzania and other countries in Africa and the developing world as a whole (Kline et al. 1969; Beeney, 1975; Singh, 1977; Dagg, 1978; Mrema, 1981; Wolff, 1982; Mrema, 1983). Proponents of each system have often quoted success examples of the system they advocate and have used them to give general and blanket policy prescription while in many cases they have overlooked or glossed over examples of failures of the system the advocate. The conclusions reached in one country are often prescribed on another country on the basis of a rather rudimentary analysis.

In addition, the success of the 'green revolution' technology package on the Asian subcontinent (improved seeds, increase in fertilizer use and better agricultural husbandry techniques), which has increased yield of some crops (e.g. rice) on small-holder farms, and the hybrid maize in high potential areas of Africa, have often been used to advocate increased investment in the low-technology agriculture even in the semi-arid areas of Tanzania (Mrema, 1984). Improved seeds and increase in fertilizer use can lead to increased agricultural production especially in irrigated and high potential areas. For the medium and low-potential areas, it is more likely that increased food and crop production can be achieved better by increasing the area under cultivation and moderate application of fertilizers and pesticides than blanket application of the 'green revolution' technology. For countries which have still large uncultivated areas, this would seem to be more feasible alternative. For this to occur, however, mechanization of their agriculture is a necessary prerequisite.

AGRICULTURAL MECHANIZATION POLICIES IN TANZANIA

Agricultural mechanization policies in Tanzania have generally moved between emphasis on mechanical power to emphasis on animal power and back over the past two decades. In the early sixties attempts were made to introduce tractors, on a fairly large scale, by Tanzanian standards. This was done on the advice of the World Bank (IBRD, 1961). Examples of these are the Settlement Schemes, e.g. Upper Kiteto, Kabuku, etc., and the Cotton Block Scheme in Mwanza and Shinyanga. Due to multiplicity of reasons all these schemes were not, by and large, successful. They were abandoned, and in most cases the tractors were put under the Regional Development Schemes. The main reasons given for failure of these schemes, were underutilization, frequent breakdowns, lack of skilled mechanics to repair them, and funds for spare parts.

After 1967, with the introduction of Ujamaa (settlement) villages, emphasis was put on animal-powered cultivation, which has continued to 1972, when the ruling party issued the policy statement on agriculture, and virtually up to today. It is difficult to assess the success of this campaign to introduce draught-animals in Tanzania on a wide scale. In a survey on agricultural machinery in Tanzania (Dagg, 1978) it was shown that a significant proportion of the ox-ploughs are in regions where the people have had animal husbandry and crop cultivation (mixed farming) traditions. In areas where people have had no tradition of animal husbandry, it would seem animal-powered cultivation has not succeeded. Large amounts of money have been spent to introduce draught-animals in these areas, where traditionally the people have no animal husbandry tradition, and coupled with the tsetse-fly problems, this investment is yet to show positive results. It is generally accepted, by agricultural engineers, that introduction of animal-powered mechanization to people who have no animal husbandry tradition, can rarely succeed both in the short term and medium term.

In 1980 the ministry of agriculture published its mechanization policy (MOA-GOT, 1980). Essentially this policy placed emphasis on animal-powered cultivation, and improved hand-tools, and tractor-powered mechanization should only be introduced in justifiable areas. This policy has been re-emphasized in the recent government paper on agriculture (MOA-GOT, 1983).

The major reason for the failure of all past efforts at mechanization in Tanzania and indeed in most other third world countries is lack of trained man-power. This is still the case, up to now, and any new policies have slim chances of success until this problem is seriously tackled. For even in the parastatal and state farms, which own most of the 9 000 tractors, presently in Tanzania tractor utilization is in the region of 300-500 tractor hours per year as opposed to 1 000-2 000 in other countries, and significant number of them have broken down to a state of beyond repair after 3-4 years. The main reason for this is lack of skilled field operators and the accompanying supervisory and managerial man-power. Mechanized agriculture requires professional trained man-power both at managerial and supervisory level and at the field-operations level. This is so whether animal-powered or mechanically powered mechanization is considered.

EXPERIENCES AT TRAINING MECHANIZATION MAN-POWER IN TANZANIA

As it is realized by most engineers, in most of the developing countries the level of technological know-how in the rural areas is comparatively low. Therefore, any introduction of new technology, whether improved hand-tool implements, or animal or mechanically powered implements, requires considerable extension effort. The frontline extension workers usually receive 2-years certificate training in general agriculture after secondary school education. The content of this course is quite limited in mechanization subjects. Therefore government efforts have been directed at training 'agro-mechanics', who are supposed to liase and direct the mechanization extension efforts of the frontline extension workers. The training of these agro-mechanics, however, is quite limited, as they receive a rather rudimentary course. They are normally based at the district headquarters (a district has an area of 8 000-15 000 km^2 and a population of 200 000 people), and thus their extension impact is quite limited. These courses have been offered since the early 1970's.

Next to these are regional mechanization officers, who normally are the agro-mechanics who go for further 2-years diploma course. They liase and manage the activities of the district agro-mechanics in their region (a region has a population of 1 000 000 people, and an area of 40 000-80 000 km^2). After this the only other mechanization staff present are those at the headquarters of the ministry of agriculture, who are normally general B.Sc. (agriculture) graduates with an interest in agricultural engineering. A few of them have gone for M.Sc. studies in agricultural engineering overseas. Consequently, therefore the technical competence of most mechanization staff is limited.

It is precisely because of this that the Tanzania government in 1979 asked the University of Dar es Salaam to start a full B.Sc.-degree programme in agricultural engineering. After some years of planning, and due to lack of adequate resources, this programme has started with effect from 1983/1984 academic year and it is a joint programme between the faculty of engineering and the faculty of agriculture. The students spend after advanced-level secondary education:

- their first two years in faculty of engineering, doing basic engineering courses with a term out of the four terms in each year being devoted to practical training in an agricultural industry, and
- their final two years in the faculty of agriculture, doing agriculture and agricultural engineering courses. The courses in this part are divided into 5 major parts:

a. basic and applied agriculture;

b. land and water engineering;

c. agricultural machinery engineering and mechanization;

d. agricultural process engineering and storage, and

e. rural structures and services.

The intake is 24 students and it is hoped the first batch will graduate in 1987. They will then go and work in government and private large-scale farms as well as in ministries as extension and technical officers, and in training institutes for lower-level staff, as well as in agricultural machinery and implements factories. It is hoped eventually that the knowledge this group acquires will trickle down through training of intermediate and ancillary man-power to the farmers. The programme is, however, short of both staff and equipment, due to Tanzania's limited resources, and it is hoped that the international agencies will assist in strengthening this programme. Past assistance of FAO (mostly in staffing), which was unfortunately terminated in 1980, is gratefully acknowledged and it is hoped FAO will be able to come in again, either jointly with other agencies, such as the World Bank or bilateral donors. More important, however, it is hoped that the agro-mechanics and diploma institutes will be strengthened to turn out more competent intermediate man-power.

AGRICULTURAL MACHINERY AND IMPLEMENTS INDUSTRY

The agricultural machinery and implements manufacturing industry in Tanzania is quite small. The first major factory to be built, which manufactured any farm implements, was the Chinese aided Ubungo Farm Implements (UFI) factory in Dar es Salaam. This was built in 1966 and has concentrated in manufacturing hand-tools (hoes, axes, sicles, grass slashers, etc.) and ox-drawn implements (single-furrow mouldboard plough, harrows and planters). Of late it has faced a number of management and planning problems and it has been operating under capacity (Table 1). This shows that the demand in the country is much higher than the capacity of this factory.

As a result of this market study, it was decided to build a second plant with Indian government help in Mbeya. Even with these two plants, their production still falls short of the demand. There were plans to build a third plant in Mwanza, in 1981, but these plans were shelved due to the adverse economic position of the country. Thus the country is not able to satisfy its own demand for hand-tool and animal-powered implements. Government efforts have so far been directed at building large plants (usually costing in excess of US $ 10 million). It may well be better for the government to reconsider this strategy and instead build smaller plants spread all over the country.

In so far as mechanically powered machinery and implements are concerned, past efforts have largely been dominated by repair and service utilities. Most of these were owned by foreign companies who held the franchise and mostly are managed by expatriates. Their main function therefore was to sell the tractors and implements on behalf of the large international manufacturers (MF, Ford, J. Deere, and International) and spare parts for the same. Most of their technicians and managers are expatriates, either from Europe or the Indian sub-continent.

The government, however, has since 1981 formed a joint company with the Finish company Valmet, which is setting up a tractor assembly plant of Valmet tractors. Assembly has started now from SKD components and it is hoped that local manufacture of components will increase gradually until it is 50 % by 1990. The plant is projected to have a capacity of 3 000 tractor units per year. It is worth-while to note that Valmet had established a similar plant in Brazil 1960 and is currently dominating 65 % of the Brazilian tractor market. This plant is however just beginning to operate, and how it will fare in the future is hard to predict, as Valmet is a completely new tractor in Africa. With proper training of man-power and supporting services, there is every hope that this venture will succeed. The Valmet tractors are 50 kW and above tractors. For tractors with a power less than 50 kW it would seem that a decision has not yet been made by the government. Several Tinkabis have been imported and these are undergoing tests in various ecological zones of Tanzania to assess their suitability. In addition a number of Indian models (25-40 hp) have been imported, but these have so far not been very successful in the market. The major problem of this sector, however, is the critical shortage of servicing man-power, and, unless concerted efforts and investments are put in training the man-power, the whole venture may prove futile.

Table 1. Demand for other farm-tools and implements.

	1973	1975	1979	1982	1986
pagas	(in million)				
demand	1.13	1.20	1.35	1.47	1.65
UFI's capacity	-	-	0.15	0.30	0.30
Mbeya capacity	-	-	0.45	0.90	0.90
short fall	1.13	1.20	0.73	0.27	0.45
axes					
demand	0.851	0.903	1.016	1.115	1.249
UFI's capacity	-		0.010	0.080	0.080
Mbeya capacity	-	-	0.125	0.250	0.250
short fall	0.851	0.903	0.891	0.785	0.919
pick axes	(in thousands)				
demand	19.00	20.30	23.00	24.00	25.80
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	10.00	20.00	20.00
short fall	19.00	20.30	13.00	4.00	5.80
sickles	(in thousands)				
demand	80.00	82.20	95.00	102.00	110.60
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	38.00	75.00	75.00
short fall	80.00	80.00	57.00	27.00	35.60
shovels	(in thousands)				
demand	50.00	55.00	60.00	65.00	70.40
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	25.00	50.00	50.00
short fall	50.00	55.00	0.45	15.00	20.40
grass slashers	(in thousands)				
demand	75.00	82.50	90.00	92.00	95.00
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	-	-	-
short fall	75.00	82.50	90.00	92.00	95.00
hand sprayers	(in thousands)				
demand	10.00	12.00	18.00	25.00	36.40
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	10.00	20.00	20.00
short fall	10.00	12.00	8.00	5.00	16.40
board ploughs	(in thousands)				
demand	12.00	10.00	21.00	27.00	41.20
UFI's capacity	8.00	10.00	10.00	10.00	10.00
Mbeya capacity	-	-	5.00	10.00	10.00
short fall	4.00	0	6.00	7.00	21.00
disc harrows	(numbers)				
demand	700	900	1 200	1 600	2 400
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	-	1 000	1 000
short fall	700	900	700	600	1 400
cultivators:	(numbers)				
demand	300	420	500	665	1 030
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	-	-	-
short fall	300	420	500	665	1 030

Table 1 continued.

	1973	1975	1979	1982	1986
ox-carts:	(numbers)				
demand	500	605	900	1 200	1 700
UFI's capacity	-	-	-	-	-
Mbeya capacity	-	-	-	-	-
short fall	500	605	900	1 200	1 700

CONCLUSIONS

In this paper past efforts at mechanizing the Tanzania agriculture have been reviewed. These have largely not been successful due to lack of properly trained man-power to manage and execute such mechanization efforts. Efforts at training the appropriate man-power, starting with graduate-level training have been presented. The graduate-level training will not only provide trainers for the lower levels (technicians, artisans and operators), but will also provide technically competent management man-power to manage the large-scale farms, which are necessary for producing surplus of food to feed the urban population, which is increasing at the rate of 8.3 %.

Finally, it is worth-while to mention that as the population pressure increases, the tendency will be to move to areas hitherto left uncultivated. Such areas require careful and proper land use planning, if they are not to be abandoned within a few years of being opened up. It is unlikely that such marginal areas can be exploited efficiently in the long term by small-holder farmers. As it has happened elsewhere in the world, agricultural production in Tanzania in the future will be carried on to a far greater extent than now in relatively large-scale farm business using advanced technical methods, including much more effective management than so far of land and water resources. Such farms, whether they are privately, publically or cooperatively owned, will require man-power to manage them which is competent both in the engineering and agricultural sciences as well as business management. The rural space will require better communications and more energy, and there will be more towns, where there are now at most hamlets and villages. The transition, like all development, will be untidy and turbulent, and it may be painful at least to some. The main aim is to produce the man-power which will tackle these problems and make the transformation of the rural areas as tidy and smooth as possible. It is contended that one type of man-power which Tanzania has hitherto lacked, both in quality and quantity, and which it critically needs to train, are engineers for agriculture.

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The position of farm machinery development in Kenya

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ABSTRACT

Farm machinery development in Kenya is discussed against the background of socio-economic requirements of the majority of the rural population, where agricultural production sustains the economy of the country. Inevitably emphasis has been laid on the development of machinery of small-scale agriculture. The large-scale machinery sector has not received much attention in the report as the country depends wholly on importation of tractors and only limited manufacture of related implements is done locally.

In the past little attention was paid to the needs of small-scale farmer and his farm machinery requirements were assumed to be similar to those of the large-scale farmer. He therefore depended mainly on hiring tractors, used hand-tools or opted to the only animal-powered equipment available, the Victory-plough.

The high cost of importation of tractors and their accessories, as well as of petroleum products, has brought about a change in the policy. The government has embarked on the promotion of hand and animal-powered equipment in order to improve the standard of living of the rural population.

The report provides the progress of the government's effort to develop a level of small-scale mechanization technology that is agronomically, economically and socially suitable to the size of farms, farming systems and the knowledge and experience of individual farmers. The Agricultural Equipment Improvement Project has developed suitable hand and animal-drawn tools that will now be manufactured and marketed through the Small Farm Mechanization Programme of the ministry of agriculture.

INTRODUCTION

Kenya's agricultural industry provides livelihood to about 90 % of the total population, employs 85 % of the total rural labour force, and generates over 60 % of the foreign exchange earnings. Agriculture is, therefore, the most important sector of Kenya's economy. With the rapidly growing population, there is urgent need to enhance land and labour productivity in order to realize self-sufficiency in the provision of food, absorb the increasing rural labour force and reduce the level of poverty of the majority of the population.

During the last twenty or so years the government and other related agencies have been directing development efforts in the large-scale agricultural sector through capital intensive mechanization, which has laid undue emphasis on imported tractors and implements. This has been carried out by a highly subsidized Government Tractor Hire Service and by encouraging private farmers or contractors to acquire tractors for contract ploughing by permitting duty-free imports of tractors and providing credit at low-interest rates. Unfortunately, the bulk of the agricultural production is by small-holders, who have not benefited from tractorization due to their small and dispersed farm units. It is estimated that perhaps 40 000 ha are cultivated by tractors, 200 000 ha by animal power and 1 million ha by hand. Access to tractors has become increasingly unsatisfactory in the recent times due to the attendant problems of maintenance, lack of spare parts, and the sharp increases in the prices of tractors, spare parts and petroleum. The performance of the Government Tractor Hire Service Scheme has not been impressive and the whole set-up requires overhauling and probably reorganizing its administration. In order to increase the production of food and cash crops a new approach to the problem had to be devised. The food shortage, which resulted in heavy importation of maize, wheat and milk in 1980, may have occurred due to the environmental problems, but it served to provide a momentum in the ever increasing effort of agricultural promotion.

In the opening remarks of the National Food Policy paper of 1981 it is stated that "The agricultural sector must continue to play the leading role in Kenya's development and nearly all the nations food requirements will need to be met from domestic production. In addition the agricultural sector must continue to generate foreign exchange earnings to pay for oil, capital equipment and other imports and at the same time it must be the major source of new jobs for the rapidly growing labour force".

On farm machinery the paper states that "... the main aim of the policy will be the development and wider usage of more appropriate technology to increase labour productivity and to reduce the present emphasis on imported capital-intensive equipment. The availability of agricultural machinery, particularly that required for land preparation and seeding, will be increased through programmes to supply mechanized, ox-drawn and hand equipment. In the long term, the government will support the development of an effective farm machinery distribution and servicing system".

Since the tractorization approach to mechanization has not yielded overall success in penetrating the majority of the farming community, the government of Kenya has started to shift to a policy of promoting animal traction, rather than tractors as a means of increasing land and labour productivity and output. The approach will suit small-holders whose farm sizes are below 4 ha. Animal power has become a tradition in many parts of the country, especially the medium and low-potential areas.

This paper, therefore, deals with the efforts of the government and other institutions, like the University of Nairobi, that have been engaged over the last eight or so years in the development of suitable hand and animal-powered tools. Some work has also been done in the evaluation of small tractors, that were felt suitable for this level of mechanization. The above cited implicit policy of agricultural mechanization through the use of tractors and hence encouraging importation was seriously questioned in a Workshop held in 1975 to discuss farm equipment for agricultural development and rural industrialization. The role played by hand and animal-drawn implements was given prominence and firm conclusions regarding the future direction were realized. Consequently, the Government Agricultural Machinery Testing Unit, which was hitherto engaged in testing of tractors, has since been charged with the responsibility of testing and developing machinery for small-scale mechanization.

REVIEW OF HISTORICAL AND CURRENT FACTORS WHICH HAVE INFLUENCED FARM MACHINERY USAGE AND DEVELOPMENT

There are three levels of mechanization in use in Kenya, which include hand-tools, animal-drawn implements, and tractors and other power equipments. In many cases all the three levels are combined, but the use of hand-tools is predominant in small-scale farming areas. The tools include the hoe (jembe), panga (machete), and the axe. The hoe is used for most tillage operations; the panga is used for harvesting, weeding and also, in conjunction with the axe, for bush clearing. These tools used to be made locally by local blacksmiths, and they could be afforded by almost all farmers, since payment could be made either in cash or in kind. To-date modern technology has phased out the local craftsmen through factory-made tools.

There is sufficient evidence to indicate that farmers suffer from severe shortages of currently available hand-tools. In a survey of random sample of 205 households in Mbeere Division of Embu District, on the average each family owned in 1974 1.5 jembes, 2.5 pangas, 1.25 digging sticks, and only one in four had an axe. The shortage of tools was confirmed in a similar survey in 1977 in Lower Machakos District. Table 1 shows the frequency distribution of the farm tools available on the farms visited. 68 % of the farmers had 2 or less jembes, and 80 % had 2 or less pangas. Considering that there are on average three adults and three children in each family, it would seem that even the most popular and the least expensive tools are so short that about 1/3 of the family labour force is rendered redundant at any one time. It is, therefore, evident that there is need for production

Table 1. Frequency distribution of farm tools in Lower Machakos.

Tool	Mean		Quantity of tools					
			0	1	2	3	4	≥ 5
jembe	2	N*	7	43	22	20	8	6
		%	7	40	21	19	7	6
panga	2	N	6	37	41	15	3	4
		%	6	35	39	14	3	3
shovel	1	N	29	56	13	4	0	4
		%	27	53	12	4	0	4
fork jembes	-	N	69	34	2	0	1	0
		%	65	32	2	0	1	0
mathock	-	N	84	21	1	0	0	0
		%	79	20	1	0	0	0
axe	-	N	68	35	3	0	0	0
		%	64	33	3	0	0	0
masululu	-	N	95	10	1	0	0	0
		%	90	9	1	0	0	0
ox-plough	-	N	32	69	4	1	0	0
		%	30	65	4	1	0	0
oxen	2	N	23	7	65	2	8	1
		%	22	7	61	2	7	1

* N = number of farmers (out of a total of 106) owing the number of tools indicated for that column.

of hand-tools at a cost that those farmers can afford, but also of a reasonably high quality.

Animal power is relatively new in Kenya. Ox cultivation was introduced from South Africa about 30-50 years ago. Before independence oxen were used on some European farms, where up to 16 animals were harnessed together. In the past the government has given little support to ox-cultivation technology, so that even in those areas where farmers had adopted the practice, there were sections with shortage of ox equipment. The inventory in a report of a survey done in Embu District, shows that out of a random sample of 205 households none of the farmers had oxen or ox plough.

Recently the government initiated a FAO/UNDP Agricultural Equipment Improvement Project in conjunction with the ministry of agriculture's Agricultural Machinery Testing Unit (AMTU). The project was established in 1977 with the aim of expanding the range of hand-tools and animal-drawn equipments that may be available to farmers. There has been available in the market only one type of ox-drawn mouldboard plough, the Victory-plough. Whereas this implement may be suitable for high and medium-potential areas, it is a very inappropriate tool in semi-arid areas, where soils are very hard before the onset of rains, and also it pulverizes the soil unnecessarily considering the scarce rainfall in the areas. It is therefore unsuitable for soil and water conservation practices and cannot be suitably used for other operations, like planting and weeding. The AEIP programme and the University of Nairobi have therefore been engaged in the screening and testing of a large number of hand and animal-powered implements and small tractors.

The third level of mechanization, namely large-scale tractor farming has been associated with European settlement, which by 1960 comprised over 3 million ha. The government and the commercial sector gave prominence to tractor mechanization. By 1960 there were about 6 403 tractors and 1 000 combine harvesters employed in this sector. The protection provided by the government through duty-free importation of tractors brought the figure to over 10 000 tractors by 1981. Previously the scale of operation allowed fairly full use of equipment (in case of tractors well over 1 000 hours per season), which was clearly economic from the farmers' point of view. However, after independence, serious subdivision of the large farms took place, as cooperatives took over land ownership and other farms were used for small-holder settlement. The use of tractors continued, although the farming patterns were changing. In particular the settlement of small holders on the formerly European large-scale farms (the Million Acre Settlement Scheme) also attracted the use of tractors. Some of the new settlers that had previously used hand and animal power, now relied on contracting tractors.

In 1966 the government set up a Tractor Hire Service in the ministry of agriculture for contracting to farmers. The aim was to open up wheat production in Masailand, cotton growing in Eastern, Central and Nyanza Provinces. It was almost inevitable that the scheme would incur losses due to management and administrative problems. It was, however, considered as a means of stimulating development and encouraging private ownership of tractors.

The use of tractors in small-scale agriculture has not been a success story, whether through ownership or contracting. The main reasons for the failures have been associated with:

- short life of tractors and equipment due to excessive wear and tear, resulting from poor maintenance and operation;
- lack of repair and service facilities;
- farmers inadequate knowledge of the nature of capital investments; some farmers buy tractors for prestige;
- physical separation and size of farms;
- equipment being inappropriate for local conditions;
- low degree of tractor utilization.

The alternative method of mechanization in the small-holder sector is by use of animal power, although it is appreciated that certain areas cannot practice animal power due to various reasons, e.g. high opportunity cost of keeping oxen on the land, disease-infested areas (e.g. trypanosomiasis), and where farm sizes are too small to justify keeping oxen.

There is scope for small tractors in these areas and the AEIP programme has been involved in the testing of available small tractors for this purpose. The recommendations will have to be considered very carefully, as small tractors will tend to be proportionally very expensive and may not have the capacity to plough an economic acreage. In areas growing high-priced crops, like coffee or horticultural crops, small tractors may prove to be viable.

Tractorization in the large-scale farming sector is still viable and may continue to be so especially in the large-scale wheat and maize growing zones. There have been efforts directed to establishing a tractor assembly plant in the country, but there is no decision reached on this subject. The local assembly plant may not serve the country appropriately at this stage, as there are over 20 different makes of tractors on sale in Kenya today.

The manufacture of farm machinery in Kenya is currently being developed on the level of hand-tools and animal-powered machinery. There are, however, firms established in the assembly and also manufacture of agricultural implements, e.g. ploughs, harrows, hammer mills (see the Appendix at the end of this paper).

THE POSITION OF LOCAL MANUFACTURING INDUSTRY

The farming techniques adopted by the large-farm sector in Kenya compare very well with those in the developed countries. Thus the very modern form of mechanization which exists has created a demand for large tractors and other equipment for field operations and post-harvest crop handling as well as farm transport. This is the main catalyst for the development of a substantial local manufacturing capacity (listed in the Appendix). The manufacturing industry is aimed at reducing the import content of an essentially foreign-designed equipment. Thus the locally made disc ploughs have imported discs, shafts and bearings, but locally fabricated frame. The trailer bodies are also made locally, while the wheels and brake systems are imported. Seldom do locally made equipment arise out of local research and development. Some locally made hammer mills and coffee machinery, namely Wilken drier and coffee pulpers, are notable exceptions. Most of the locally made equipment tend to reflect the image of imported counterparts, thus failing to take account of the unique characteristics of the Kenyan agriculture.

With regard to the small-farm sector, there have been sufficient import restrictions to give the government-financed Kenyan Engineering Industries and Kenya Industrial Estates, as well as others, some monopoly of the local market. At the moment almost all the hand-tools are made locally without imported components. This protection has, however, tended to bring into the market low-quality tools as compared to the imported ones.

The production of animal-drawn equipment has been done by Ideal Casement for many years. Mamuki Industries Ltd. and other firms have also recently embarked on manufacture of ox-ploughs. Lack of research and development to support the industry and also neglect by extension services to promote animal power, has meant stagnation in the demand of the equipments. Ideal

Casement reports sale of about 5 000 (1983) mould-board ploughs per year. Sales of interrow-cultivators amount to only about 250 units per year.

It has been established that in Narok District there is increasing demand of animal-drawn implements due to problems of arranging for contract ploughing by either the THS or private contractors.

The screening and evaluation of animal-drawn equipment started by the University of Nairobi and Agricultural Machinery Testing Unit (AMTU) under the auspices of FAO/UNDP's Agricultural Equipment Improvement Project has the capacity and the ability of satisfying this demand both in the quantity and variety of equipment (details are provided later in the report).

The government has been trying through the Rural Industrial Development Centres, that are established in most district headquarters in the country, to promote local entrepreneurs in the development and manufacture of hand-tools and other equipment. The contribution of these craftsmen has not been significant, except in the areas of furniture and window and door casements for the building industry.

Perhaps the greatest drawback with currently locally made hand-tools and animal-drawn implements is the quality of the tools and especially the soil-engaging parts which tend to wear very fast. The problem seems to arise from lack of quality steel and the technical capacity for processes such as hardening and tempering. Furthermore, there is the fundamental problem of understanding the functional and operational forces likely to arise. Overdesigned tools may be over-priced out of the market, or worse, still inadequate material may fail to transmit the forces encountered at work.

The AEIP of AMTU has been charged with the responsibility of the proper design both material and structural in order to ensure quality production by the RIDC craftsmen, some of whose will be used to execute the mass production of the recommended implements in various RIDC centres. This approach is also aimed at creating employment in a rural set-up.

THE POTENTIAL OF SMALL-SCALE FARM EQUIPMENT

Kenya has a total land area of 569 137 km² and a population of about 16 million people (Statistical Abstracts, 1980) with a very high growth-rate of about 4 %. Only about 17 % of the total land area is climatically suited to cropping and one third of this is classified as medium potential (Table 2). About 70 % of this medium potential land is found in Central and Eastern Province, where the estimated population growth-rate is higer than the national average. The population-density in some areas is being further increased as a result of migration from higher-potential areas, where the shortage of land is very acute. Figures from the Integrated Rural Survey 1974/1975 indicate a total nearly 1.5 million small-holdings in Kenya, of which 74 % are under 3 ha (Table 3). This farming community depends mainly

Table 2. Categories of agriculture land according to rainfall (x 1 000 ha). Source: Statistical Abstracts (1978).

Province	High potential (857.0 mm and more)	Medium potential (735-857 mm)	Low potential (612 mm or less)	Total	All other land	Total land area
Central	909	15	41	965	353	1 318
Coast	373	796	5 663	6 832	1 472	8 304
Eastern	503	2 189	11 453	14 145	1 431	15 576
Nairobi area	16	-	38	54	14	68
North Eastern	-	-	12 690	12 690	-	12 960
Nyanza	1 218	34	-	1 252	-	1 252
Rift Valley	3 025	123	12 220	15 368	1 515	16 883
Western	741	-	-	741	82	83
grand total	6 785	3 157	42 105	52 047	4 867	56 914

Table 3. Percentage distribution of small-holdings by site and province (except the pastoral and large farms) 1974-1975. Source: Statistical Abstracts (1978).

Acreage (ha)	Provinces (%)						
	Central	Coast	Eastern	Nyanza	Rift Valley	Western	total
below 0.5	6.74	20.37	9.55	15.72	22.99	21.53	13.91
0.5-1	10.50	18.46	17.35	28.18	12.11	17.67	17.92
1-2	36.96	22.52	33.39	22.03	17.59	17.27	26.99
2-3	16.47	11.42	14.82	15.23	14.78	14.68	15.11
3-4	11.86	7.68	8.57	6.79	10.11	8.60	8.89
4-5	5.92	8.15	9.63	8.13	5.72	4.36	7.22
5-8	7.63	5.87	5.43	4.09	6.87	10.22	6.50
8 and more	3.92	5.53	1.22	1.83	9.83	5.68	3.47
number of holdings	329 530	69 861	353 431	386 431	89 823	254 618	1 483 422

on hand-tools and to a certain extent on animal power.

If the productivity of hand and labour is to be increased, there is dire need to provide both hand and, most important, animal-powered tools. Generally, hand-tools are inefficient and time and energy consuming (Table 4 and 5). For instance, hand digging consumes human energy at the rate of 12 kcal./min., which means that the operator will expend about 750 kcal./h. It also implies that he or she can carry out active performance of the task for two hours since the human energy available for work is expected to be no more than 1 500 kcal. per day in tropical climates.

A survey conducted in Lower Kirinyaga revealed that the number of man-hours needed to cultivate 1 ha using hand, oxen, and tractor are 377, 50 and 6, respectively. Moreover, various studies have indicated that 0.5 ha is about all the land that can be prepared by hand per adult, and this figure is consistent across the African continent.

The use of oxen can appreciably increase the production capacity of hand

Table 4. Man-hours per hectare for mechanized and hand hoe cultivation of cotton. Source: Clayton (1971).

Method of cultivation	Land prep.	Weeding	Harvesting	Total
mechanized	27	74	519	620
manual	336	566	551	1 452

Table 5. Man-hours per hectare for ox-plough and hand hoe cultivation of cotton. Source: Okai (1966).

Method of cultivation	Cultivation		Weeding		Total
	1st	2nd	1st	2nd	
ox-plough	27	25	7	7	67
manual	124	114	114	114	464

labour. For instance, oxen power can increase the productivity of human labour up to four times. Okai (1966) has shown that land preparation and weeding of cotton with oxen reduced the labour requirement to 14 % of that required to do the work by hand (Table 5). It has been reported that a pair of oxen can pull an average of about 110-135 kg. Work being done by the University of Nairobi in the semi-arid Machakos area has shown that a pair of zebu bullocks, raised locally, can easily pull about 120 kg, but cannot sustain a draught of more than 150 kg. It is possible to cultivate up to 4 ha of land in some suitable areas. The use of donkeys for draught and transport purposes is receiving fast adoption in Narok District, where the animals are easily available.

It is, therefore, needless to say that animal-drawn implements are superior to hand-tools. In the areas where animal power is adopted, 40-60 % of farms depend on hiring at a great risk of being late for planting.

Estimation of farm-machinery demand in the small-scale sector is not easy. As shown in Table 2 Kenya has a total of 10 million ha of agricultural land, consisting of 6.8 and 3.2 million ha of high and medium potential land, respectively. It is also reported that 3.5 million ha is under small-scale holding (Table 6); only 1.3 million ha (37 %) of this is cultivated. The rest of the land comprises of unutilized land. Estimates of the potential farm machinery demand would therefore be based on the expansion of cultivated land.

For an estimated 1.5 million holdings, averaging 6 heads per holding, there are about 10 million people, working in the small-scale farm sector currently cultivating 1.3 million ha. Table 7, taken from a survey by the ministry of agriculture, shows how this land is cultivated.

The expanded cultivated land would be expected to be 2.2 million ha and 1.4 million areas, respectively. The total of 3.6 million ha being about

Table 6. Land utilization by provinces (small farms only) (x 1 000 ha). Source: Statistical Abstracts (1979).

	Province						Total
	Central	Coast	Eastern	Nyanza	Rift Valley	Western	
area of holdings[1]	880.1	166.0	769.3	744.9	267.8	630.2	3 458.3
area under cultivation[2]	296.1	111.6	434.0	232.4	74.3	132.9	1 281.9
additional area planted[3] 1975	224.8	65.0	354.8	264.1	68.9	247.5	1 225.0

[1] Excludes pastoral and large farms.
[2] Includes permanent crops, but excludes fallow and pasture.
[3] This area include land planted during the long rains, 1975, that had contained a crop at the time of initial measurement in October 1974. The total land cultivated is therefore not more than that cultivated in October 1974.

Table 7. Cultivation of the land.

	ha	%
hand-tools	1 039 000	84
ox cultivation	150 000	12
tractor cultivation	42 000	4
total	1 231 000	100

equal to the land currently being held by small-scale farmers.

In terms of the quantities likely to be in demand, it can be assumed that the high-potential farmers will use hand-tools. The growing of cash crops, like coffee, tea, pyrethrum, and dairy, spreads out labour requirements to make hand-tool cultivation feasible. Hand-tools would be required in the medium-potential areas to supplement ox-cultivation in planting, weeding and harvesting.

The currently available animal-drawn mould-board plough is a suitable alternative to either the hand-tool or small tractor for small-scale farmers having more than 4 ha in high-potential areas. Table 3 shows that the percentage of farmers with more than 4 ha ranges between 14 % in Nyanza Province, to 25 % in the Rift Valley. Assuming that about half of the small-farm population in the high-potential areas, especially in Western, Nyanza and Coast Provinces cannot grow high-valued perennial cash crops and may keep dairy or beef cattle as an alternative, about 88 000 farmers (8 % of 1.1 million) may be able to use the animal-drawn mould-board plough.

Application of four-wheeled tractors to small-scale and medium-size farms has been a success in areas adjacent to large-scale farming, especially in the Settlement Schemes. Long-term success of tractor cultivation in these areas will depend on a choice of a tractor which is inexpensive to buy and sufficiently simple to operate and maintain to the extent that it can be owned by one or a few farmers who can then share its services among themselves. It is estimated that a small (20-30 hp) tractor would be able to cater for up to 50 ha per year. The demand would be about 4 000 tractors per year, given a lifespan of 5 years.

SCREENING AND IDENTIFYING EQUIPMENT FOR SMALL-SCALE FARMERS AND LOCAL MANUFACTURING PROPOSALS

As mentioned earlier, the small-holder farming sector has for a long time been left out in considering the appropriate level of agricultural mechanization. However, since the mid 1970's, due attention has been given to these farmer plight, and work has been going on in finding solutions to their mechanization problems.

The present manufacturers of farm machinery in the country have concentrated in production of tractor-allied implements and at the very best mould-board ploughs for animal power. Little or no research and development has been injected in the development of animal-powered implements by the commercial and manufacturing industry. This is probably due to the static market, caused by lack of extension, leading to lack of enthusiasm.

The government and the university of Nairobi has been carrying out research and development in this apparently neglected areas. The stage of development is encouraging, as some of the items tested and/or developed, have been passed to manufacturing agents to test the market position.

Development of tillage equipment for small-holder semi-arid agriculture

In small-scale agriculture in arid and semi-arid Kenya the major constraints that call for suitable mechanization practices are soil and water conservation, and timeliness in planting and weeding. The dry spell that follows after harvest, renders the land too hard to be worked with the 'traditionally accepted' mould-board plough before the rains set in. Farmers invariably wait for the first showers, before embarking on land preparation, hence losing valuable moisture due to late plantings.

The university of Nairobi has been engaged with the testing and development of suitable equipment for tillage in semi-arid areas of Kenya. Efforts have been concentrated in Lower Kirinyaga and Machakos districts. The approach to the problem was, initially, by collecting available pieces of equipment from other parts of the world for testing, improvement and possible adoption. This was necessitated by the lack of variety of implements within the country. It was also important to consider equipment that had been tried elsewhere in similar climatic conditions. The choice of potential equipment was governed by the following constraints:

- that agricultural power is normally restricted to two bullocks that the farmer can afford to keep;

- that due to socio-economic factors of land (5 ha) labour (3 adults) and capital, farmers can only afford inexpensive equipment, comparable to the existing ox-plough, costing about US $ 31 (K.Sh. 400);
- equipment for semi-arid areas should be suitable for soil and water conservation practices.

The pieces of equipment that were tried include:
- the ard of desi-plough;
- the tropiculteur;
- the ariana, and
- sine hoe tool bars.

The desi-plough had relative merits: it is far less expensive and simple. Its limitation was the shallow depth of penetration, but the draught could easily be managed by a pair of oxen. The tool is similar to a ridger and therefore makes shallow furrows and ridges ideal for soil and water conservation.

The sine hoe tool frame was the simplest of all: a T-frame to which can be attached several tools separately, e.g. chisel plough, mould-board plough, weeding attachment, planter, and groundnut lifter.

The system developed at Katumani Research Station, after experiments with several combinations of the above tools, is the combination of the sine hoe and the desi-plough. The recommended package would comprise of chisels, desi-plough bottom, A-shares, planter and the tool bar.

Limited farmer acceptance trials were conducted in the later stages of the experiment and the results were encouraging. Fabrication was done at the local (Machakos) Rural Industrial Development Centre, using the local craftsmen as a way of testing the degree of quality of manufacture.

The programme was not done in isolation from related on-going research, but with consultation and in conjunction with the AEIP of the FAO/UNDP programme. The final package that is ready for mass production by a recognized industrial set-up has gone through a limited adoption programme by farmers in high, medium and low-potential areas of the country. The farmers is given a choice of a set of tools from which he can select those pieces suitable for his area.

Improvement of animal power

The development of suitable animal-drawn implements for tillage and other operations would be incomplete without the parallel improvement of the power source, namely the animal. This constraint in efficient transfer of power from the source to the implement has been recognized and the research work in the university of Nairobi has taken keen interest in the harnessing methods.

Traditionally, farmers use a yoke over the neck of the oxen and utilize hump as the pulling point. The contact area of the yoke is relatively small and therefore the pressure the animal experiences is high. This creates discomfort to the bullock and no wonder oxen are not able to sustain a continuous work load.

Guiding the animal by shouting at it and whipping it, leads to haphazard work, and therefore precision operation of weeding or planting cannot be achieved. Proper control of oxen by the use of reigns through the nose ring or a hole in the nose has been shown to give a systematic guidance of the animals, which with proper training of the oxen can be used to do precision weeding and planting in rows. This method has been in practice in India, and Kenyan farmers have started adopting it.

Presently, there are about 93 000 working oxen in the country. Under improved conditions of feeding, training and harnessing a pair of oxen can develop 1 kW. The total output of the present population of oxen would be 46 500 kW.

Improvement in using ox draught-power has been carried out in various parts of the country, like Kokise, Bukura and Sakago. Most of these activities have drawn on Farm Equipment Innovations for Agricultural Development and Rural Industrialization (Westley & Johnston, 1975).

It is common practice for farmers to use two pairs and sometimes three pairs of oxen to pull an ordinary 20 cm mould-board plough. It has been demonstrated that with proper control of the animals, a single pair can do equally well. The AEIP has launched a training programme of extension officers in various Farmer Training Centres in the use of the improved control of the animals with the recommended package of implements.

In some parts of the country, the donkeys are commonly used for transport purposes as pack animals. It has been observed that in Narok, the trend is changing and the farmers are now using the animal for tillage purposes as well.

The development of harnessing system, both for oxen and donkeys, is aimed at improving the efficient transfer of power from the animal to the load and also at improving the comfort of the animal, leading to a longer working period. In a demonstration performed in Narok, it was shown that two donkeys provided an equivalent pull of two oxen, when hitched to the harness as compared to the two oxen hitched with the yoke.

Acceptance trials are being conducted in several parts of the country (Narok, Kisumu, Taita, Machakos). The feedback from the farmers is very encouraging. During the Nairobi International Show over 50 orders of harness were received and are now in the course of being manufactured at the university.

Transportation of farm produce from the farm and to the market is a major constraint to many farmers. Development of a suitable cart to go along with the developed harness is in advanced stage of fabrication, and is already being tested by farmers that have acquired them.

The manufacture of the harness and the carts is not envisaged for implementation by the university, but would have to be recommended for the village craftsmen, who can be trained to produce both the cart and harness. In the meantime the university is manufacturing a limited quantity.

The agricultural equipment improvement project

In order to promote a suitable mechanization policy in the small-scale agricultural sector, the government of Kenya set up the AEIP in 1977. This project was funded by FAO/UNDP, and was established in Nakuru at the Agricultural Machinery Testing Unit of the ministry of agriculture. Since the inception of the project, a number of hand and animal-powered implements and small tractors have been screened and tested. Test stations were set up in various parts of the country, so that developed implements could be tested in different agricultural zones. The project has shown that small tractors are not economic for small-scale farmers in Kenya, but seven manual or animal-powered items of equipments have been identified that will be promoted by a test marketing programme.

The conclusion reached on small tractors was in addition to test results of a reasonable amount of small tractors of different makes and countries of origin tested by AMTU. There exists a small market for small tractors of about 40 tractors per year. There could be potential market of over 200 tractors per year.

The project has thoroughly tested 23 small tractors both two- and four-wheeled, but all with 27 hp or less. The Eicher tractor from India was the best of the lot tested. A company was set up to import the Eicher tractors, but only a few were sold.

SELECTED AND IMPROVED HAND AND ANIMAL-POWERED EQUIPMENT

Nearly a hundred items of hand operated or animal-powered equipment have been tested by the project. Seven of these were considered as being especially promising under various farming conditions prevailing in the country. All these items were modified in order to improve their adaptation to local conditions. They are expected to boost crop production through more timely planting, better crop spacing, and timely weeding, in addition to easing labour bottlenecks. The selected implements include:

1. Rolling punch (injection) planter. The planter was adapted from IITA model and hence can also be used for minimum tillage. The estimated cost price is US $ 27 (K.Sh. 350). A commercial version that includes fertilizer applicator, is being manufactured by M/S Ndume Ltd. of Gilgil, and being sold at US $ 107 (K.Sh 1 400).
2. Hand-pushed weeder. This is a modified Planet Junior with two L-blades, that is designed to control weeds at the seedling stage, when the adverse effects of weed competition are most serious. The estimated cost price is US $ 8 (K.Sh. 100).
3. Hand-operated maize sheller. This was simplified from the original

Indian one, so that it has only two castings to facilitate local manufacture. Estimated cost price is US $ 19 (K.Sh. 250).

4. Improved mould-board plough. This is a substitute for the standard Victory mould-board plough, manufactured with hollow section tubular steel, which avoids the bending problem common with locally made Victory-plough, and is 11 kg lighter. Estimated cost price US $ 42 (K.Sh. 550).

5. Multipurpose plough. This is a simple tool-bar, to which a number of implements can be attached using an ingineous and simple wedge-system. It is designed to accommodate interrow cultivator, chisel plough, a desi-plough, a ridger, a potato lifter or a version of the punch planter. The estimated cost price of the plough and cultivator is US $ 53 (K.Sh. 690).

6. Long-beam plough. This plough uses a long beam or pole as commonly used in Asia, and in Ethiopia rather than the yoke chain system. The estimated cost price for the plough plus the interrow cultivator is US $ 42 (K.Sh. 550).

7. Ox cart wheel assembly. At present ox-carts that are made by commercial agents, have axle assemblies from old cars: they are scarce and expensive. There is a high demand and very limited supply and therefore the price is very high. The recommended wheel assembly uses a metal wheel and wood-block bearing, that can be readily manufactured locally. They use old tires that are no longer retreadable. The estimated cost price is US $ 61 (K.Sh. 800). The cart body that is attached to the wheel assembly requires easily available wood working skills.

All the above pieces of equipment have received a good deal of on-farm testing, and the farmers feedback was accounted for in the modification.

DIFFUSION AND LOCAL MANUFACTURE OF IMPROVED EQUIPMENT

The ministry of agriculture has formulated a Small Farm Mechanization Programme to promote the diffusion and local manufacture of the improved equipment identified by the AEIP. The central feature will be a 'test marketing' of the seven items discussed above. Funds were made available by UNDP, which allocated the shilling equivalent of US $ 2.7 million of 'reflow' funds to enable the ministry of agriculture to place orders with local firms for the manufacture of from 500 to 2 000 units of the selected items. Special short courses will be offered to farmers at 12 Farmer Training Centres in areas where there seems to be considerable potential for farmer adoption of improved equipment. At these courses the new equipment will be demonstrated and the farmers will be encouraged to acquire the equipment at the cost price.

There has been a delay in the implementation of this plan, partly due to the government's financial crisis, which led to a freeze of funds for new projects, and partly due to the cumbersome and time-consuming tendering procedure.

In the meantime the AEIP and AMTU staff have been carrying out training courses for the agricultural extension field staff to prepare them for future work with farmers in promoting the adoption and efficient use of the new equipment. A handbook for guiding the extension staff in this exercise has also been prepared.

The promotion of the AEIP equipment, the package recommended by the university and the harness of oxen and donkey, will be an integrated effort of the two institutions. Exchange of ideas and consultation has been going on during the development period in order to avoid overlap or duplication of efforts.

CONCLUSION

It is evisaged that with the government support and utilizing the 'reflow' funds available, there will be established a widespread and effective manufacture of equipment for small-scale agriculture. In the past, private and commercial firms were not prepared to risk production of equipment whose market potential was unknown. The market testing operation and the sale to farmers through Farmer Training Centres will determine the potential acceptability of the recommended tools.

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APPENDIX. List of local agricultural machinery manufacturers

Name of manufacturer	Annual production	
	items manufactured	quantity
Alaf Din Blacksmiths & Sons	ox-driven ploughs	2 000
	plough shares	5 000
	plough laurides	5 000
	mould boards	1 000
	plough breasts	1 000
	plough beams	500
	plough chump	2 000
	u-bolts	2 000
Alliance Steel Works Ltd.	agricultural implements	N/A*
Almetalo	agricultural machinery	N/A
Biri Engineering Works	rain water gutter pipes	N/A
	water tanks	N/A
	engineering implements	N/A
Bob Harries Engineering Ltd.	windmills	N/A
Burns and Blane Ltd.	tractor-drawn implements	N/A
Cassini and Tonolo Ltd.	sprayers	150
	ploughs	50
	harrows	30
	loaders	30
	cabs	50
	conversions	150
	accessories	200
	others	500
Chohan Engineering Works	posho mills	N/A
	ploughs	N/A
	spares	N/A
Cooper Motor Corporation	agricultural machinery	N/A
	and coffee machinery	N/A
J.S. Davis & Co. Ltd.	engines	87
	pumps	129
	pump sets	42
	water treatment dosers	88
Dhiman & Sons Ltd.	coffee and tea machinery	N/A
Eastern Engineering Works	ploughs and agricultural implements	N/A
George Williamson Engineering Ltd.	tea machinery	N/A
Gian Singh Bansal & Co.	agricultural machinery	N/A
Hammers Engineering Ltd.	agricultural machinery	N/A
	mechanical engineering ploughs	N/A
Hughes Ltd.	ploughs	N/A
Ibrahim N. Baksh	water tanks	N/A
	hand well pumps	N/A

Appendix continued.

Name of manufacturer	Annual production	
	items manufactured	quantity
Ideal Casement E.A. Ltd.	ploughs	10 000
	jembes	100 000
	shovels	10 000
Industrial plants E.A. Ltd.	dairy machinery	N/A
International Tractors	agricultural implements	N/A
	harrows	N/A
	trailors	N/A
	tractor parts	N/A
	lorry bodies	N/A
J.F. McCloy Ltd.	coffee driers	N/A
	tea machinery	N/A
	heavy duty trailors for cattle etc.	N/A
Jandu Workshop	tea machinery spares	N/A
	sawmilling machinery spares	N/A
	tea machinery and general	N/A
Joe Handen & Sochne E.A. Ltd.	water pumps	N/A
Kalsi Engineering Works Ltd.	agricultural machinery	N/A
K. Kay Engineering Services Ltd.	tea drying stoves	5
	tea driers	4
	coffee pulpers	3
	boilers	1
	agricultural trailers	12
	fans	
	conveyors and associated equipment	--
Kenya Engineering Industries	pangas	N/A
	shovels	N/A
Kisumu Engineering Works	cotton ginneries	N/A
	sisal machinery	N/A
Leading Engineering Works Ltd.	ploughs	50
	harrows	5
	mobile saws	3
Mangal Singh Engineering Works	sugarcan crushers (both power and ox-driven)	N/A
	sets of juice cooking pans	N/A
	furnace doors, chimney	N/A
	fire bars, cooling trays	N/A
	countershaft, pulleys	N/A
	couplings and all spare parts	N/A
Modern Industrial and Engineering Works	sugarcane crushers	N/A

Appendix continued.

Name of manufacturer	Annual production	
	items manufactured	quantity
Ndume Ltd.	harrows	60
	ploughs	30
	mills	220
	seeders	10
	hand mills	1 200
	hand planters	N/A
Nyanza Engineering Works Ltd.	posho mills	N/A
Paramount Engineering Works	cane carrying trailers	7
	mose guards (for tractors)	55
	knave plates for tractor wheels	243
	hitch saddlers	6
	winches	1
Reliance Engineering Works	sugarcane crushers	N/A
	maize mills	N/A
	ginneries	N/A
Shaw R.B. Ltd.	spares for friction materials:	
	brake lining sets	N/A
	disc pad sets	N/A
	clutch facing sets	N/A
Sihra Engineering Works	coffee machinery	N/A
	water pumps	N/A
	agricultural and irrigation equipment	N/A
Southern Engineering Works Ltd.	sugarcane crushers	N/A
Station Engineering Works	agricultural equipment	N/A
Tunnel Estate Co. Ltd.	Hutchinson sugar vats	N/A
	Hutchinson methane gas plants	N/A
Warren James & Co. (Africa) Ltd.	tanks	N/A
	trailers	N/A
Western Garage and Engineering	agricultural equipment	N/A
	ploughs	N/A
Winkinson Swords (K) Ltd.	hand-tools	N/A

* N/A = not available

Development of the small-scale farm equipment industry in Kumasi and Tamale, Ghana

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INTRODUCTION

All engineering schools are established to play a fundamental role in the technological development of the people and states that they serve. In traditional universities and colleges, the services provided are usually listed under the headings of teaching, research and consultancy. For largely historical reasons, these services have usually been related to advanced technologies and in developing countries this has meant that most of the technology taught, researched and transferred by consultation has been of an exotic nature.

However, the Technology Consultancy Centre, a department in the Kumasi University of Science and Technology in Ghana, from a decade of experience, has attempted to develop a structure and a method to serve as an effective interface between the university and the people at large; especially the small farming and industrial community. Therefore, the centre has attempted to concern itself with intermediate or appropriate technology because it is by this means that it can best identify itself with the needs of all the people and immerse itself fully in their problems.

ESTABLISHING THE ENGINEERING CAPABILITY

In the development of the small-farm equipment industry in Ghana, the TCC has adopted a strategy of establishing a chain of small private light engineering workshops in Kumasi and Tamale. It is believed that when an engineering capability exists locally to produce a range of farm equipment, agriculture and a whole range of secondary industries can be assisted with technological innovations.

As early as 1972, the services of the TCC were being sought in the north, the granary, of Ghana, in the provision of such farming tools as hoes and cutlasses, bullock ploughs, carts, etc. The reason being that the Ghana government had suspended the importation of such agricultural implements due to economic difficulties. This brought farming activities in most parts of Ghana to a very low level. In that same year, a survey conducted in Ghana's largest informal industrial area at Suame Magazine, Kumasi, revealed an unsatisfied demand for steel bolts and nuts. At that time, the magazine consisted of more than 5 000 craftsmen, most of whom were engaged in some aspect of vehicle repair or rebuilding. A few craftsmen, the blacksmiths, made coach bolts by hand forging and hand threading. The quality was poor and did not meet the needs of the market. A few others, about seven in number, were lathe turners, who produced special bolts and nuts for vehicle repair. These were produced only to order and there was no evidence of any quantity sale. The prices charged were very high. Steel bolts and nuts of a quality to meet general engineering requirements could not be made in any viable quantity. It was thought that capstan lathe operation could quickly be learned by those apprentices and ex-apprentices who had already learned to operate a centre lathe. So in August 1972 the TCC embarked on a project to test the viability of an industry using capstan lathes to produce steel bolts and nuts.

From an engineering point of view, the introduction of the use of capstan lathes was of more fundamental importance than the production of bolts and nuts. Clearly, if the market demand changed, the machines could be switched to producing other items, e.g. pins and bushings, of great variety. Any way, this was judged to be a suitable product on which to base the introduction of the new technology. This project began in February 1973 with the arrival of machine tools from England, purchased with a grant from Barclays Bank International Development Fund. This started what came to be called the Production Unit at the TCC workshop on the campus.

THE CAMPUS OPERATIONS UNIT

The initial equipment of the unit consisted of two capstan lathes and a milling machine employing five trainee machine operators. Over the next three years, the unit expanded to employ five capstan lathes and a centre lathe, two milling machines, a drilling machine, a blacksmith forge, a powered hacksaw and ancillary machines for grinding lathe tools and milling cutters. The production unit was equipped mostly with used machine tools. This reduced capital costs and more closely identified with the informal industrialists, who invariably depended upon the acquisition of second-hand machines. The aim was to find an appropriate technology for the local industry which existing craftsmen could both afford and master. The technology was intended to be suitable for integration into the existing informal industrial environment in technical, economic, social and cultural terms.

Originally, the production unit was conceived as a small industry operated by the centre on the campus to demonstrate products or processes developed or adapted to suit the Ghanaian situation. The purposes were:
- to train craftsmen and managers in the skills of the new industry;

- to complete product development under production conditions;
- to test the market for the new product in a realistic way;
- to demonstrate to entrepreneurs the viable operation of a new industrial activity.

It was not planned that the TCC become a manufacturer in any permanent sense, but rather that any development or production be eventually taken over by craftsmen. But with the passage of time, the products of the unit became increasingly determined by requests from small industries for intems which had been imported in the past, but which were no longer obtainable. These items ranged from spare parts for agricultural machinery and implements, and industrial equipment to complete equipment such as bullock ploughs, gate hinges, post-harvest machinery, and small chemical plants. Thus, it was found that instead of the production unit serving as a prototype for a new industry, it became regarded as a more supporting institution supplying a supporting service to small off-campus industries. The main impediment to the transfer of technology was identified to be non-availability of machine tools. The government was petitioned to provide the TCC with an import licence with which to import machines for resale to small industries. The scheme was approved but was never implemented. The TCC also sought the help of various international agencies, but there was little enthusiasm for the importation of used machine tools. When no help was forthcoming, the TCC took the decision to sell two of its own capstan lathes to proven lathe turners. This was the start of a long-term ambition of the TCC to help establish a whole range of small light enineering workshops all over the country to sustain agriculture and its allied industries.

THE SMALL PRIVATE LIGHT ENGINEERING WORKSHOPS

To date the TCC has helped to establish ten small engineering shops in Kumasi and one at Tamale in the north of Ghana. The TCC and its supported workshops now produce a whole range of agricultural machinery and spare parts and other post-harvest machines and equipment for the agro-based industries in Ghana and other West-African countries. Some of these products are:

- rotary punch planter for maize and other cereals, which was adopted from one developed at the International Institute of Tropical Agriculture in Nigeria;
- pedal-operated rice thresher, which was funded with a grant from the International Development Research Centre, Canada;
- bullock ploughs and bullock carts;
- hoes and cutlasses;
- gear wheels and sprockets;
- farm gate hinges, fencing turnbuckles, corn shellers;

- steel bolts and nuts and other replacement parts for tractors;
- non-ferrous metal castings;
- palm-oil screw press for the extraction of oil;
- palm-fruit boiling tanks and palm-fruit pounding machine;
- soap making equipment;
- gari processing plants and corn-milling machines;
- palm-kernel crackers.

This manufacturing capability can be used in support of other industrial development projects. For example, the ministry of agriculture in Accra recently asked the TCC to produce 1 000 rotary punch planters for maize farmers in Accra. If the raw materials were made available to the TCC and its allied workshops, it would be possible to arrange manufacture even on this scale. Each planter would then enable a farmer to increase his planted area fivefold. The return on capital is very significant. The project provides a good example of how the profit motive can be used to stimulate small-scale rural industrial development by the introduction of an appropriate intermediate technology that is made possible by the existence of a basic engineering capability.

To generate effective support for these small-scale informal industries, the TCC has developed and established Intermediate Technology Transfer Units (ITTU's) at Kumasi and Tamale.

THE INTERMEDIATE TECHNOLOGY TRANSFER UNIT (ITTU)

In its basic form, the ITTU is a TCC workshop, established in the heart of an informal industrial area. It has been realized from TCC's experience that the best people, equipped to take up the manufacture of products pioneered by the University, are the informal industrialists who gather together in informal industrial areas. These men work in primitive conditions with a minimum of equipment, but they are renowned for their resourcefulness and ingenuity. They are masters of improvisation and the recycling of used materials. However, many are illiterate and none has any formal contact with a university. All are suspicious of educated persons and of institutions, because of a fear of taxation by local or central authorities. Winning the confidence of such men is a task which is almost impossible without a permanent presence in their midst. This realization led to the idea of the ITTU. The ITTU consists of a group of production units, demonstrating products and processes developed or adapted to local conditions by the TCC. The activity cannot fail to be noted by the surrounding craftsmen and entrepreneurs, who are encouraged to study it closely and are offered every assistance if they wish to take up the manufacture of any of the products demonstrated.

The aim of the ITTU is to use all available means to stimulate the introduction of new products and new manufacturing processes. It does this by providing the following services:

- advice is offered on all technical, economic and social aspects of new businesses, based upon actual operational experience;
- on-the-job training is provided in new techniques (the trainees are expected to have basic skills and to be ready to learn improved methods);
- skilled technicians from the ITTU may be seconded to work at client workshops to initiate a new manufacturing operation;
- machine tools and equipment may be hired to artisans who wish to introduce a new product before they can acquire their own machines;
- machine tools and equipment purchased overseas with aid funds are resold to artisans who wish to produce new products or upgrade their manufacturing techniques;
- assists clients with the installation and repair of machine tools;
- support in obtaining finance and assistance with marketing.

Thus, the operations of the ITTU lead to the spinning-off of new private enterprises, and when a technology has been transferred, the ITTU turns to a new activity. By this means, the TCC has generated a network of light engineering workshops, engaged in the manufacture of agricultural and rural industrial equipment in Kumasi and Tamale.

The TCC has to date established two ITTU's in the country. The first one is sited at the Suame magazine in Kumasi, the largest informal industrial area in Ghana. The Suame magazine ITTU was funded by the Canadian International Development Agency (CIDA). The second ITTU being financed by the United States Agency for International Development (USAID) is sited at Tamale in the north of Ghana, the area of greatest farming activity in Ghana.

FUTURE PLANS

The ITTU is a new and relatively untried concept. The Technology Consultancy Centre is testing the concept and developing its ideas derived from operating experience. If successful, it is conceived that a network of ITTU's could be established throughout the country. These would be operated mostly by regional development agencies and the like, and the university would play a supporting role in product development, staff training and socio-economic research. The government of Ghana has expressed interest in establishing such a network of ITTU's and the ministry of industries science and technology has taken steps to establish its own ITTU at Tema. Thus, it can be seen that a university-based programme, pursued over a number of years, can influence government policy and by that means achieve a national effect.

Agricultural mechanization in the Sudan

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ABSTRACT

Sudan is essentially, and will remain, an agricultural country. If it ever becomes an oil producing country, as the hunt for oil continues, oil revenues should be directed towards the improvement of the agricultural sector. Agriculture now comprises about 95 % of the country's total exports and over 50 % of the government revenues. Almost about 90 % of the population are engaged in agri-business.

Agricultural mechanization remains the solution for the problems associated with intensification and horizontal expansion and labour shortage. Considering the total machinery available and the total area under cropping, machinery supplied at this level is short of the demand. The degree of mechanization in the mechanized areas, as it stands now, is about 0.32 hp/ha for the irrigated subsector, and 0.13 hp/ha for the rainfed subsector. With the programmes underway, and the Sudan being 'the world basket for food' as claimed, the need for machinery is steadily increasing.

Deterioration of agricultural productivity in the last few years triggered the government policy for more involvement and contribution of the private sector. The World Bank is undergoing a rehabilitation programme for the existing projects and a number of non-government organizations are invited in. Government-tenant partnerships were revised in a number of leading projects and non-profitable state-owned projects are being turned into 'companies' with the private sector.

INTRODUCTION

Sudan is a north-eastern African country with an area of 2.56 million km^2 and a population of about 22 million. From the agricultural point of view Sudan may be divided into two subsectors: the irrigated subsector along the river Nile and its tributaries, and the rainfed subsector. Rainfall generally increases fairly uniformly from north to south (< 100-1 200 mm annually). The Central Clay Plain Belt runs across the centre of the country from east to west (400-800 mm). It is in this area where rainfed agriculture is mostly practiced. The Sudan Gezira Project, one of the largest in the Middle East and Africa, lies in this belt between the White and Blue Niles.

Out of the estimated 84 million ha suitable for arable crop production, only about 7 million ha are actually under cropping (2 million for irrigated and 5 million for rainfed). Another 34 million ha is used as range land.

Cotton is the main cash and export crop, accounting for about 50 % of all exports, followed by sesame (9 %) and groundnuts (8 %). Sorghum is the main grain crop, grown widely in the rainfed sector, whereas wheat, which is gaining a lot of importance, is being grown in the irrigated sector.

Water for the irrigated sector is drawn from the river Nile and tributaries. With the present demand and future projections Sudan will use up its share from the 1959 Nile Water Agreement (18 million m^3 + 4 from Jonglei Project), as early as 1985. Efficient water use and introduction of modern irrigation practices, such as sprinkler and trickle irrigation, seems to be the solution.

Agricultural mechanization in the Sudan started as early as 1946 after the Second World War to grow sorghum. Since then there was a steady increase in the number of machinery imported. The government then was the sole responsible body for importing machinery. Now there are a number of companies in business representing the manufacturers.

Hand-operated tools and animal-drawn implements dominate traditional farming, which is characterized by small operated farms with subsistance level of production. Since mid 60's 'modernization' of agriculture aimed towards improving traditional practices by developing methods of cultivation and introduction of a selected form of mechanization. Modern mechanized subsector includes large-scale farming of rainfed agriculture and major irrigated projects.

Since 1974, and due to the economic crisis, oil producing countries attracted a large number of workers, who mainly used to be engaged in agriculture. This, and a series of other events, led to disastrous effects on agricultural productivity. Cotton yields, dropped to as low as 0.7 t/ha in 1980/1981 season. A rehabilitation programme was then undertaken by the World Bank for existing projects. A number of private and non-government organizations, led by the Arab Organization for Agricultural Development and the Arab Authority for Agricultural Investment and Development (both an affiliate of the Arab Nations League), were invited in. Government-tenant partnerships were also revised in a number of leading projects, including the Gezira project.

IMPORTS OF AGRICULTURAL MACHINERY

Even though some hand-operated tools and animal-drawn implements are locally made, all power-driven machinery are imported. Table 1 shows the

Table 1. Number of agricultural tractors imported in Sudan 1970-1982.

	MF	Ford	Int. Harv.	Ley-land	Bel-larus	John Deere	Steyr	Zetor	Allis Chal-mers	Univ.	David Brown	Fiat	Ebro	Shib-ura	Total
1970	253	80	115	198	175	-	-	450	-	-	-	-	-	-	1 271
1971	-	-	75	109	571	32	-	-	13	-	-	-	-	-	800
1972	-	5	50	-	75	-	-	-	-	-	-	-	-	-	130
1973	1 105	64	100	185	635	-	15	-	-	-	-	-	-	-	2 104
1974	348	609	50	532	-	587	130	-	-	-	-	1	-	-	2 257
1975	21	62	110	250	25	110	130	-	16	-	-	1	-	-	725
1976	1 522	-	50	50	-	60	40	-	-	-	-	382	-	-	2 104
1977	312	-	35	245	-	-	200	-	-	-	-	-	-	-	792
1978	-	141	-	190	-	500	4	-	17	-	-	-	-	-	852
1979	125	128	27	-	-	-	-	-	-	250	15	-	-	-	545
1980	250	152	90	30	-	-	-	-	-	-	10	-	-	-	532
1982	816	20	90	-	-	-	-	-	-	-	-	-	295	12	1 256
total	4 752	1 261	792	1 789	1 481	1 312	519	450	46	250	25	384	295	12	13 368

Table 2. Number of agricultural machinery imported in Sudan 1970-1978.

Type of machinery	1970	1971	1972	1973	1974	1975	1976	1977	1978	Total
disc plough	193	187	550	100	510	1 206	292	-	416	3 454
ridger	385	425	-	-	400	29	500	90	100	1 929
wide-level disc with seed box	1 130	520	500	500	147	56	97	75	132	3 166
offset disc harrow	35	70	20	64	213	32	132	56	-	622
planter	-	120	-	3	76	206	12	-	13	430
fertilizer distributor	10	2	-	10	10	-	1	-	-	33
groundnut digger	-	-	-	-	70	131	121	120	-	442
grain combine	118	135	50	20	22	387	187	106	30	1 253
pick-up baler	20	35	10	-	5	-	-	-	-	70

number and makes of agricultural tractors imported from 1970-1982, whereas Table 2 shows the number of machinery imported. European makes of Massey-Ferguson, Ford and Leyland are the most widely imported. New makes and models, such as the Japanese Shibura and the Spanish Ebro, are being introduced, whereas some are going out of the market, such as the Russian Belarus. The diversity in tractor and machinery makes and origin has created problems of services and spare parts. Companies in business are interested in sale of their products more than the after-sale service or the undertaking of any training programmes. All tractor and machinery makes to be introduced, are tested in training and testing centres. The country's financial situation was reflected in the number of machinery imported during the last few years. The supply has always been short of the demand, and it could be assumed that all tractors imported before 1973 are now out of service, as reflected by the numbers available at present time (Table 3 and 5). The rehabilitation programme; undertaken by the World Bank, and the growing contribution by the private sector, has boosted the number of imported agricultural machinery.

Now there is a tendency to introduce high-horsepower tractors (more than 150 hp) and heavy machinery, such as heavy off-set discs and large seed-drills. This followed the allotment of large areas to private companies. Most of the tractors available now are medium-horsepower tractors (60-90 hp), whereas low-horsepower tractors are used for the introduction of a selected form of mechanization in the traditional subsector with small operational farms of 1-2 ha.

IRRIGATED SUBSECTOR

The Gezira Project leads the country in the irrigated subsector with a total area of about 840 000 ha. Table 3 shows the number and types of machinery available in different projects of the subsector, owned by public and private sectors. Table 4 shows the major crops grown, areas and average yields. Irrigated subsector outyielded the rainfed subsector by about 3.25 times for cotton yields per hectare and 2.6 times for sorghum. Wheat is grown only in the irrigated areas of Gezira, New Halfa and Northern Province.

The level of mechanization differs with various projects and crops grown. Land preparation is completely mechanized in all projects for all crops. In the Gezira, there are more privately-owned tractors than by the public sector. Except for cotton, mechanization of all other crops is carried out by the privately-owned machinery. Sowing and picking of cotton in the Gezira are manually done, whereas application of pesticides is carried out by aerial spraying. Fleco blades with large tractors are used as subsoilers in areas of heavy weed infestations. Combine harvesters, used for wheat harvesting in the Gezira, are taken to the Gedarif area in the

Table 3. Number of agricultural tractors and machinery in the irrigated subsector.

Item	Gezira		Rahad		New Halfa		White Nile		Blue Nile		Suki		Khartoum		North Province		Total
	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	
tractors																	
100-150 hp	90	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	150
60-80 hp	300	1 000	450	-	245	34	260	80	90	-	74	-	50	40	112	85	2 820
Abu XX ditcher	13	-	12	-	13	-	3	-	4	-	2	-	-	-	-	-	47
Abu VI ditcher	-	50	80	-	25	-	-	-	16	-	12	-	6	-	2	-	191
Fleco blade	70	-	-	-	-	-	3	-	1	-	-	-	-	-	-	-	74
disc plough	38	-	-	-	245	20	110	50	10	-	32	-	50	30	61	78	724
disc harrow	62	-	225	-	109	-	58	-	20	-	8	-	12	-	-	-	494
ridger	27	800	248	-	221	34	93	50	70	-	40	-	18	30	18	3	1 652
leveller	30	600	80	-	77	15	33	20	-	-	8	-	6	12	27	46	954
WLDH	20	70	-	-	40	-	-	-	3	-	-	-	-	-	-	-	133
seed drill	12	-	-	-	-	-	-	-	-	-	-	-	6	-	2	-	20
planter	72	-	168	-	105	-	-	-	-	-	10	-	6	-	-	-	361
fert. distr.	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
sprayer	80	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	100
digger shaker	26	-	190	-	25	-	-	-	-	-	45	-	-	-	-	-	286
g/n. thresher	83	-	200	-	63	-	-	-	-	-	20	-	-	-	-	-	366
baler	21	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	71
c.picker	-	-	50	-	-	-	-	-	-	-	-	-	-	-	-	-	50
comb. harv.	-	300	-	-	32	-	-	-	-	-	-	-	-	-	4	-	336
stalk cutter	-	-	1 000	-	-	-	-	-	-	-	-	-	-	-	-	-	1 000
stalk puller	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
rotary cutter	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	18
border disc	-	-	40	-	-	-	-	-	-	-	8	-	-	-	-	-	48
rotivator	20	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	26
chisel plough	-	-	-	-	-	-	67	-	20	-	-	-	-	-	-	-	87

rainfed subsector for sorghum threshing.

Complete mechanization of cotton is being tried out in the Rahad Project, where all operations are done by publicly-owned machinery. The level of mechanization in the Northern Province is limited by the small areas and land fragmentation. Khartoum Province mainly grows horticultural and fodder crops, and machinery present are mainly for land preparation practices. With the increasing areas put under horticultural and fodder crops in various projects, new machinery, which is lacking at present time, will be needed for the mechanization of such crops.

RAINFED SUBSECTOR

Table 4 also includes major crops grown in the rainfed subsector, areas and average yields. Compared with the yield of similar crops grown in the irrigated subsector, rainfed areas are characterized by low yields, which could be attributed to quantity and distribution of rainfall and poor land preparation.

Table 5 shows the number and types of machinery available in the rainfed subsector. The role of private sector is more profound here than in the irrigated subsector. Except for the state-owned pilot farms, all areas are alloted to private sector. The World Bank-financed directed sector, the Canadian Project and the Military Agricultural Corporation, are in the Gedarif area, together with privately-owned projects. The Arab Authority for Agricultural Investment and Development and the Sudanese-Egyptian Agricultural Integration Company, together with other private companies, are in the Damazin area (Blue Nile Province).

As practised now, the wide-level disc harrow with a seeder box is the only machinery used in this subsector, except for the state-owned pilot farms. The use of the wide-level disc harrow is questionable, due to uneven distribution, loss of soil moisture, and the formation of a hard pan, due to continuous cultivation at a shallow depth. Post-harvest tillage, with harrowing and chisel ploughing, are being tried, and in the future this will be applied with harrowing before seeding. All wide-level disc harrows which go out of work, will be replaced by seed-drills for sowing.

Self-propelled combine harvesters, which come from the Gezira at harvest time, are not fully utilized. This is so because the local varieties grown are non-combinable and are preferred for palatability and export. Combine harvesters are then merely used as stationary threshing units of sorghum.

TESTING AND TRAINING

The Engineering Affairs Administration of the ministry of agriculture and irrigation is undertaking a programme of testing agricultural machinery introduced, and training of agricultural workers. Three centres are engaged

Table 4. Total areas (x 1 000 ha) and average yield (t/ha) of main crops in the irrigated and mechanized rainfed subsector (1982/1983).

	Cotton		Sorghum		Wheat		Groundnut		Sesame	
	area	yield	area	yield	area	yield	area	yield	area	yield
Irrigated subsector										
Gezira	210	1.30	135	0.96	66	0.25	62	1.9	-	-
Rahad	56	2.03	24	1.30	-	-	20	1.9	-	-
New Halfa	38	1.30	21	0.84	20	1.24	12	2.1	-	-
White Nile	21	0.85	21	0.71	4	0.60	-	-	-	-
Blue Nile	25	0.87	22	1.10	-	-	-	-	-	-
Suki	16	1.37	-	-	-	-	3	1.5	-	-
Northern Province	6	1.20	0.5	1.40	7	2.40	-	-	-	-
Rainfed subsector										
Gedarif	5	0.40	1 244	0.55	-	-	-	-	92	0.30
Damazin	20	0.41	520	0.46	-	-	-	-	128	0.30
Rank	-	-	147	0.61	-	-	-	-	5	0.40
Southern Kordofan	25	0.36	206	0.63	-	-	-	-	6	0.48
White Nile	-	-	101	0.48	-	-	-	-	-	-

Table 5. Number of agricultural tractors and machinery in the rainfed subsector.

Item	Gedarif		Damazin		Rank		Southern Kordofan		Southern Darfor		Total
	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	pub.	priv.	
tractors											
> 100 hp	8	-	8	18	-	-	2	-	-	-	36
60-80 hp	25	3 000	68	480	21	310	193	389	90	-	4 576
chisel plough	13	3	10	2	-	-	6	-	-	-	34
offset disc harrow	8	3	7	9	-	-	4	-	-	-	31
tandem disc harrow	6	-	3	-	-	-	3	-	-	-	12
seed drill	7	2	3	5	-	-	2	-	-	-	19
WLDH + seed box	34	5 520	87	464	22	300	95	243	40	-	6 805
planters	7	-	46	-	-	-	4	-	-	-	57
sprayers	4	-	2	2	-	-	4	-	-	-	12
combine harvester	4	*	8	16	2	-	2	-	-	-	32

* Combine harvesters move to and from the Gezira.

in training, where workers are trained in dealing with agricultural machinery, tractor driving and maintenance routines. Unfortunately most of the trainees leave the country after completion of the programme to work in other countries, where they get a higher pay.

Testing of agricultural tractors and machinery is done in one of these centres, where the efficiency and adaptability to Sudan conditions are to be tested. No tractor or machinery should be imported, unless it has undergone and passed these tests. There are some questions raised as to the extent of these tests and that a minimum of 9-12 months of work under local conditions is needed.

FUTURE NEEDS AND DEVELOPMENT

Based on the peak need for machinery at times of cultural operations of different crops, the machinery available falls short of the requirement. This is reflected by the delay in timeliness of operations and low yields, especially in the rainfed subsector. With future policies of intensification and horizontal expansion, the shortage in machinery will even be more profound. For any future development the needs must be met and problems faced solved.

Two assembly lines for machinery are now being proposed for the West-European Massey-Ferguson and the Romainian Universal. Studies have already been completed and in the near future construction and production presumably will start.

PROBLEMS OF MECHANIZATION IN SUDAN

Difficulties facing mechanization in Sudan could be summarized as:

1. Problems of financing. Due to the economic situation of the country, a rehabilitation programme was started by the aid of the World Bank. Private companies and non-governmental organizations were invited in for investment.
2. Problems of research. Even though some research is being conducted, it is not keeping pace with the needs and problems faced. State pilot farms have been used for commercial production, rather than development and application of new techniques and practices.
3. Problems of harvesting. Practically all crops, except wheat and groundnuts, are manually harvested. Long stable cotton faces problems of uneven maturity and economic feasibility to be mechanically harvested. Shattering varieties of sesame and non-combinable varieties of sorghum grown, render the mechanical harvesting of these crops difficult. Harvesting problems are thus closely tied to research problems.
4. Problems of socio-economics. The change in social structure and probably unemployment in localized areas should not be overlooked when mechanization

is undertaken.
5. Problems of testing and training. Adequate testing of newly-introduced machinery is necessary. The testing carried out now is not far from confirmation of manufacturers specifications. Shortage of trained workers is a problem, and trainees seek higher pay elsewhere.
6. Problems of service and spare parts. The diversity in types and makes of machinery available contributed to the lack of service and spare parts. A policy should be adopted whereby agent companies and manufacturer representatives would make services and necessary spare parts available.
7. Problems of land fragmentation. In the traditional sector, small areas alloted to farmers adds to problems of mechanization. Probably cooperative farming and introduction of a selected form of mechanization could be a solution.

CONCLUSIONS

Sudan is a country with a great potentiality for agricultural production. Increasing productivity by horizontal expansion and intensification calls for mechanization as an essential tool. Machinery supply now is in short of the demand and problems of financing, research, harvesting, testing and training, service and spare parts, and the socio-economic effect of mechanization need be solved. To help solve these problems, the government policy is now aiming towards the increase of the role of the private sector. The World Bank is engaged in a rehabilitation programme of the exisisting projects, and a number of non-government organizations and private companies are in business now.

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Agricultural mechanization in Syria

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INTRODUCTION

General agricultural information about Syria is listed in Table 1.

Since half of the population lives in the rural areas, agriculture in Syria is an important section of the economy. During the past decade most of the public investments were allocated for heavy irrigation infrastructure, however at this junction an increasing priority is given to rainfed agriculture in comparison to large-scale new irrigation projects. Due to various reasons at present the country is not self-sufficient and is importing cereals for human and livestock feeding in addition to animal by-products, like fats and others. In order to ameliorate this situation, the

Table 1. General information about Syria.

Area of the country	18.5 million ha	
	33 % cultivable lands	
	45 % steppe, range of pasture	
	3 % forests	
	17 % non-cultivable lands	
Cultivable area	6 142 00 ha	
	irrigated:	367 000
	non-irrigated:	3 286 000
	fallow:	1 906 000
	non-exploited:	383 000
	total	6 142 000
Total population	9.4 million people	
Average density of population	45.2/km²	
Rural population	5.002 million (52.9 %)	
Average annual growth rate	3.48 %	
Birth rate (per 1 000)	47.8	
Mortality rate (per 1 000)	13.4	
Life expectancy	58 for females and 52 for males	
Estimated 1981 gross domestic products per capita at market price	6.915 L.S.	
Contribution of agriculture	20 % plant production: 15 %	
	animal production: 5 %	
Climate	average rainfall ranges from 300 mm in the western coastal regions and the north to under 250 mm in the arid southern and eastern part of the country.	

government has given first priority to the development of the agricultural sector.

The potential for increasing the output of agriculture are as follows:

- expanding and raising the productivity of presently irrigated lands;
- improving the productivity in rainfed areas by the intensification of the cropping systems;
- expanding the cultivated land in rainfed areas;
- improving fodder production with a better livestock management.

The annual rate of population growth is one of the highest in the world, requiring special attention for a judicial use of scarce resources to feed the growing population; on the other hand the agricultural labour force has declined from 40 % of the total labour force in 1970 to about 30 % in 1980, due to migration of the young from the urban areas to the neighbouring oil producing countries in search for better income opportunities. This has resulted in serious shortages of farm labour in agriculture. Mechanization of most of the work in this sector became one of most important issues.

VIEWS AND POLICIES ON MECHANIZATION

The active policy of the government is to promote mechanization. However, at present, mechanization is limited to a few operations, particularly planting and a major part of harvesting. The number of tractors increased from 15 000 in 1975 to 28 000 in 1980, at an annual rate of 13.3 %. According to FAO-projections (AT 2000), tractorization will increase during the 1975-1990 period at an average of 10.4 % per year, a moderate rate by international standards. Allowing for replacement of 1 800 tractors annually. This would mean an addition of 27 000 tractors during the 1981-1985 plan period (at US $ 16 000 per tractor, representing investment requirements of US $ 432 million). In 1980, a tractor cultivated on average 116 ha; in 1985, after allowance of a 10 % reduction in draught-animals, a tractor would cultivate 81 ha, still a large figure, considering that nearly 15 % of total cultivated area would be under irrigation.

The long-term perspective is for large-scale mechanization of an increasing number of operations. FAO's AT 2000 projects that the total man-days required for agricultural production under the high scenario will increase by 87 % between 1975-2000, from 219 million to 419 million. In 1975, labour contributed 69 % of total man-days worked, tractors 17 %. In the year 2000 the share of labour would have fallen to 40 %, while that of tractors would represent 53 % of total man-days required (a minimum of 88 000 tractors depending on the intensity of their use). According to these projections labour requirements in the year 2000 would amount to 1 100 000 (at 150 days per labourer per year) compared to 1 230 000 (134 days per labourer per year) according to the national projection. Table 2 and 3 are projection sheets prepared in 1973 by a team of experts

Table 2. Annual need of tractors (increase plus renewal). Solution A.

Year	45/50 C 1.64 %	80/85 C 2.98 %	100 C 3.71 %	45/50 W 10.71 %	60/65 W 14.20 %	75/80 W 52.69 %	100 W 14.07 %	Total
1973	66	120	149	431	571	2 120	566	4 023
1974	66	120	149	431	571	2 119	566	4 022
1975	66	120	149	431	571	2 118	566	4 021
1976	66	120	149	431	571	2 117	566	4 020
1977	58	105	130	377	500	1 855	495	3 520
1978	58	105	130	377	500	1 855	495	3 520
1979	44	80	99	287	381	1 412	377	2 680
1980	44	80	99	287	381	1 412	377	2 680
1981	44	80	99	287	381	1 412	377	2 680
1982	44	80	99	287	381	1 412	377	2 680
1983	93	169	211	609	807	2 994	800	5 683
1984	93	169	211	609	807	2 994	799	5 682
1985	93	169	211	609	807	2 993	799	5 681
1986	93	169	211	609	807	2 992	799	5 680
1987	85	154	192	555	736	2 729	729	5 180
1988	85	154	192	555	736	2 729	729	5 180
1989	71	129	161	465	616	2 287	611	4 340
1990	71	129	161	465	616	2 287	611	4 340
1991	71	129	161	465	616	2 287	611	4 340
1992	71	128	160	461	611	2 268	606	4 305
total	1 382	2 509	3 123	9 028	11 967	44 392	11 856	84 257

suggesting two solutions (A and B). Table 4 and 5 are tables showing the actual state of affairs that took place in the country.

During the 1960-1980 period, relatively little increase in productivity was achieved in agriculture compared to other sectors. The relatively slow structural change of the composition of labour force and the possible absence of induced adjustments outside agriculture have hampered productivity in agriculture and widened intersectoral disparities.

Mechanization has both beneficial effects (increased income per worker) and detrimental effects (reduction of farm workers resulting in migration). During the past decade, output per unit of land/livestock increased slowly, due to better irrigation and improved practices (essentially in the irrigated and assured rainfall sectors). Increased labour productivity, through better yields per unit area and animal, results in increased per capita incomes, but without the negative effect of reducing the farm population. Therefore, at this juncture, an increase of productivity per unit of land and per labourer is strongly linked with mechanization and better land use practices.

Table 3. Annual need of tractors (increase plus renewal). Solution B.

Year	Tractors	Increase in number of tractors	Replacement of old tractors	Renewal of tractors in service for the increase of tractors*	Renewal of tractors put to work for the renewal of old tractors*	Annual need
1972	10 206	-	-	-	-	-
1973	13 206	3 000	1 023	-	-	4 023
1974	16 206	3 000	1 022	-	-	4 022
1975	19 206	3 000	1 021	-	-	4 021
1976	22 206	3 000	1 020	-	-	4 020
1977	24 706	2 500	1 020	-	-	3 520
1978	27 206	2 500	1 020	-	-	3 520
1979	28 866	1 660	1 020	-	-	2 680
1980	30 526	1 660	1 020	-	-	2 680
1981	32 136	1 660	1 020	-	-	2 680
1982	33 846	1 660	1 020	-	-	2 680
1983	35 506	1 660	-	1 500	512	3 672
1984	37 166	1 660	-	1 500	511	3 671
1985	38 826	1 660	-	1 500	511	3 671
1986	40 486	1 660	-	1 500	510	3 670
1987	42 146	1 660	-	1 250	510	3 420
1988	43 806	1 660	-	1 250 + 1 500 = 2 750	510 + 511 = 1 021	5 431
1989	45 466	1 660	-	830 + 1 500 = 2 330	510 + 511 = 1 021	5 011
1990	47 126	1 660	-	830 + 1 500 = 2 330	510 + 510 = 1 020	5 010
1991	48 786	1 660	-	830 + 1 500 = 2 330	509 + 510 = 1 019	5 009
1992	50 411	1 625	-	830 + 1 250 = 2 080	509 + 510 = 1 019	4 724
total		40 205	10 206	19 070	7 654	77 135

* 50 % after ten years; 50 % after fifteen years.

Table 4. Actual state of affairs.

Year	Number of tractors	Horse-power	Total cultivated area (ha)	Area cultivated per tractor (ha)	Horse-power needed as per FAO norms per half hectare	Horse-power per hectare	Number of harvesters and threshers	Number of water pumps
1975	15 303	851 655	5 475 400	357.8	2 737 700	0.15	1 607	40 416
1976	18 567	1 073 485	5 544 700	298.6	2 772 350	0.19	2 088	40 500
1977	20 672	1 221 465	5 509 350	266.5	2 754 600	0.22	2 254	40 650
1978	23 329	1 397 550	5 588 466	239.5	2 794 200	0.25	2 106	41 557
1979	25 340	1 539 020	5 585 156	220.4	2 792 570	0.27	2 206	47 986
1980	27 544	1 704 000	5 684 000	206.3	2 842 000	0.29	2 244	47 206
1981	31 387	1 960 800	5 759 000	183.4	2 879 000	0.34	2 368	56 499
1982	35 533	2 230 725	5 767 000	162.6	2 883 000	0.38	2 587	60 057

Table 5. Actual state of affairs.

Year	Number of tractors less 15 %	Horse-power of tractors	Total area cultivated by tractors (ha)	Area to be cultivated by one tractor (ha)	Horse-power input per hectare by tractors	Horse-power of tractors and harvesters	The share of 1 ha input by tractors and harvesters	Total horse-power capacity of tractors, harvesters and water pumps	The share by 1 ha received in horse-power from tractors, harvesters and water pumps
1975	13 008	723 910	5 475 400	420.9	0.13	884 610	0.16	1 996 047	0.36
1976	15 782	912 463	5 544 700	351.33	0.16	1 121,263	0.20	2 235 013	0.40
1977	17 571	1 038 245	5 509 350	313.54	0.18	1 263 645	0.22	2 381 520	0.43
1978	19 830	1 187 917	5 588 466	281.81	0.21	1 398 517	0.25	2 429 129	0.44
1979	21 539	1 308 167	5 585 156	259.3	0.23	1 528 767	0.27	2 848 379	0.50
1980	23 412	1 448 400	5 684 000	242.78	0.25	1 672 800	0.29	2 992 412	0.52
1981	26 579	1 666 680	5 759 000	215.86	0.28	1 903 480	0.33	3 457 201	0.60
1982	30 203	1 896 116	5 767 000	190.94	0.32	2 154 816	0.37	3 779 382	0.65

INSTITUTIONS

Government institutions directly involved with agricultural mechanization are:

- Ministry of Agriculture and Agrarian Reform, Damascus;
- Al-Furat Company for Manufacturing of Tractors, Aleppo;
- The Distribution Company of Agricultural Machinery, Aleppo;
- The General Administration for the Development of the Euphrates Basin, Raqqa;
- The Cotton Bureau, Aleppo;
- The Sugar Plants Organization, Homs;
- General Organization for Poultry, Damascus;
- General Organization for Cows, Hama;
- General Organization for Fodder, Damascus;
- General Organization for Agricultural Mechanization, Damascus.

Further there are the private sector (very limited scale), and the Farmers Union.

MANUFACTURING OF TRACTORS: AL-FURAT COMPANY, ALEPPO

This factory is 15 km from Aleppo and is a joint-venture project between Syria (75 %) and Spain/Hepro Company (25 %) (Recently Hepro Co. sold 12.5 % of their shares to NISSAN Japanese Company). Although in 1973, when the factory was established, it was proposed to manufacture tractors of 60, 70 and 82 hp, later, in accordance with the government Five-Year Development Plan, it was decided to concentrate on manufacturing 4 000 tractors of 60 hp and 1 000 of 80 hp annually. An 85 % of the parts of tractors are imported and only 15 % are manufactured locally. Table 6 shows tractors produced by this company.

TRAINING INSTITUTIONS FOR MECHANIZATION

1. Institution for Mechanization, Raqqa;
2. Institution for Mechanization, Aleppo;

Table 6. Number of tractors produced during 1974-1978.

Year	Number of tractors			Total
	60 hp	70 hp	80 hp	
1974	1 905	-	-	1 905
1975	3 305	-	774	4 079
1976	1 463	1 401	1 319	4 183
1977	305	1 673	683	2 661
1978	2	1 828	-	1 830

3. Agricultural School for Machinery in Kamishly (joint-venture with FAO/ UNDP project).
4. Some vocational training centres in the country provide mechanical training.
5. Some training on agricultural machinery is provided in the curricula of the five faculties of agriculture in the country.
6. The General Organization for Agricultural Machinery, which is the major organization interested in agricultural machinery, is planning to train locally and abroad, for the year 1983/1984, 1 700 persons in agricultural machinery.

Workshopcentres are to be found in: Damascus, Homs, Raqqa, Deir-ez-Zor, Hassakeh, Kamishly, Tartous, and Hama. Furher 62 mobile workshops all over the country are foreseen in the new Five-Year Development Plan in addition to two big regional stations in Damascus and Deraa.

Agricultural mechanization in Jordan

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Jordan has a population of 2.5 million and an area of about 9.3 million ha, out of which 1.2 million ha are arable; only 0.54 million ha are under cultivation, 0.04 million ha are irrigated, and 0.5 million ha are rainfed. The most important crops produced and area planted are shown in Table 1 (statistics on Jordan refer to East Bank of Jordan only).

The agricultural sector in Jordan contributed in 1981 6.5 % of total gross domestic products, down from 10 % in 1970 (Monthly Stat. Bull., 1981 and 1982). It employed in 1980, 18 % of total national labour force, down

Table 1. Area planted and production of most important crops in East Bank of Jordan in 1982. Source: Agr. Stat. Yearbook and Agr. Sample Survey. The Hashemit Kingdom of Jordan, Dept. of Statistics, 1982.

	Area (ha)	Production (tonne)
field crops	173 295	-
wheat	101 965	52 250
barley	48 663	19 658
lentils	10 789	8 084
vetch	3 387	2 573
chick peas	2 023	1 497
tobacco	2 846	1 092
broom millet	2 000	3 091
others	1 622	-
vegetables	33 895	-
tomato	11 741	195 274
eggplant	2 638	45 412
summer/squash	3 063	41 207
cucumber	2 817	55 025
watermelon	5 229	3 295
sweetmelon	1 526	1 291
okra	1 026	285
others	5 855	-
fruit trees	38 047	-
olive	30 305	40 366
grapes	2 841	26 795
citrus	3 770	46 451
others	1 131	-

from 34 % in 1970 (Nat. Planning Council, 1976). However, the role of this sector is important not only to Jordan, but also to several non-agricultural Arab States, namely the oil-producing ones.

Cultivated areas in Jordan are devided into small holdings (Table 2). In the Jordan Valley, where about 75 % of the irrigated lands are located, the size of land parcel was set by law to a minimum of 3 ha and maximum of 20 ha. In the rainfed areas, there is no limit on the size of land holdings. However, agricultural lands were divided among family members due to the inheritance law, which led over the past years to fractionating the larger holdings into smaller ones. The small holdings form one of the obstacles to using machinery in performing agricultural operations. Agricultural areas in Jordan are in general accessible to tractors.

Tractorization in agricultural areas is common in Jordan. Primary tillage implements, such as the disk and the mould-board ploughs are widely used in both irrigated and rainfed areas. Draught-animals are used in ploughing and weeding operations in orchards. Operations performed mechanically, are less expensive than those performed manually or by animal-drawn implements (Table 3).

The labour shortage problem in the agricultural sector, which was created abruptly in the late 1970's due to labour movement to the oil producing countries in the region, was solved in part by importing foreign labourers and to a lesser extent by mechanizing the agricultural operations. The increase in the use of agricultural mechanization is reflected in the increasing number of imported and sold farm machinery and implements during the 1970's (Table 4). Mechanization in the last 10 years was mainly introduced in the cereal production rainfed areas and in the irrigation techniques.

Table 2. Number of agricultural holdings and area by size group. Source: Agr. Census. The Hashemite Kingdom of Jordan, Dept. of Statistics, 1975.

Size group (ha)	Number of holdings	Area (ha)	Average area per holding (ha)	Percentage to total area (%)	Accumulative percentage (%)
Less than 0.5	8 522	1 604	0.19	0.41	0.41
0.5-1	3 825	2 568	0.67	0.66	1.07
1-2	6 926	9 223	1.33	2.36	3.43
2-3	5 337	12 189	2.28	3.12	6.55
3-4	4 666	15 082	3.23	3.86	10.41
4-5	2 968	12 591	4.24	3.23	13.64
5-10	8 634	57 079	6.61	14.62	28.26
10-20	5 479	70 183	12.81	17.98	46.24
20-50	3 359	93 377	27.80	23.92	70.16
50-100	719	45 213	62.88	11.58	81.74
100-200	253	29 973	118.47	7.68	89.42
200-500	84	22 049	262.49	5.65	95.07
500-1000	10	5 892	589.20	1.50	96.57
1000-2500	9	13 380	1 486.67	3.43	100.00
total	50 791	390 403	-	100.00	-

Table 3. Cost of different agricultural operations performed by different methods available in Jordan. Source: Own estmation and from agencies providing custom service.

Operation	Method and cost in Jordan Dinar per hectare		
	manual	draught-animal	machine
ploughing	-	20-30	5-12
stone picking	50-60	-	20-30
planting and fertilizing	-	-	5-6
planting	2-3	-	5-6
fertilizing	2-3	-	3-4
seed covering	-	-	2-3
weeding	15-30	10-15	-
spraying (boom)	-	-	5-6
spraying (hand gun)	-	-	3-5
cutting	20-30	-	7-10
raking	10-15	-	2-3
threshing (per tonne)	-	5-7	2-3
winnowing (per tonne)	5-7	-	-
threshing and separation (per tonne)	-	-	4-5
harvesting:			8-10
cereal	30-40*	-	-
legume	40-50**	-	-

* Cutting by hand.
** Harvesting by hand pulling.

Table 4. Number of principal agricultural machinery and implements imported and sold during 1970-1981. Source: Various Agr. Statistical Yearbooks, Dept. of Statistics, Jordan.

Year	Tractors			Imported implements	Imported harvesting machines and implements
	total end of year	imported	sold		
1970	2 758	-	96	-	-
1971	2 856	-	98	-	-
1972	3 060	-	204	-	-
1973	3 344	-	284	-	-
1974	3 547	-	203	-	-
1975	3 748	501	201	167	119
1976	3 914	437	166	460	156
1977	4 074	278	160	656	217
1978	4 223	344	149	189	397
1979	4 343	152	120	832	54
1980	-	218	-	107	948
1981	-	238	-	129	61

Realizing the labour shortage problem and the advantages of mechanization, the government of Jordan in both the 1976-1980 and 1981-1985 Five-Year Plans emphasized the role of mechanization in the development of agriculture in Jordan. The following activities were initiated by the government of Jordan in order to promote the use of mechanization in agriculture:

- encouraged the establishment of agricultural cooperative societies in

order to collect small-size land holdings into larger ones;
- exempted farm machinery and implements from import duty;
- provided soft and long-term loans through some credit sources available to farmers for purchasing farm machinery and implements;
- established marketing centres to enable farmers to obtain a reasonable price for their products;
- established the Jordan Valley Farmers' Association (JVFA) to provide different services to farmers in the Jordan Valley, which include custom service of farm machinery;
- established irrigation projects to enable farmers to use sprinkler and drip irrigation systems, which in turn will replace the Zig-Zag method of furrow irrigation, which was restricting the entery of machinery into the fields;
- experimented the use of proper farm machinery and implements through agricultural projects such as the Arid Land Development Project and the Rainfed Areas Development Projects, which included the introduction of new technology in agriculture;
- encouraged the private sector to provide farm machinery custom service at a reasonable cost through providing loans and credits as well as supplying them with machinery at cost-price;
- provided finance for research projects which deal with developments, modifications and testing of farm machinery and implements needed for agriculture in Jordan;
- established farm machinery units and stations in different parts of the country to provide custom, repair and maintenance services at reasonable cost;
- established network of agricultural roads to facilitate transporting agriculture products by means of trailers, trucks and pick-ups;
- established schools, institutes and centres to provide training programmes in agricultural mechanization;
- established agricultural pilot projects, using farm machinery and implements to demonstrate to farmers the advantages of mechanization;
- encouraged private sectors such as blacksmiths to manufacture some of the widely-used agricultural implements.

The tendency in Jordan is towards providing farm machinery services through the custom operations, because high capital investment and small land holdings make owning farm machinery unprofitable. Custom service operations are available in Jordan through private sector. However, few government and semi-government agencies are newly entering this market, not to compete with the private sector, but to complement its services. These new agencies are providing wider selection of custom services that most private ones do not provide, especially in the rainfed areas. For the first time these new agencies introduced proper implements, such as the chisel plough, sweep, harrow, sprayer, mower, rake, balers and stone picker in the rainfed areas. Jordan Cooperative Organization (JCO), Jordan Valley Farmers' Association (JVFA), and the ministry of agriculture are providing farm machinery custom service operation, along with the private sectors, at an acceptable charge (Table 5).

Sources of financing to purchase farm machinery and implements are limited in Jordan. Commercial banks (CB, JCO, JVFA), Agricultural Credit Corporation (ACC), own saving and dealers are the main sources of financing (Table 6). Farmers tend to depend on their own savings when buying farm machinery. This may be due to religious belief, which forbids paying interest on borrowed money. In a survey conducted by a team from both the faculty of agriculture at the university of Jordan and the university of Göttingen (West-Germany) during 1979 and 1980, it was found that out of 197 farmers own farm machinery, 127 used own saving to purchase them, 21 used dealer financing (dealers use the term fees instead of interest), 19 obtained loan from ACC (at about 6 % interest rate), 11 obtained loan from professional money lender and commission agents (at interest rates of 15-20 %), 10 obtained financing from JCO (6-8 % interest rate), 5 borrowed money from relatives and friends at no interst, and 4 from CB (12 % interest).

Farm implements manufacturing in Jordan is modest. All implement manufacturing or modification are made by private workshops or blacksmiths or by dealers' workshops. The above-mentioned survey indicated that in 1980 there were 13 workshops and blacksmiths in Jordan to produce farm implements. The domestic production involved hand-tools, animal-drawn implements and some modern implements, such as tractor-driven threshers and assembly

Table 5. Type and cost and farm machinery and implements available through custom services. Source: Agencies providing custom service.

Type of mechanized operation	Sectors provide custom service and cost of operation in J.D./ha			
	private sector	ministry of agriculture	JCO	JVFA
disk plough	7.5-12.5	-	-	-
mold-board plough	7.5-12.5	-	-	-
chisel plough	-	-	4.5	-
roller and pulverizer	-	-	2.5	-
stone picker	-	-	20.0-30.0	-
disk harrow	2.5-3.5	-	-	-
sweep	-	-	3.5	-
rotary hoe	10.0-30.0	-	5.0	-
grain drill	-	-	5.5	-
boom sprayer	7.5	-	5.5	-
gun sprayer (per 1 000 lit.)	3.0	5.0	-	2.0
grain combine	10.12.5	-	10.0	-
mower	-	-	7.5	-
rake	-	-	2.0	-
baler (per 100 bales)	-	-	6.5	-

Table 6. Amount of loans given to farmers for purchasing farm machinery and implements and irrigation system (in Jordan Dinar).

Source of loan	Year and purpose of load									
	farm machinery and implements					irrigation system				
	1978	1979	1980	1981	1982	1978	1979	1980	1981	1982
Agr. Credit Corp. (ACC)[1]	186 360 (90)[2] (5.7 %)[3]	93 993 (46) (4.0 %)	199 795 (52) (4.1 %)	181 183 (50) (2.7 %)	183 145 (40) (2.9 %)	1 034 854 (235) (32.2 %)	1 444 472 (NA) (41.7 %)	1 334 323 (77) (27.5 %)	950 596 (120) (14.0 %)	842 875 (95) (13.4 %)
Commercial Banks (CB)[4]	1 101 952 (136)[2]	1 061 687 (163)	1 889 787 (118)	1 841 341 (223)	2 961 985 (290)	included in loans given to purchase farm machinery				
Jordan Coop. Org. (JCO)	-	purpose of loans not specified				---				

1 Source: Various Annual Reports of Agricultural Credit Corporation, Jordan.
2 Number of borrowers in brackets.
3 Percentage of loans for the specified purpose to total loans given by the source.
4 Various Agricultural Statistical Yearbooks, Department of Statistics, Jordan.

of ploughs and harrows. Manufacturing modern and sofisticated machinery or implements in Jordan is not possible, due to the small market of Jordan for these items. However, traditional tools and implements could be developed further and enlarged through amalgamation of small workshops in a cooperative society fashion, where loans and credits could be accessible through JCO in order to enlarge the capital investments, thus making such production profitable.

Importing farm machinery and implements are done by dealers. Dealers in Jordan started dealing with farm machinery as early as 1949. The survey indicated also that there are 16 farm machinery dealers in Jordan. They are agents for 16 different makes of tractors of all sizes. Farmers in Jordan started owning tractors as early as 1936. In 1948 there were 74 tractor owners and in 1980 estimated number of tractors was 4 500, and of grain combines was 210.

Private workshops play an important role in performing the repair and maintenance of farm machinery. These workshops are usually located and spreaded well over the agricultural areas. Dealers' workshops are mainly located in large cities, away from the farms. The survey indicated that 73 % of farm machinery repairs were performed in the private wórkshops, 21 % in the dealers' workshops, and only 6 % on the farm by either private or dealers' mobile workshops.

Research on mechanization in Jordan is very limited. It is mainly conducted through the faculty of agriculture at the university of Jordan. Research activities in Jordan include modifying and testing some machines and equipments, as well as designing small machines and equipments for harvesting purposes.

Mechanization training on maintenance, repair and operation is performed in high schools belonging to the ministry of education, the faculty of agriculture, and the private sector. However, farm machinery dealers and private workshops, as well as providers of farm machinery custom service are considered the most important training centres, which supply the farm machinery sector with large numbers of well-trained mechanics and operators.

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Future development of agricultural machinery industry in developing countries

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INTRODUCTION

The main purpose of this paper is to examine critically the actual status of agricultural machinery industry in Zambia, and ways and means of promoting international cooperation in the field of agricultural machinery industry. Like any other developing country, Zambia is still dependent for its agricultural inputs, as well as technology transfer, from the industrial nations. However, due to problems in foreign exchange, spare part problems and maintenance much of these inputs are either laid out before the actual time of usage or become too expensive to the production system. Looking at the countries existing metal working technologies as well as indigenous farm resources (Table 1) it can be reliably concluded that with the international collaborations it is possible to strengthen the present status of the agricultural machinery industry in Zambia. Although Zambia, like the other neighbouring countries, has carried out a considerable amount of work in farm equipment innovations, these are limited to simple implement development technologies or some of them still remain at the research and development stages. Looking at the prevailing economic conditions and the available skills, it appears much emphasis need to be placed on animal-drawn and hand-operated equipment as well as on intermediate technologies, such as small tractors and transport devices at the initial stage of agricultural machinery development in Zambia.

Farming in Zambia is also influenced by a number of critical factors, such as pattern of rainfall, temperature, soil, marketing and credit facilities. New technologies are very much desirable in the field of soil science, lift irrigation systems, and marketing. In Zambia nearly 60-70 % of the farmers can be categorized as subsistence farmers (ILO, 1980). They do not have adequate money to purchase expensive farm implements, their technical knowledge is limited, a large number of women participate in farming; as such special innovations are needed for this category of farmers.

Table 1. Production resources of the metal working industries.
Source: Wester (1980).

Machinery required for production	Number required for one workshop	Available at present*					
		A	B	C	D	E	F
brake presses	1	1	1	2	1	1	2
cutting machines	1	2	2	2	1	2	4
drilling machines	2	2	2	4	2	2	4
forging hammers	1	1	0	1	1	1	1
grinding machines	2	2	2	3	1	3	3
hydraulic presses	1	1	3	3	1	1	1
lathes	1	1	1	4	3	3	5
heat treatment furnace	1	0	0	0	0	0	0
sheaving machines	1	1	3	2	1	1	3
spray units	1	2	2	1	1	1	2
welding units	2	20	10	8	2	10	30
bending machines	1	1	0	2	1	2	1
production workers	50	100	300	150	52	98	150
estimated number of units per year (x 1 000)		6	12	18	3	6	12

* A = Lenco Ltd. Zambia.
B = Shonga Steel Ltd.
C = Northland Engineering Ltd.
D = Reunited Engineering.
E = All Metal Engineering.
F = Turning and Metal.

CURRENT LEVEL OF AGRICULTURAL MECHANIZATION IN ZAMBIA

In Zambia there are three distinct types of farmers, namely commercial, emergent, and peasant or subsistence. Commercial farmers, who are mainly settlers, have always been using tractors and other modern equipment, and they still continue to use them. The emergent farmers, who can be considered as those who took to farming after independence, employ intermediate technology, such as animal-drawn implements and ox-carts. The subsistence farmers whose cultivatable land is usually 5 acres, use intensive labour and hand-hoes. The present status of farm machinery industry can be viewed as a 3 tier-system (Table 2)

It may be interesting to point out the historical reasons for the above 3-tier set-up of the agricultural machinery industry in Zambia. Basically the colonial economic policies did not favour the development of agriculture, although Zambia has a good climate and environmental advantage for mechanized agriculture. This is understandable, because the major colonial economic objective was to develop the mining sector in Zambia. Any agriculture that was encouraged, was directed towards providing food to miners (Kinsey, 1980). The agriculture so encouraged, had nothing to do with socio-economic development of Zambia as a whole.

As pointed out earlier, agricultural machinery used by farmers differ

Table 2. Categories of farm machinery industries.

Sophisticated agricultural implements, tractors, harvesters, etc.	imported or assembled
Intermediate agricultural implements, small tractors, ploughs, cultivators, hammer mills and agricultural pumps	imported and locally assembled
Animal-drawn implements, hand-operated implements, cultivators, ploughs, etc.	partly imported and majority locally assembled

according to their income as well as the influence of the above colonial background. In 1980, the total area under cultivation for selected crops, such as maize, groundnuts, sunflower, cotton, soyabeans, wheat, tobacco, rice and sugar, can be estimated as 650 000 ha (Bank of Zambia, 1980).

Commercial farmers, who constitute 5 % of the total farming community in Zambia, have access to modern technology and use tractors and other implements for farming. Emergent and subsistence farmers mainly use animal-drawn implements, hand-operated equipment, and intensive labour for farming. Demand for animal-drawn implements, such as ploughs, cultivators, drag harrows, planters, ridgers, and hand-hoes, is increasing with the increase of imported price of tractors and other mechanized implements. The relationship between the average farm size and the types of crops grown by the farmers is shown in Table 3. The production of crops in the non-commercial sector, where the future farm mechanization is needed, is shown in Table 4, let alone the uncultivated land.

In the area of harvesting among the non-commercial farmers, implements such as hand-hoes, axes, sickles, hand and animal-drawn diggers and petrol/

Table 3. Production of crops in the non-commercial sector (in thousand bags). Source: Central Statistics Quarterly, Zambia.

Province	Types of crops*					
	A	B	C	D	E	F
Central	17 528	124	1 034	1 343	296	79
North Western	1 399	161	1 246	2 760	153	141
Eastern	22 914	255	199	N/A	1 980	25
Luapula	400	N/A	444	4 068	425	46
Northern	392	512	1 728	411	514	537
Southern	4 076	14	38	N/A	310	8
Western	197	18	440	944	41	4

* A = maize.
B = sorghum.
C = millet.
D = cassava.
E = groundnuts.
F = beans.

Table 4. Average farm size and types of crops from selected households. Source: ILO (1981).

Crops	Group 1 (%)		Group 2 (%)		Group 3 (%)		Group 4 (%)		All groups (%)	
	M*	L	M	L	M	L	M	L	M	L
maize	98	56	99	72	98	88	100	92	99	66
groundnuts	28	24	52	46	40	38	47	58	42	35
cotton	6	-	5	-	29	-	28	-	14	-
sunflower	8	-	18	-	33	-	62	25	25	1
cassava	-	67	-	74	-	83	-	58	-	71
millet	-	13	-	27	-	24	-	33	-	23
sorghum	-	24	-	21	-	12	-	17	-	21
average farm size (ha)	1.33	0.57	3.08	1.45	4.76	1.70	10.70	4.61	4.14	1.28

* M = more favoured areas.
L = less favoured areas.

diesel-driven hammer mills, are widely used. On the other hand, commercial farmers have access to modern implements that are basically imported.

The high oil prices and the fall in the price of copper has severely affected the Zambian economy, which directly restrict the imports of agricultural implements. This has led to increased demand for locally manufactured agricultural tools and implements (Wester, 1980).

NEED FOR AGRICULTURAL MECHANIZATION

In general the objective of mechanization is to improve the output for local self-reliance and to export. Besides these, there are few more national benefits, namely the improvement of socio-economic development of the communities, and the creation of gainful employment in the farming sector, which includes food processing for export.

It has also been argued that there are additional benefits that could be derived from a good mechanization policy (Sunyoto, 1978), namely:

- development of industrialization and improvement of other economic sectors;
- initiation of equipment manufactured locally;
- increase of marketable products and processing of different types of agricultural products locally for local consumptions as well as for export market.

The pattern of mechanization in developing countries may differ from that of developed countries because of the influence of demographic, economic, social and environmental factors. Therefore it is important to accommodate these factors as well as understand the following constraints presently imposed on the resource-production system:

- lack of capital;
- lack of industrialization policy directed towards maximum utilization of land using modern methods;
- low-level of technical know-how;
- lack of required man-power and resources.

With the increased population and massive drop-out from secondary school leavers, it is important to mechanize agriculture at least to some extent. Present methods adopted both by peasant and emergent farmers do not significantly contribute to the Gross National Product, nor improve their living standards. Therefore mechanization of agricultural activities such as ploughing, harrowing, planting, weeding, harvesting and processing is a must in Zambia.

Zambia has enjoyed a high standard of living, mainly due to copper. It is now clear that the foreign exchange earned from copper is hardly enough to meet the needs of the increasing population of Zambia. Diversification of economy from copper to agriculture is important, if Zambia wishes to go forward and enjoy a higher standard of living. With the increased knowledge of the world technology and the possible bilateral cooperations, it is possible to achieve these objectives. In view of this it can be concluded that there is a provision for international cooperation, especially in the field of agricultural mechanization using technology that is appropriate to Zambian conditions and taking the advantage of the available human resources.

ROLE OF THE INTERNATIONAL COOPERATION IN THE FIELD OF AGRICULTURAL MECHANIZATION

It has been pointed out on several occasions that the countries in the developing world will not be able to strengthen their technological capacities unless they initiate technological development themselves through their initiative (ref. Unido). However, technological experience of many other countries can contribute to collective process of strengthening the technological capabilities of developing countries by way of specific cooperation. Equally industrialized countries will continue to remain the suppliers of much more modern technology to all the countries, developed as well as developing, for years to come. Cooperation with the governments of the developing countries and those collaborating enterprises should become a vital link. Such process should ensure that the technology transfer that takes place, will positively contribute to the national development of the collaborating countries, rather than to increase profit. In other words, the collaboration should benefit both parties equally.

The Buenos Aires Plan of Action has stated clearly that the bilateral links of cooperation at sub-regional, regional and international levels are important for technological development, and has clearly pointed out that one of the aims of this plan of action is, to enable developing countries to attain a greater degree of participation in the international economic activities and thereby provide an opportunity to expand international cooperation (ref. Unido). This therefore calls for special type of international cooperation, one that is directed towards mutual benefits.

There is also a need to intensify the international cooperation among developing and developed countries in order that the world will be able to share the benefits of science and technology. At present, science and technology which had to a greater extent made our life comfortable, is still concentrated on the hands of few countries only. However, it is important to remember that such need, need for cooperation and transfer of technology, should arise not with the intention of domination, but from the awareness that the accumulated technological and innovative experience can be beneficial to both parties.

It is also important for developing countries to understand and agree with developed countries issues such as the extent of foreign holding, degree of participation, duration of agreements, technology remuneration, technical services and technology transfer mechanism of international cooperations. Many developing countries still continue to import their food, and it is therefore in the field of farm machinery industry that the greatest potential lies for technical cooperation.

Looking at the present trends in developing countries, it appears that such cooperation and joint-ventures will become viable. When such collaboration has taken place, it is equally important to organize a very effective network for maintenance and supply of spare parts. On many occasions, international cooperation with developing countries fails or becomes nonprofitable due to poor service networks. However, it should be kept in mind during the cooperation period, that the efforts of the developing countries to strengthen their technological autonomy, should not be jeopardized.

During the past much has been said about technological cooperation, but the effective linkages were not created yet. At this stage, it is not the validity of the technological cooperation that should be questioned, but rather the relevance of the past approaches and methods adopted. However, as pointed out earlier, if the right approach can be adapted, the technological expertise accumulated in industrialized countries, could be brought to developing countries via technological cooperations to stimulate a conscious process of technological change in farm equipment and machinery industries in developing countries, which is considered most important of the international technological cooperation.

At present there is a big misunderstanding with regard to international technological cooperation, especiallly in the field of farm inputs. However, such technology will continue to flow from industrially developed countries through various mechanisms. In almost all cases, there is provision for technology transfer, however, in many instances this has not happened in a manner positive to developing countries. It is therefore the nature and the content of the contracts that should be reviewed in order to rectify this situation. Given the screening arrangements already operating in many developing countries and those that are likely to be introduced from time to time, it would be possible to expect more reasonable terms in future. When such guidelines are followed by developing and developed countries, more appropriate climates can be created for future investments as well as technological cooperation. In a recent address to the nation, the president of the Republic of Zambia said that the possibility of international cooperation for industrial development in Zambia still exists, provided such collaborations are not directed towards one-way profit systems.

CONCLUSIONS

At present, as pointed out earlier, most of the subsistence farming is done either using hand-hoes and human labour or using animal-drawn implements. However, with the increase of population and 'grow more food' programmes, as well as government policy of diversification economy from copper to agriculture, more mechanization is needed, if the economy has to stay at the same level as that of copper production. This will not be an easy task, but with the international cooperation and technology transfer systems, it will be possible for Zambia to enjoy higher level of living. Any mechanization programme to be introduced should be a long-range one. Such mechanization should lead to higher productivity and should bring in more profit to the farmers. It should also provide an opportunity to intensify farming and enable to plant his crops in time.

Human labour constitute a major source of power in farming in Zambia. Once the mechanization comes to Zambia, the fear of unemployment may worry the policy makers. However, it is also important to make necessary arrangements to absorb this labour force as well as the drop-outs from the secondary schools in industries that provide the necessary tools and implements for mechanization. The other factors, like cost of fuel and oil, foreign exchange, spare part services, inadequacy of designs for equipment, lack of skilled craftsmen, problems related to irrigation of farms, general economic, social and political problems of the country, should also be taken into consideration. This then suggest that, when introducing mechanization, it is important to start with intermediate technology and then move to higher technology, where appropriate.

Finally, successful mechanization depends much on availability of appropriate machinery and continuous supply of spares and other service facilities, increase acreage cultivation, selection of high-yielding food and cash crops, observation of soil conservation and irrigation practices, maximum usage of climatic conditions, increase of output per hectare and training of farmers to use new techniques as well as machinery. International cooperation can be made available almost in all above areas.

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Agricultural mechanization in México

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INTRODUCTION

The land area susceptible to cultivation in Mexico covers some 23 million ha, of which during the last two years about 20 million ha have been used, 25 % irrigated, and 75 % rainfed (México, DGEA, 1981). Of this area it is estimated that 10.9 million ha can be mechanized (Gómez Jasso, 1983). Federal government plans are directed towards incorporating more land to agriculture to give a total of 26 million ha in the medium term (México, DGP, 1982).

MECHANIZATION

Agricultural mechanization, as we understand the term today, was started in Mexico in 1880, when the first Osborne mowers were used in the field together with Albion and Avery cultivators and 'La Mexicana' threshers, made especially for Mexico in St. Louis Missouri, USA (Gómez Jasso, 1983). Between 1918 and 1920 the Mexican government bought tractors and farm equipment in the USA with the intention of permitting complete mechanization of the agricultural land. Between 1953 and 1957 the Ejidal (Rural Official Bank) bank acquired 1 013 tractors with a variety of implements. In this way it has been mainly through the official agricultural banks that the federal government has implemented its plans to provide tractors for Mexican farms.

At the moment there are about 143 000 tractors in the country (México, DGEA, 1981), which equates to one per 140 ha of cultivable land. Unfortunately the distribution is not even, as a high proportion of tractors is concentrated in the irrigated areas, where there is an average of 56 ha per tractor. The most heavily mechanized areas of the country are the north-east, north-west and central zones; the lowest tractor population is in the southern zone. The average number of hectares per tractor in the different regions is: northern: 86; central: 178; southern: 740.

The form of land distribution and the physical and topographical conditions of the cultivable land has lead to a preference for tractors of 70 hp

(52 kW), which represents approximately 60-70 % of total sales.

MANUFACTURE OF AGRICULTURAL MACHINERY

Tractors

Basically tractor production in Mexico has been undertaken by Ford, Massey-Ferguson, International Harvester, John Deere and Sidena (a nationalized steel foundry). As far as market penetration is concerned Massey-Ferguson leads with 38.4 % of sales, followed by Ford (29.1 %), John Deere (15.7 %), International Harvester (14.3 %), and Sidena with its soviet Belarus T-25 tractor (2.4 %).

During 1983 all the companies have experienced a sharp decline in sales; in the period January to May total sales fell more than 50 % compared with the same period in 1982. This situation is principally due to the economic problems that the country is facing and the resultant restrictions on government purchasing, which represents a high percentage of annual tractor sales. The Central Office for Analysis of Economic Affairs established the prognosis of tractor sales (Table 1). This prognosis was calculated on the basis of a 9.7 % annual growth rate in accordance with the tendency to date. It also considered reaching a figure of one tractor per 93 ha, which has not been achieved for the reasons given.

It should be mentioned that, despite the actual economical problems, the Mexican government and some companies consider that in 1984 the national economy will recover and this will be reflected in a slight increase in sales of tractors and agricultural implements.

Implements

With reference to agricultural implement manufacture it should be pointed out that all soil engaging implements are nationally made, with the exception of those used with tractors of over 100 hp (75 kW). At the moment there are about 365 agricultural implement factories in Mexico. Nevertheless, combine harvesters, small seed planters, cotton pickers, etc., continue to be imported.

The Mexican government is trying to resolve the problem of the lack of tractors in different regions of the country by means of machinery pools, managed by the federal or state government. The prices charged to the farmers are slightly lower than those of the private sector. Unfortunately,

Table 1. Prognosis of tractor demand in Mexico for 1983-1985.

	1983	1984	1985
Number of tractors	29 055	31 718	34 488

the fact that a large proportion of replacement parts needs to be imported, has meant that many tractors are standing idle through lack of servicing. The federal government, aware of the problem, is implementing a plan of heavy investment in spare parts, in order to repair and put to work a large number of the tractors affected.

PRACTICAL TRAINING AND FORMAL TEACHING

Formal courses in agricultural engineering are an innovation in Mexico. In the last ten years some eight universities have started to offer degrees in agricultural engineering or its equivalent. These are located in the central and northern zones of the country. In addition there exist various federal government institutions which offer short courses on farm machinery, focussing principally on operation and servicing. Besides, tractor distributors are under obligation to train personnel in the use and repair of equipment.

RESEARCH

Research in agricultural engineering is carried out in the universities, although there are no very profound programmes. Most of the work is done in the course of student-thesis projects, but some teaching staff develop their own lines of research.

The National Agricultural Research Institute of the ministry of agriculture and hydraulic resources started an Agricultural Engineering Research Programme in 1978. This has been directed towards the design, modification, evaluation and fabrication of prototypes of low-cost machinery, aimed at resolving the problems of mechanizing various agricultural tasks.

Some of the more striking results have been in the area of improving the productivity of labour by better use of animal traction. For example, the Multibarra, which is a simple tool frame to which a variety of tools, such as a plough, ridger, cultivator and seeder, can be attached. Another multipurpose animal-drawn tool is the Yunticultor, based on a design contributed by the National Institute of Agricultural Engineering in Britain and similar to the French Tropicultor.

Other technologies that have met with success are a disc harrow, equipment for no-till sowing, threshers of various crops, including broom sorghum, maize and beans among others, nixtamal milling for tortilla dough, etc. In addition work is carried out to utilize better natural resources (such as wind and water), and examples are wind mills, simple pumps and hydraulic rams.

In collaboration with other national programmes, research is being directed towards, for example, evaluation of cassava harvesters and planters, and the design of cassava chippers for sun drying the crop.

Considering that more than 30 % of the agricultural land in Mexico is prepared with animal power, using oxen and mules, the technolgies of improved animal-drawn equipment generated and evaluated by the Agricultural Engineering Research Progamme, are likely to have considerable impact on the problems of mechanization, especially in the south of the country.

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L'Expérience argentine en mécanisation agricole

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L'INDUSTRIE DES MACHINES AGRICOLES EN ARGENTINE

Les antécédents

L'industrie argentine des machines agricoles a réalisé un long parcours dans le pays, jusqu'à nos jours. La première industrie s'est installée (à Esperanza, provence de Santa Fé) en 1978. En 1900 on a commencé à produire de différents accessoires; en 1920 on a initié la fabrication de moissonneuses et de rouleaux, en 1925 on a construit déjà dans le pays les moissonneuses remorquées, partant d'une technologie développée en Argentine, auparavant pour les batteuses, en 1930 on a construit la première moissonneuse automotrice du monde. En 1936/38 on a fabriqué la moissonneuse automotrice à plate-forme avec coupure centrale, tel qu'on connait actuellement dans le monde entier. Pendant la Deuxième Guerre Mondiale l'industrie de machines agricoles commence à satisfaire la totalité de nécessités on producteur agrarien argentin, jusqu'à maintenant. En 1951 on fabrique le premier équipement de récolte de maïs dans le monde, applicable à ces moissonneuses. D'autres fabriques étrangères célèbres ont profité (du variant de vitess pour les moissonneuses, etc.), ce qui démontre sa réelle importance.

Les caractéristiques principales

Les dimensions des 190 entreprises relevées par la Commission pour le Développement des Machines Agricoles (CODEMA) sont données dans Tableau 1.

Comme on a déjà exprimé, l'industrie argentine de machines agricoles, satisfait presque à toutes les nécessités du producteur agraire, depuis le labourage, le semis et son traitement, jusqu'au moment de la récolte, le transport et le soin envers le grain, le fanage, le magasinage, etc.

Cet essemble se compose de produits adaptés à de différentes pétitions, accordés à de différents zones du pays (les conditions topographiques, pluvieuses, climatiques, la classe de culture, l'extension des terrains). On peut dire que les produits fabriqués en Argentine, sont les suivant:

- le labourage (charrues, herses, rouleaux, etc.);
- le semis (du grain fin, du grain gros, des combinés, on coton, pneuma-

Tableau 1. Dimensions des 190 entreprises des machines agricoles en Argentine.

Personnel employé (nombre de personnes)	Pourcentage d'entreprises (%)
moins de 5	7
6 - 10	10
11 - 25	28
26 - 50	27
51 - 100	14
101 - 200	9
plus de 200	5
total	100

tique, labourage minimum, etc.);

- la récolte (des moissonneuses-battage de grains, des moissonneuses-battage de canne à sucre, des moissonneuses-battage d'arachide, des moissonneuses-battage de foin (les matériels de ramassage, ramasseuses-presses, faucheuse);
- le transport (des élévateurs, des chariots agricoles, des remorques agraires, etc.);
- le traitement du grain et du fanage (des moulins, des machines à ramasser le foin, séchoir à grain, etc.);
- le magasinage (des silos, des hangars, etc.);
- des parties (des plates-formes pour moissonnage-battage céréale, maïs, soja, etc., des pelleteuses-chargeuses, des charrues à socs, des charrues à disques, etc.);
- d'autres (matériel de sevrage mécanique).

Les fabriques se trouvent surtout (à l'intérieur du pays) dans les villages, avec quarante-mille habitants pas plus, les voilà: Santa Fé, Buenos Aires, Tucumán, La Pampa, et dans d'autres provences: Mendoza, Salta, etc. Les provences de Santa Fé, Córdoba et Buenos Aires réunent plus de 90 % de la production de machines agricoles.

Commercialisation

Les systèmes de commercialisation utilisés dans le pays ce sont ceux-la:

- le 35 % des entreprises commerce directement leurs produits;
- le 34 % des entreprises commerce à travers un réseau de distributeurs;
- le 31 % des entreprises commerce en utilisant les deux formes.

En le qui concerne les résultats satisfaisants de leurs ventes dans le pays, la situation est la suivante:

- le 50 % des entreprises vendent leurs produits dans la région même;
- le 44 % des entreprises vendent leurs produits dans tout le pays.

Par rapport au commerce extérieur, le 33 % des entreprises exporte. Les exportations ont commercé surtout à la décade du 60, avec la pénétration dans les supermarchés latin-américains. Pendant la décade de 1970, on exportait des machines agricoles et on a commencé aussi à vendre la technologie et à réaliser des investissements de production, surtout dans les pays latin-américains. Dernièrement, pendant la décade de 80, on a réalisé des opérations importantes dans d'autres pays, particulièrement dans les pays africains. Les principaux marchés servis dans les dernières années ont été la Bolivie, le Brésil, la Colombie, Costa Rica, Cuba, le Chili, L'Equateur, le Guatemala, le Méxique, le Paraguay, le Pérou, la République Dominicaines, L'Uruguay et le Vénézuela. On a fait aussi quelques incursions sur les marchés des pays développés (Etats-Unis, Canada, Italie, etc.) Seulement dans les positions NAB 84-24 et 84-25 (2) on a réalisé des exportations annuelles supérieures aux valeurs de US$ 15 000 000 et probablement certaines augmentations à partir de l'an 1982 (84-24: des machines et des appareils agricoles, des légumes pour la préparation et pour le travail de la terre et pour la culture de celle-là; 84-25: les moissonneuses pour le fanage).

L'importance des machines agricoles en Argentine n'a pas été grande, à l'exception des années 1977/1981, où on a importé à peu près la valeur de US$ 18 000 000 (position NAB 84-24 et 84-25), et tende à diminuer. Cette somme représente un pourcentage relativement bas par rapport à la production national.

Possibilités de l'apport technologique

Le développement de la technologie en elle même, souvent patenté en Argentine et aussi à l'exterieur, a eu comme conséquence le permis étranger de travail de très peu de fabriques (7 %). Dans ce sens l'industrie argentine de machines agricoles est dans les conditions de satisfaire aux marchés externes qui demandent une technologie intermediaire, du aux caractéristiques de leurs produits (plus grand durée, moins de satisfaction, plus résistance au fort soin des équipements, etc.) et à l'expérience sur le terrain (learning-by-doing) sur les produits et sur le processus, capable d'être transmise dans des conditions accessibles dans des marchés pareils au moins sofistiqués. Le rapport qualité, durée et prix, et en plus la capacité d'adaptation aux échelles de production réduites, et encore des caractéristiques semblables par rapport au maniement des entreprises, les conditions culturelles, etc. A donc obtenu, la vente de la technologie et du développement de l'ensemble d'entreprise en Bolivie, au Brésil, en Colombie, au Vénézuela, etc.

Commercialisation des machines agricoles argentines

Les ventes des machines agricoles (excepté les tracteurs) atteindaient en 1982 6 236 unités (les tracteurs: 2 806). L'évolution du parking de tracteurs (production national, total d'unités) montre:

- 1960: 99 580;
- 1970: 124 702;
- 1980: 141 702;
- 1981: 129 460;
- 1982: 118 110.

EXTENSION ET CAPACITÉ DES MACHINES AGRICOLES

L' importance de l'extension des machines agricoles

L'évolution de l'industrie des machines agricoles pendant les dernières années, une idée du progrès de la grande variété des machines offertes par cette industrie, a été extraordinaire. Comme résultat de cette évolution on a intégré au champ argentin des différents sortes de machines agricoles nationales et importées. Cette incorporation massive de machines agricoles, au champ, a demandé aux producteurs, un besoin urgent de capacité technique, surtout rapporté au bon usage et à la manutention de les machines.

L'action développée

Dans la République Argentine cette action s'est effectuée à travers les entités officielles en privées. Dans la zone officielle on peut dire que la plus grande activité a été organisée et développée par l'Institut National de Technologie Agricole et d'Elevage (INTA), institution qui en 1958 a commencé à développer une tâche d'extension destinée au producteur agricole en général. Cette tâche, nomée 'Cours pour ceux qui conduisent les tracteurs', s'est donné avec la collaboration des usines qui fabriquent des tracteurs et des machines agricoles. L'objectif pratique des cours était celui de capaciter et d'apprendre à ceux qui avaient vraiment la possibilité à la responsabilité du maniement, de l'utilisation et de la manutention correcte du tracteur et des machine dans les différents travaux agricoles. Les cours ont été dictés dans toutes les zones agricoles de la République Argentine, pendant, presque 2 semaines, on ajoutait un programme théorique-pratique sur la thématique mentionnée avant.

Depuis 1979, un préliminaire étude et une évaluation de ce qu'on avait déjà fait jusqu'à ce moment-là en extension, on réalise à l'INTA cours de capacité destinés à ceux qui avaient un niveau professionnel, sans laisser du coté le producteur agraire. Le Département d'Ingéniérie Rurale s'est chargé des cours fondés sur les thèmes suivantes:

- des tracteurs agricoles;
- des machines pour le labourage;
- des machines pour le semis;
- des machines pour la défense de cultures;
- des moissonneuses.

On a considéré convenable effectuer cette nouvelle méthodologie dans les cours qui ne demandent que 2 ou 3 jours. On a dédié la première partie à la capacité théorique sur la base d'un matériel correct d'appui, et la deuxième partie à pratiquer les connaissances acquises. On peut dire que les différents niveaux satisfaisants, sont les suivants:

- les universités;
- les Associations de Professionelles;
- les écoles agricoles;
- les techniciens, des entités nationales et de provences;
- les professionnels indépendants;
- les producteurs et les chauffeurs de tracteurs en activité.

Alors, voilà les cours disposés:

Cours effectués dès 1958 à 1978: nombre de cours: 243;
nombre d'assistants: 8 502.

Cours effectués dès 1979 à 1982: nombre de cours: 161;
nombre d'assistants: 6 310.

Après avoir du les résultats obtenus à travers l'application de la méthodologie remarquée dans le dernier paragraphe, on a unité de différents travaux, basés sur l'application antérieurement appelé 'système d'appui dans la mècanisation'. On prétend organisé, par rapport à l'extension ce qui pourrait être la dernière chaine relative aux objectifs originaux, cela veut dire transférer à travers le service d'extension et du INTA, aux producteurs, les connaissances primaires sur des thèmes déjà soulignés.

La particularité de cette tâche, c'est celle-ci de choisir dans l'intuition, les professionnels, naturellement liés au sujet. Ceux-là après un entraînement apprendront aux producteurs les connaissances nécessaires, pour qu'ils la développent sur le terrain.

Dans l'activité officielle, mais hors INTA, on peut dire qu'on a parlé de la capacité sur le niveau du producteur, et à ce qui concerne la mécanisation agricole, d'autres institutions, telles comme le ministère d'affaires agraires de provinces et les universités.

Dans la zone privée de la République Argentine la capacité en ce qui concerne les machines agricoles, s'est fondée sur les cours organisés par des fabricants de tracteurs et des machines. Les cours, dans lesquels le but est de réussir la capacité de leur personnel, aussi que la capacité du producteur agrarien, on peut juxtaposer le schema de travail:

- la capacité technique-commercial du personnel de l'entreprise;
- la capacité de techniciens d'agences concessionnaires;
- les services de post-ventes aux usagers;
- les démonstrations de la vente et de présentation de nouveaux produits.

Non seulement le travail de capacité réalisé par les entreprises individuellement méritent détacher les activités effectués par des différents groupes de professionels.

ESSAIS ET ADAPTATION DES MACHINES AGRICOLES

Introduction

Il y a dans la mécanisation agricole deux activités qui sont de très grandes importance:

- les essais des machines agricoles, pourque à travers ces essais on puisse réunir une connaissance de leurs capacités d'usage;
- le travail d'extension, pour montrer à l'usager les résultats des essais réalisés.

Quand on sait que les essais ont par but à déterminer comment travailler, les caractéristiques positives et les inconvénients des machines agricoles, on suppose que quand on les soumit à une série d'études méthodiques le plus proche possible durée caractéristique d'utilisation, après quelques jours de travail contrôlé, les caractéristique manifestéront tout de suite leurs caractéristiques mécaniques et la disposition de l'équipe. Cela veut dire que le moyen d'évacuation sert à développer avec exactitude et les utiliser pour disposer des certains renseignements, comme par exemple la capacité opérationnelle, la puissance exigée, la durée des composés, etc.

On doit penser qu'étant donné que les fabricants des machines agricoles s'inquiètent à cause du développement de nouveaux appareils ou de l'actualisation de ceux qu'il y avaient déjà pour servir à une grande demande, et par consequence, une augmentation dans la compétence du marche, on se demande avec la même gravité la possibilité d'organiser une étape dans le processus à laquelle on appelle expérimentation, qui n'étant pas variable, arrive à la perfection des machines, et puisqu'elle a corrigé les inévitables défauts manifestés par les études pratiques, qui conduisent à disposer des machines capables de travailler de plus en plus sûrement, avec efficacité et économie. En plus, le producteur agricole actuel prend de plus en plus conscience de la fonction d'entrepreneur avec les responsabilités que sur le point de vue économique, provoqué par cette fonction, l'une de ses principales préoccupations c'est le choix des machines, les plus convenables deviennent de plus en plus difficile à cause de coûts, de l'augmentation et de la complexité mécanique. On ne peut pas exiger au producteur la connaissance de chaque sorte de machine et non plus la connaissance mécanique de plusieurs machines, qui lui permet de les juger rapidement.

Objectif des essaies

On sait que la réalisation d'essais de machines agricoles doit avoir utilité pratique, soit pour l'usager, soit pour le fabricant, un essai des machines doit avoir les caractéristiques suivantes:

1. Pouvoir donner à l'usager des informations techniques essentielles de son intérêt.
2. Les déterminations doivent se réaliser à côté d'un rigueur scientifique,

pour lequel on doit compter sur le personnel qualifié et sur les appareils convenables.

3. Les essais doivent être appliqués à différents machines, ça veut dire, leurs résultats doivent être appliqués à différents machines, doivent être comparables (cette condition relativement facile à effectuer dans les essais de laboratoire, constitue un obstacle pour la normalisation d'essais des machines qui doivent être essayées dans le champ).

Cela suppose établer une politique d'expérimentation et de développement de nouvelles classes de machines, chargées aux entités officielles avec la collaboration des entreprises privées. Mais o vent que les résultats obtenus ne soient pas des déductions extraites de simples démonstrations des appareils, mais au contraire, des informations précises et controlées sur les caractéristiques du travail, des machines doivent être envisagées et effectuées pour établir une sorte de norme d'essaie pour les machines dont les résultats semblent être les plus utiles, soit pour le producteur, soit pour le fabricant. La tâche n'est pas facile, étant donné que dans chaque cas, on prétend l'active participation des techniciens de différents entreprise qui fabriquent, comme par exemple d'autres techniciens de cette spécialité, professionnel dans plusieurs facultés ou dans les associations de producteurs.

Protocole et normes d'essais

Pour établir un protocole d'essai, el a fallu faire très attention, on a dû analyser profondément la conception, pour savoir quand on devait appliquer à toutes les machines du même modèle, et el ne fallait pas introduire des importants modifications, les résultats des essais des machines pareilles, devaient être comparables. Le protocole d'essai doit inclure:

- les déterminations à réaliser;
- les conditions dans lesquelles ces déterminations doivent se réaliser;
- l'instrument à utiliser et la précision des résultats, possibles à obtenir avec ces;
- la présentation de ces résultats.

Ces protocoles sont élaborés, basés sur les renseignements des professionels et techniciens de l'Institut National de Technologie Agricole et d'Elevage (INTA), de l'Institut National de Technologie Industrielle (INTI), et des entreprises des fabricant de machines agricoles. Dans une étape postérieure, on accorde techniquement et une fois vérifiée la posibilité de son application, on transforme à project de normes d'essais, en permettant le développement des tâches.

Développement de l'essai

- connaissance organique de la machine;
- réussite de l'essai;
- étude fonctionnel;

- facilité de l'opération de la machine;
- historie mécanique;
- des avertissements au producteur;
- les dernières conslusions.

Essais effectués dans notre pays

Il n'y a pas longtemps le plus grand travail a été réalisé sur les tracteurs, et il y avait très peu d'essais dédiés aux machines agricoles. Les premiers tracteurs ont commencé à essayer il y a plus de 30 ans. On avait analysé jusqu'à maintenant 325 modèles différents. On a conservé dans le Centre d'Essais du Département d'Ingéniérie Rurale du INTA, tous les antécédents catalogués selon la marque, le modèle, l'an d'exécution des essais, etc.

A partir de 1977, ce Département a réalisé beaucoup de réunions avec la participation de techniciens des firmes qui fabriquaient les tracteurs du pays et a adopté pour réaliser les essais de tracteurs de Norme IRAM No 8005; cette norme a été appliquée depuis cette date. La norme a été orientée sur la base du code normalisé et sur la cédule d'essai de l'Organisation Européenne de Coopération Economique (OECD) pour les tracteurs agricoles.

Par rapport à d'autres machines agricoles le panorama est plus complexe, étant donné que les antécédents sont rares et l'exploitation est très limitée. Pour les machines, surtout les semoirs pulvérisatrices et les moissonneuses, on a utilisé les normes d'essai acceptés par les groupes de travail déja remarqués.

Diffusion des résultats

Une fois fini l'essais et compilé l'information obtenue, on la met sur la cédule d'essai, elle est accompagnée par des taux qualitatives et quantitatives, alors on donne au fabricant la machine essayée.

On a commencé la publication de bulletins d'essai, ces bulletins financiés par les fabricants, prétendent être au même un instrument de travail pour les spécialistes du thème. Le but des essais est celui de donner les renseignements nécessaires au producteur. Les bulletins d'essai sont envoyés aux entités officielles, coopératives et societés rurales, groupes de producteurs, etc. On est en train d'activer la préparation des résumés destinés à la presse agricole pourque l'information arrive tout de suite au producteur, qui lorsqu'il s'intéressé à l'utilisation de certaines machines, il demandera les bulletins correspondants.

Adaptation et dessin des machines agricoles en Argentine

On a concrétisé cette adaptation à travers le renseignement de techniques abordées dans les essais où on a figé des règles qui ne font pas seulement référence à des critères constructifs, mais aussi à des critères référents à l'utilisation des machines mêmes. Voilà quelques adaptations:

- Des appareils pour réaliser le semis simultané de gros grains mis dans la machine de boyer, qui remplacent à celles de semoins de gros grain.
- Des tubes de déchargement laterales (patentées), qui permettent le semis a grande vitesse avec un beau dégré de régularisation de distribution.
- Des appareils à doser à disques plans, pour les légumes (patentés) ils assurent le semis de ces grains en jaillissement, et ne pas rompre les téguments.
- Monotolva (une seule boîte pour les semailles) (patentées) dessin qui augmente l'autonomie on semis, diminue le poids qu'influence sur les courants on sillon profond constamment, indépendant du consomme de semailles.
- Les appareils, les semoirs de grain fin, adaptés aux semoins de gros grain, qui permettent le profit intensif de cette machine pendant les cultives, soit en hiver, soit en été.
- Charrue broyer à cercles avec 'zafe' de sécurité dans les arcs, devant un système hydro-pneumatique. Avec cet appareil on donne une indication importante aux systèmes de 'zafe' qui existent déjà (dans tous les cas, ils étaient mécaniques), offrant à l'usager des facilités à l'opération plus efficaceté, moins consommation.
- Adaptation de plate-formes pour soja avec une barre copieuse flexible et bouée, avec une boîte de mouvement tout droit pour actionner la barre de tranche et avec un molinet à points rigides dans la même direction.
- Une plate-forme pour moissonneuse-batteuse pour le maïs de 5-10 sillons profonds, adaptés à n'importe quelle sorte de moissonneuse d'industrie national et importée.
- Une plate-forme pour moissonneuse-batteuse pour le sorghum de 5-6 sillons profonds, adaptés à n'importe quelle sorte d'industrie national et importée.
- Une plate-forme moissonneuse-batteuse pour tournesol de 7-10 sillons profonds à 70 cm, adaptés à n'importe quelle sorte d'industrie national et importée.
- Une plate-forme moissonneuse-battuese pour soja de 5-7 sillons profonds à 70 cm, adaptés à n'importe quelle sorte d'industrie national et importée.
- Un système de double caméra de broiement pour les moulins à marteaux.
- Un système d'alimentation automatique de balles pour les moulins à marteaux.
- Un système mouvementé par l'action hydraulique pour extraire le fanage ensilé.
- Un système de coupure pour la moissonneuse de fanage de précision.
- Un système de coupure et broyer pour la culture de la machine à plusieurs cultures de canne à sucre.
- Un système de mécanisme pour charger et décharger les pelles pour le mouvement du sol.

CODEMA: UNE EXPÉRIENCE DE COOPÉRATION ENTRE L'INDUSTRIE ET LES ENTITÉS OFFICIELLES

Les antécédents

On doit mettre en relief que CODEMA est né par l'initiative du secteur privé, qui a cherché l'appui à travers le travail de groupe avec les institutions officielles, pour fortifier son développement pour améliorer et récupérer sa position dans le marche mondial des machines agricoles: on constitue en décembre de 1978, CODEMA (Commission pour le Développement des Machines Agricoles).

Objectifs et organisation de CODEMA

Dans la réunion réalisée on a défini comme objectif de CODEMA: celui de diffuser le développement des machines agricoles Argentines dans ses différents aspects. L'organisation comprend le comité directif, un secrétariat et les sous-commissions techniques.

Le comité directif est le responsable de planifier, de diriger et de contrôler les activités de CODEMA. Le comité directif est intégré par un réprésentant de chaque caméra de fabricant des machines agricoles: Caméra de Fabricants de Buenos Aires et Caméra de Fabricant de Rosario, AFAMAC et AFAC, un représentant de l'Institut National de Technologie Agricole et d'Élevage (INTA), et un représentant de l'Institut National de Technologie Industrielle (INTI).

Les fonctions des sous-commissions techniques sont:

- préparer les plans de travail pour le développement;
- proposer la création de groupes de travail dédiés aux thèmes spécifiques, quand on les considère convenable;
- proposer au comité directif l'approbation des travaux réalisés par les différents groupes avec les avertissements opportuns.

Les représentants des entités intéressés aux thèmes à développer, peuvent faire partie des sous-commissions.

Les fonctions du secrétariat sont:

- faire partie des réunions au comité directif et des sous-commissions techniques et préparer les actes des réunions;
- préparer son aide aux activités que organise CODEMA;
- coordonner les réunions techniques de CODEMA, comme représentants du comité directif.

Réalisations

On peut grouper les principales réalisations de CODEMA au cours de 4 ans:

- les protocoles d'essais;
- les réunions techniques;
- les études et les travaux;

- les bulletins CODEMA;
- d'autres reálisations.

La fonction de protocoles d'essais, élaborés à CODEMA, est celui de connaître objectivement les caractéristiques fonctionnelles, la capacité de travail et l'efficacité des machines à essayer. Maintenant cinq Normes ont été rédigées; elles correspondent à:

- semoirs de grains fins;
- semoirs de gros grain;
- becs pulvérisateurs;
- machines pulvérisatrices à rampes;
- équipements fertilisants attelables aux semoirs.

Le but principal des réunions techniques est celui de communiquer aux entités de participer dans les activités de CODEMA, ainsi comme faire la propagation de connaissances, ce qui intéressent aux machines agricoles. On organise à peu près 3 et 5 réunions par an, où des techniciens relationés avec le thème des machines agricoles y participent. Ces réunions se réalisent alternativement dans différents villes dy pays pour faciliter la participation des intéressés. En général, ces réunions, sont divisés en deux parties. La première partie a pour but présicer les informations des sous-commissions, de groupes de travail sur la démarche de leur travaux, les prochaines activités et la diffusion des nouvelles pour les fabricants des machines agricoles. Dans la deuxième partie, on développe des thèmes techniques; on invite des experts des différents spécialités relative aux machines agricoles.

Au milieu de l'année 1980 la publication d'un bulletin, édité par le secrétariat de CODEMA, a été récidé. Il apparaît sans périodes fixes, afin d'informer sur la marche des travaux et des activités réalisés à CODEMA et de diffuser les nouvelles et les thèmes technolgiques d'intéret au fabricants de machines agricoles, et en général, pour tous les institutions et personnes intérésses, appartenants, au secteur.

D'autres réalisations sont:

- L'étude sur le secteur industriel des machines agricoles, afin d'établir son évolution, sa capacité, ses caractéristiques, et de connaître ses expectatives et ses besoins. L'étude s'est basé sur les renseignements fournis par 190 entreprise, qui représentaient plus de 80 % sur le total du chiffre de ventes du secteur.
- Mécanisation de la culture d'arachide (Archis hypogaea). Ce travail, qui se developpe coordonné par des techniciens de la Station Expérimentale du INTA, à Manfredi, insère l'adaptation d'équipements existants et l'étude de différents alternatives avec l'évolution du produit, finalement obtenu pour proposer un nouvel système de culture.
- Les démonstrations 'dans le champ' des machines agricoles.

Present state of Brazilian agricultural mechanisation

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In a modern sense, agricultural mechanization in Brazil started rather recently, right after the Second World War, and was stimulated by a great number of imported tractor models. The manufacture of tractors in Brazil was supported by the Farm Tractor Industry National Plan and became effective only in the early sixties, following the implementation of the Brazilian automotive industry.

The establishment of a subsector of machines and implements, as well as other farm equipments, primarily based on national capital (95 %) and technology, preceded and was developed parallelly to the tractor and harvester manufacture, which was implemented and developed predominantly with foreign capital (95 %) and technology. While the first subsector presently consists of over 400 enterprises (generally small-sized), the tractor and self-propelled harvester subsector, consists of a small number of enterprises, with about 80 % of the production concentrated around three manufacturers.

With 37 units produced in 1960 and 11 018 in 1963, the tractor industry maintained this level of production up to 1969. From 1969 to 1976, an annual average growth rate of 30 % was experienced by the sector, reaching 75 121 units yearly. From 1976 on, the sector presented a declining trend, with a major fall (-32,6 %) occuring during the period 1980-1981, reaching about 26 000 units in 1983, thus returning to the production level reached in 1971. In 23 years, the total accumulated Brazilian tractor production has reached 775 000 units, as compared to the existence of almost 5 million farms in Brazil (Table 1 and 2).

Governmental action offered national and foreign financing incentives, including a concern related to nationalization indexes, with a view to developing an industrial production of farm machinery. Besides, emphasis was also given aiming at the execution of compulsory testing, as foreseen in the Farm Tractor Industry National Plan, since 1959.

However, intensification of testing became effective only during 1979, with support from INMETRO, National Institute of Meteorology, Standards and Industrial Quality, firmly stressed during 1980-1981 with a joint effort developed by the Ministry of Industry and Commerce (MIC) through its Indus-

Table 1. The manufacture of tractors in Brazil, 1960-1983.
Source: SINFAVEA/CDI.

Years	Wheel-tractors	Motocultivators	Crawler-tractors	Total
1960	37	-	-	37
1961	1 679	-	-	1 679
1962	7 586	-	-	7 586
1963	9 908	1 110	-	11 018
1964	11 537	1 915	-	13 452
1965	8 401	2 153	-	10 554
1966	9 360	3 216	13	12 489
1967	6 295	2 500	73	8 868
1968	9 819	3 613	106	13 538
1969	9 882	1 966	91	11 939
1970	14 457	2 065	185	16 707
1971	22 557	2 190	770	25 517
1972	30 224	2 911	1 299	34 434
1973	39 232	3 348	1 961	44 541
1974	46 841	5 409	2 678	54 928
1975	59 161	5 620	3 824	68 605
1976	65 310	5 315	4 496	75 121
1977	53 161	5 161	3 514	61 836
1978	48 673	5 497	3 058	57 228
1979	54 996	6 062	3 202	64 260
1980	58 325	6 896	4 285	69 506
1981	39 341	4 548	3 133	47 .022
1982	30 346	5 364	1 900	37 610
1983*	22 029	3 278	718	26 025
total	659 157	80 137	35 306	774 600

* The December 1983 production was estimated considering the monthly average production from January to November 1983.

trial Technology Secretariat (STI), Industrial Development Council (CDI), and Ministry of Agriculture (MA) through the National Centre of Agricultural Engineering (CENEA). Quite recently, MIC and MA have been considering the necessary steps to extend compulsory testing to other farm implements, mainly primary and secondary tillage equipment, with a view also minimizing energy consumption. Nevertheless, it is intended to extend compulsory testing to all farm machinery and equipment used in Brazilian agriculture, as a policy of the ministry of agriculture.

With this objective in mind, considerable efforts are being developed to improve and enlarge CENEA's laboratories and actions in order to cope with the demand for testing of farm machinery and equipment industry.

Since the establishment of the tractor industry until recently, governmental policies for agriculture were based on subsidized agricultural credit, by means of a real negative interest rate. This policy, in the view of some experts, has been responsible for an artificial demand for farm machinery and implements, resulting in an over-dimensioning of the tractor industry production capacity. The Brazilian government has recently withdrawn subsidies of rural credit and limited the financing ceiling not to

Table 2. Annual growth rate of the Brazilian manufacture of tractors, 1960-1983. Source: SINFAVEA/CDI.

Period	Wheel-tractors	Motocultivators	Crawler-	Total tractors
1960/1961	4 437.84	-	-	4 437.84
1961/1962	351.82	-	-	351.82
1962/1963	30.61	-	-	45.24
1963/1964	16.44	72.52	-	22.09
1964/1965	-27.18	12.43	-	-21.54
1965/1966	11.42	49.37	-	18.33
1966/1967	-32.75	-22,26	461.54	-28.99
1967/1968	55.98	44.52	45.21	52.66
1968/1969	0.64	-45.59	-14.15	-11.81
1969/1970	46.30	5.04	103.30	39.94
1970/1971	56.03	6.05	316.22	52.73
1971/1972	33.99	32.92	68.70	34.95
1972/1973	29.80	15.05	50.96	29.35
1973/1974	19.39	61.56	36.56	23.32
1974/1975	26.30	3.90	42.79	24.90
1975/1976	10.39	-5.43	17.57	9.50
1976/1977	-18.60	-2.90	-21.84	-17.68
1977/1978	- 8.44	6.51	-12.98	- 7.45
1978/1979	12.99	10.28	4.71	12.29
1979/1980	6.05	13.76	33.82	8.16
1980/1981	-32.55	-34.05	-26.88	-32.35
1981/1982	-22.86	17.94	-39.36	-20.02
1982/1983*	-27.41	-38.89	-62.21	-30.80

* Considering the production of December 1983 estimated by the monthly average of January to November 1983.

exceed 25 % of the selling price of wheel tractors and 10 % of the same value of self-propelled harvesters. Up to this moment no other policy has been implemented by the government in substitution to subsidized agricultural credit.

With solid investments to meet projections contained in governmental plans, the farm tractor and implement industry began to face problems after 1976. Although most of these difficulties have been attributed only to frequent changes in agricultural policies, they deserve to be fully investigated as preliminary results of studies being carried out at CENEA indicate. As an institution, nowadays CENEA aims at proceeding with agricultural mechanization studies, taking into consideration the need for a harmonic industrial and rural technological development, so as to meet the real needs of Brazilian agriculture.

As a function of a demand originated by agricultural credit policy, farm mechanization industry oriented its investment, as well as the design of manufactured units, to serve mainly large farmholds. Considering that farms with up to 200 ha represent 95 % of Brazilian farmholds, and that they are responsible for 70 % of the production of staple foods, vegetables and industrial transformation products (raw material) (Table 3), a significant utilization of machinery and tractors in the operation of these farms would

Table 3. Farmholds according to the nature of its agricultural production; Brazil, 1972 (accumulated percentages). Source: INCRA. Estatisticas Cadastrais 2, 1976.

Total area (ha)	Total area	Area harvested with			Area exploited wit plant and/or fores extraction
		staple foods	industrial raw material	vegetables fruits	
less than 10	1.3	8.1	5.0	10.8	0.6
10 - 50	10.8	43.9	38.4	43.4	5.9
50 - 100	17.5	58.0	51.5	56.8	9.6
100 - 200	25.6	70.3	63.5	68.4	14.4
200 - 500	38.6	83.1	78.5	81.8	23.0
500 - 1 000	48.6	89.8	87.4	88.8	31.4
1 000 - 10 000	80.9	99.0	99.1	98.9	66.0
10 000 and over	100.0	100.0	100.0	100.0	100.0

be expected. However, the fact that 96 % of these size of farms do not own a tractor is outstanding (Table 4, 5 and 6). Even though the situation is different in farms with over 200 ha, still 77 % of these farms do not have a tractor. Besides, only 4 % of total number of Brazilian farms do have a tractor.

Farmholds with total area under 200 ha have an average cropping area that equals to 9 ha. Therefore, in general, Brazilian farms present relatively small cropping areas, where production is carried out mainly by human or animal power. This leads to very low labour productivity rates, which, in the medium term, affects production considerably.

The cropping-livestock enterprises with area under 200 ha hold 60 % of the total number of tractors utilized in Brazilian farming. Of all tractors between 50 to 100 hp and those above 100 hp utilized in this country, 55 % and 28 %, respectively, are working in these farms (Table 7). This demonstrates the occurrence of a significant utilization of medium-size and large tractors on these farms. Considering the average cropping area per tractor on these farms, in the order of 4,6 ha, there is, as a consequence,

Table 4. Synthesis of some characteristics of farms in Brazil. Source: FIBGE, Censo Agropecuário, Brazil, 1979.

Characteristics	Farms with less than 200 ha	Farms with 200 ha or more	Total
number of farms (%)	95.0	5.0	100.0
total area of farms (%)	25.6	74.4	100.0
total cropping area (%)	66.6	33.4	100.0
farm with tractors (%)	3.4	22.9	4.3
average cropping area on farms (ha)	9.0	93.3	12.9
cropping area per tractor on farms with tractor (ha/tractor)	4.6	24.0	5.4

Table 5. *Cropping-livestock farms with tractors and total area of farms and crops per tractor* and per groups of cropping-livestock farm areas, Brazil 1975 (percentage). Source: FIBGE, Censo Agropecuário, Brazil 1979.

Total area (ha) Groups of cropping-livestock farms	Number of farms with tractors divided by total farms	Total area of farms divided by total number of tractors	Total cropping area divided by total number of tractors	Total cropping area of farms with tractors* divided by total number of tractors
less than 10	0.57	542.27	352.18	2.01
10 - 50	5.22	390.24	129.57	6.76
50 - 100	10.09	540.23	101.91	10.28
100 - 200	11.72	759.54	104.03	12.19
200 - 500	18.34	917.14	100.56	18.44
500 - 1 000	26.13	1 189.89	106.20	27.75
1 000 - 10 000	34.99	2 218.12	106.27	37.18
10 000 and over	57.53	10 072.39	122.39	70.41

* Estimated considering that farms with and without tractors have the same average cropping area in the respective total area.

Table 6. Distribution of number, area and average area of cropping-livestock farms, Brazil 1975. Source: FIBGE, Censo Agropecuário, Brazil 1979.

Total area (ha) Groups of cropping-livestock farms	Number of farms (%)	Average cropping area (ha)	Cropping area of farms (%)
less than 10	52.16	3.68	14.58
10 - 50	30.97	11.02	29.38
50 - 100	7.10	20.58	11.69
100 - 200	4.75	30.09	10.91
200 - 500	3.14	57.60	13.11
500 - 1 000	1.05	107.53	8.08
1 000 - 10 000	0.79	205.53	10.76
10 000 and over	0.04	929.22	1.49
total	*100.00*	*12.86*	*100.00*

Table 7. Distribution of tractors per power and per total area group of farms, Brazil 1975 (percentage). Source: FIBGE, Censo Agropecuário, Brazil 1979.

Total area (ha) Groups of farms	Tractor power (hp)				
	<10	10-50	50-100	≥100	total
less than 10	24.91	6.71	2.05	1.07	5,13
10 - 50	46.28	36.36	23.88	8.07	28.08
50 - 100	10.03	15.12	15.10	7.49	14.20
100 - 200	5.89	12.59	14.35	11.44	12.98
200 - 500	6.23	13.66	18.29	19.70	16.15
500 - 1 000	3.33	7.22	10.67	15.14	9.42
1 000 - 10 000	3.04	7.69	14.16	30.36	12.54
10 000 and over	0.29	0.65	1.50	6.73	1.50
total	100.00	100.00	100.00	100.00	100.00

a peculiar economic stituation occuring at small and medium-size farms, due to a rather high cost of mechanization, as a result of a high investment and low tractor working hours. This situation is held true also for large farms, in which tractors with power higher than 50 hp are predominant (Table 8) and the average cropping area per tractor is 24 ha (Table 4).

The whole situation as previously discussed, somehow traces the evolution of industrial production and demand for tractors in Brazilian agriculture. During the period 1970-1975, when growth rates in industrial production were high, tractors with power equal to or higher than 100 hp presented the highest increase rate (454 %), followed by tractors with 50 to less than 100 hp (207 %). The group with least increase (7 %) was that of tractors with 10 to less than 50 hp (Table 9). Some studies have detected an average power increase of about 35 % for tractors during the period 1970-1975.

A leading conclusion is that in Brazil small and medium-size farms

Table 8. Distribution of tractors per total area groups of farms and per power, Brazil 1975 (percentage). Source: Censo Agropecuário, Brazil 1979.

Total area (ha) Groups of farms	Tractor power (hp)				
	<10	10-50	50-100	≥100	total
less than 10	40.25	35.09	23.32	1.34	100.00
10 - 50	13.67	34.75	49.73	1.85	100.00
50 - 100	5.85	28.57	62.19	3.39	100.00
100 - 200	3.76	26.00	64.58	5.66	100.00
200 - 500	3.20	22.70	66.26	7.84	100.00
500 - 1 000	2.93	20.54	66.21	10.32	100.00
1 000 - 10 000	2.01	16.45	65.98	15.56	100.00
10 000 and over	1.60	11.52	58.11	28.77	100.00
total	8.29	26.82	58.46	6.43	100.00

Table 9. Evolution in number of tractors according to power in Brazilian agriculture, 1970-1975 (percentage). Source: FIBGE, Censo Agropecuário, Brazil 1975.

Total area (ha) Groups of farms	Tractor power (hp)			
	<10 70/75	10-50 70/75	50-100 70/75	≥100 70/75
less than 10	32.22	9.81	146.68	-11.20
10 - 50	52.57	22.43	312.12	197.51
50 - 100	25.48	7.03	246.59	451.42
100 - 200	19.67	2.32	211.40	623.78
200 - 500	16.57	-7.18	180.48	523.32
500 - 1 000	17.24	-3.55	159.82	601.56
1 000 - 10 000	8.53	-7.99	146.31	547.79
10 000 and over	32.20	5.66	140.34	472.95
total	36.44	7.05	206.84	454.46

constitute an important share of the real market for the agricultural machinery industry. However, this was overlooked, and, as a result, most of the mechanized systems produced by the industry, are either imcomplete or rather over-dimensioned, leading to an unfeasible economic utilization.

Recent government withdrawal of agriculture subsidies will probably lead industry to design mechanized systems so as to meet adequately the requisites of a real demand. This demand will be determined primarily by size and type of farm exploitation, as well as regional agricultural requirements. Furthermore, these systems must be complete so as to attend all the steps involved in the agricultural production process, with special attention to those related to harvest, pre-processing and storage at farm level.

At short and medium run, market expansion needed for future growth of manufacture industry involved in the application of capital goods to Brazilian agriculture, will require deep concern toward the development of these complete agricultural engineering systems, suitable to the regional, multiple and combined activities peculiar to small and medium size farmholds. This must be accomplished without disregard to the improvement of engineering means and technology utilized by large farmholds.

For defining agricultural engineering systems suitable for characteristics peculiar to Brazilian agriculture, in-depth studies on the predominant agricultural production systems must be developed, with the objective of determining the real needs, in technical, social, and economic terms, of the application of agricultural engineering and, specifically, of agricultural mechanization. Such information is essential for the definition of agricultural policies, as well as for planning the growth of the Brazilian agricultural machinery industry.

By 1980, after consolidation of the National Alcohol Programme, created in 1975, a tentative substitution of diesel fuel by ethanol was started in agricultural tractors and engines. Presently, the total number of ethanol-powered tractors in agriculture does not reach 1 000 units, the majority of which are employed in sugar-cane crops, due to typical circumstances. Four tractor manufacturers utilize about four different engines and systems, with power varying from 60 to 100 hp. Fuel consumption of these engines could certainly be minimized, and for some types design characteristics should be adjusted in order to become more adequate for agricultural tasks. The future of ethanol in Brazilian agriculture, presently powered mainly with diesel fuel, will depend, among others, of the following factors:

- ethanol fuel price policy compatible to energy content of other farm fuel;
- up to the moment mostly adaptations of diesel and otto cycle engines are being implemented to operate with ethanol fuel. Manufacturers must design ethanol engines with desirable efficiency and prices competitive to diesel structural engines.

In the last two years CENEA has tested all ethanol-powered tractors put out in Brazilian market, and gathered performance as well as preliminary operational cost data.

Qualified handlabour and operators for the duties of farm mechanization are also becoming a problem. While in the fifties the ministry of agriculture supported many operators training schools, in the sixties all of them had their courses discontinued. This task was attributed to the manufacturers and, for many reasons, it was not maintained at a desirable level during the seventies.

Following to activities already on the way viewing the development of a system of farm machinery and equipment courses, CENEA is attributing priority to its Training Division in order to train machine operators instructors, with participation of the Gesellschaft für Technische Zusammenarbeit (GTZ), of the Federal Republic of Germany.

Agricultural mechanization in Peru

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Lima, Peru

PRESENT STATE OF THE AGRICULTURAL MECHANIZATION IN PERU

Peru has around 2 million ha under cultivation plus around 1 million ha of natural pastures to raise cattle. The area which can be potentially mechanized, covers 60 % of the cultivated land (1 200 000 ha). The remaining 800 000 ha cannot be worked with tractors, due to the slope of more than 20 % of hillside lands that are found in the Andean Mountains. Under these conditions the work is done with animal-drawn implements.

The present quantity of tractors in Peru in operational condition is of around 5 000. Around 70 % is of medium-size, with a power range of 60-90 hp, 5-10 % is of more than 90 hp, and 20-25 % of low power, varying from 30 to 45 or 50 hp. The ratio between the total power used and the amount of land available for tractor work is roughly 0.3 hp/ha. The majority are rubber-tire tractors of the conventional type and 2-wheel drive, although there is an increasing number of 4-wheel drive units being introduced in certain regions.

The most intensive and most productive type of agriculture is in the coast, which is a narrow strip, 30-40 km wide, that is between the Pacific Ocean and the mountains. All of the land of the coast is irrigated with water from the rivers that are formed up in the highlands and come down running to the ocean. These rivers give origin to the valleys that are located along the coast, being separated one from the other by a desert of arid land. All this regions can be satisfactorily worked with tractors, because the soil topography is flat. The tractors do the land preparation work, the planting, the cultivation operations, and pull trailers to carry seeds, fertilizers, pesticides, crop products, etc.

In the case of the harvesting and crop handling operations, the situation is different due to the peculiarities of each crop. In the case of rice, for instance, 25-30 % of the area is harvested with combines, but in the rest the cutting is done by hand in 50 % of the area and then pushed by front loaders with rakes that push the cane to the ends of the fields, where it is lifted by means of cranes that unload it in trucks that carry the cane to the factories. In the other 50 %, all the operation is mechanized by means of the use of push-rakes, that cut and push the cane previously burned, and loaded by cranes to the trucks. The sorghum is harvested with combines and the corn for grain production is also harvested with combines, if the areas are more or less big. In smaller areas, as it is common, it is picked by hand and carried to a corn sheller for the grain separation. The cotton is only picked by hand, and in other crops most of the work is done by hand.

In general, the harvesting operations occupy a lot of hand labour and the mechanization of them has to be carefully considered, both from a social and economic stand point. The replacement of people by machinery could leave many people without work. On the other hand, of course, the cost and the correct operation time have to be taken in consideration.

In the Andean region (the 'sierra') the farmers can afford the purchase of tractors of medium or small size in the case in which they grow potatoes, wheat and barley in important areas. In the hillsides, it is impossible to use tractors, and the farmers have to use animal-drawn implements (for oxen) or even, in some cases, hand-tools of traditional Indian origin. In this region, the tractors are used in no more than 30 % of the area.

The tropical region is the largest of the country. However, the land that can be used for agriculture, is rather small. There is a lot of land suitable for forestry work. The part of the region that can be used for agriculture, may be called subtropical. This is a very important area and has a great future. In the north, there is the zone of the Maranon river and its tributaries, and in the centre, there is the zone of the Huallaga river, in which there is a very important development project of the government under execution. There is a great tendency to the mechanization of the tropical agriculture of these regions of medium humidity (rain of 1-1.20 m per year), in which there is no rain or little rain during 4-6 months, allowing the execution of the farm operations that are proper of crops, like rice, tobacco, sugar-cane, and forage for cattle raising. A certain quantity of tractors between 40 and 70 hp of 4-wheel drive has been introduced in the last years.

PROBLEMS FOR THE DEVELOPMENT OF THE FARM MECHANIZATION

At the present time the main problems for the development of the farm mechanization in Peru are the following ones:

1. The high purchase cost of tractors, farm machinery and capital goods that are required by the farmers due to the great devaluation of the national currency in relation with the foreign currency. At the same time, the high rate of the interest for the financing of the purchases.

It can be mentioned that the World Bank, which is the international banking institution that usually supplies most of the capital for this purpose to the Agrarian Bank of Peru, requires that the rate of interest should be at the commercial level or very close to it. In the case of the International Development Bank (IDB) loans, there is a special concession of charging a lower interest in the case of the farmers of the tropical or subtropical areas. In 1983 the purchases have decreased to the third part of the average quantity sold in a year.

2. The changes that are happening in connection with the ownership of the land, and those that can happen in the near future, have a great influence in the tendency to the type and size of tractors and other machinery that will be required. As a matter of fact, after the Agrarian Reform of 1969 in all the important valleys of the coast, the farms of more than 150 ha and even of more than 100 ha were expropriated and were established cooperatives. In many cases several farms integrated a cooperative, and, as a great area of land had to be worked under the same administration, it was necessary to have several tractors of medium size. Recently, due to a new law, it is possible for the members to decide by majority the parcelation of a cooperative, and that has happened in many cases. This tendency means that for the parcels of 10 to 15 ha tractors of smaller size will be required, and it is also possible that multifarm use schemes will be established either as government 'pools' or cooperative 'pools'.

3. The high cost of maintenance and repair of the tractors and machinery, as well as the lack of a proper financing policy for the repair of the equipment, is another problem of great importance that makes difficult to keep it in fairly good operational conditions.

GOVERNMENT POLICIES

It cannot be said that there is a definite policy of the government with reference to the mechanization of the agriculture at national level. It is not intended to apply a planning policy in the farm mechanization, and the farmers decide freely what they believe is most convenient for them. On the other hand, the development of new zones in the central subtropical region as is the case of the Huallaga and the Pichis-Palcazú zones is an objective of the highest priority at the present time. For the Central Huallaga, the National Service of Farm Mechanization has organized a 'pool' of tractors and machinery to give service to the farmers, both in land clearing and land preparation. For all the tropical regions, the Agrarian Bank gives financing credit lines at a lower rate of interest to promote the purchase of farm machinery and capital goods.

The National Service of Farm Mechanization (SENAMA) has a national pool, prevailingly of land-clearing and land-levelling machinery, as well as grain combines. About two thirds of the tractors are more than ten years old and there is a need for replacement of those units. There is a project for this purpose, but, due to the economic situation, it has been postponed for some time. It is possible that in the near future some policy decisions will be taken in connection to the mechanization of the parcels resulting of the parcelation process of the cooperatives, as well as in the case of the parcels of new development projects, as it is the case of Majes in the south of the country.

TRAINING AND RESEARCH

Training

With reference to the training, there are programmes at three different levels: professional, intermediate for mechanics and technicians, and practical for operators. At professional level, the faculty of agricultural engineering of the National Agrarian University of La Molina, gives the courses on the subjects of the curriculum for bachelor's degree for the future agricultural engineers as well as for the agronomy students. Besides its academical activity, it gives special courses for professionals on specific subjects of an intensive nature in a short time (for instance, 30 days), such as: tractors repair, workshop organization, field work of certain machinery, etc. At intermediate level, the National Service of Industrial Training (SENATI) gives courses on diesel engines, workshop equipment, welding, etc. It is also usual that the farm machinery distributors give courses in maintenance and repair of the equipment that they sell. In the same way, the training at the practical level for operators is given in most cases by the distributors and dealers in different places with the support of the technicians and specialists of manufacturers of the equipment that they sell.

Research

Very little is being done in the country concerning the research on farm mechanization, due to the lack of funds available at the present time. There is a shortage of economic resources for research, in general, at the present time, and the programmes do not give priority to research in farm mechanization. There are no facilities for the testing of farm machinery, and the privat company does very little effort to introduce new equipment, considering the small size of the market.

It would be very important to test equipment that is being applied in the tropical zones of other countries, in order to determine the possibility of its introduction in Peru. This is particularly important in the case of combines of small size that have being designed and are being built in the Asiatic countries for the use of the small farmers.

MANUFACTURE OF FARM MACHINERY AND EQUIPMENT

In Peru, there has been in operation a Tractor Assembly Plant of Massey Ferguson tractors. A company was organized to build and equip the plant on the basis of even parts of the Peruvian government and Massey Ferguson. The operation of the plant lasted ten years, and has been recently closed, due to different problems of economic nature in the national market and the lack of policies to export the tractors to the countries of the Andean market, as it was originally planned.

The government has given the license recently for the assembly of EBRO tractors, but it is still unknown when the plant will start the production. In any case, the production would be small. There is a plant (FIANSA) for the assembly of farm implements, like ploughs, harrows, tool bars, etc. These are small workshops for the production of farm implements and tools. However, the prospects for the development of farm machinery manufacture in the short term, are not encouraging. The main problem is the market, which will continue to be extremely small, until the economic crisis is controlled. It will also be necessary to give incentives to the private capital to invest in the production of farm equipment.

The mechanization of agriculture in Colombia. Historical evolution, present conditions and outlook

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COLOMBIAN ECONOMY AND THE AGRICULTURAL SECTOR

During the past decades, the Colombian economy has experienced a dynamic process which is reflected in a GNP average rate of growth of 5.2 % in the sixties and 6.1 % in the seventies. These high rates of growth have enabled the country to develop from a fairly closed economy to a condition of capably competing in international markets. The vigorous growth of the GNP, and the raise of per capita income over the thousand dollar mark, was largely made possible by expanding exports through a diversification of agricultural products and an increased production of industrial commodities, to which must be added foreign loans obtained in favourable terms. Nevertheless, economical growth has slowed down in the past three years to levels which barely average 1.5 % yearly. This phenomenon is undoubtedly related to the economical crisis of the developed countries, which have caused disturbing effects, such as rising international interest rates and inflation, that, in Colombia's particular case, was made evident in the decline of the main export items (including coffee), and a generalized deterioration of trading terms.

There are also internal causes for this slowdown in Colombia's economy, amongst which must be mentioned a restrictive monetary policy that pressed interest rates to higher levels, deteriorating private investment. Furthermore, this monetary restriction affected sensibly the funds directed to private enterprise, since the government concentrated in public expenditures in order to check the low level of economical activity, whilst accumulating a high fiscal deficit, that in 1983 surpassed 3 % of the GNP.

Colombia's economical recession can then be explained by a low dynamism in the internal and external demand, added to a lack of motivation in the offer. Additionally, in the near future, the economy will face a difficult situation, as a consequence of the growing deficit in its balance of payments, the incidence of the fiscal deficit, and the low margin of its financiation by internal savings. In these circumstances, the way that foreign exchange rates are handled, the import-export policies, foreign debt, and fiscal deficit control, are key elements in Colombia's present junction and will determine, depending on government measures, the recovery of productive activities.

The share of agriculture in the GNP has dropped in the last years; whilst in 1970 it contributed 25.3 %, in 1980 diminished to 22.9 %. Notwithstanding, agriculture remains as the main productive activity of the country, followed by the manufacturing industry and commerce, which contributed in 1980 18.1 % and 17.1 %, respectively.

The growth of the agricultural sector within the GNP was slightly above 5 % between 1970 and 1975, and then descended to about 4 % between 1975 and 1980. In the past three years a downward trend can be observed, to the point that in 1982 the national gross agricultural production diminished approximately 2 % with a slight gain in view for 1983, which will probably not exceed 1 %.

The causes for the stagnation of the agricultural sector are, in general, the same that explain the recession of Colombia's economy. But, due to the ample share that external markets have in agricultural activities, both in imports and exports, the over-valued peso face to the dollar and other currencies, notorious since 1974, has sorely affected Colombian farmers, and diminished the competitiveness of Colombian products in foreign markets. Furtheremore, government investments in storage facilities, land recovery, investigation and technology transfer, have sharply declined since 1970, practically freezing the productive basis of the agricultural sector and it's capacity for generating greater growth.

EVOLUTION OF AGRICULTURAL MECHANIZATION IN COLOMBIA

Although the idea and reach of agricultural mechanization is very broad, this evaluation limits this concept to the introduction of agricultural machinery in the process that begins with the readying of the soil till the reaping of the harvest. This machinery consists basically of tractors, and the auxiliary implements for sowing and harvesting, or a mixture of both. In this context, it is considered that the use of tractors is the most appropiate index for measuring mechanization, since their use brings along the complementary machinery employed in the various activities proper to the agricultural process.

Since the early fifties, when the mechanized area amounted to 715 000 ha (1 ha = 0.4047 acres), some 400 000 ha have been additioned. Although the technically appropiate area for mechanization is not precisely known, it is calculated to be between 2.0 and 3.3. million ha.

The machinery used in Colombian agriculture is mainly imported, being tractors its main component. Since 1960, the national industry of agricultural implements has been gaining importance in the development of mechanization through a gradual and sustained process of import substitution.

The useful life of tractors in Colombia is estimated above ten years. Meanwhile, the average power of imported tractors has increased with time, though lately a tendency towards tractors of lower horse-power can be detected, probably as a result of the great increase of international prices, due to the 1974 oil crisis. In Colombia there are about 25 000 tractors, with an average power of 65 hp. The stock of tractors, measured in horse-power, grew in the fifties at an average rate of 11.5 %, while in the sixties this rate decreased to 5.1 %. During the seventies, this rate decreased further, and is actually estimated to reach barely 2 %.

At a national level, the intensity of mechanization, in terms of potential per cultivated hectare, equally shows a diminution through the years. In the fifties the rate of annual increase was 7.0 %, in the sixties descended to 3.9 %, and in the seventies dropped to levels close to 1 %.

In terms of hectares cultivated per tractor, this relation was of 202 ha per tractor in 1950, 113 in 1960, and approximately 90 at the end of the seventies. If it is measured in terms of ploughable hectares per tractor, the level of mechanization in Colombia (200 ploughable hectares per tractor) is similar to the Latin-American average, though there are agricultural zones in the country that have a similar average to North-America (Valle del Cauca, 47), Soviet Union and Australia (Tolima and Cundinamarca, 100 to 108, respectively).

Agricultural mechanization in Colombia has been characterized by a relative concentration of machinery in large-scale exploitations. In the case of small properties, the intensity of mechanization is much lower, and leased machines are predominant.

NATIONAL PRODUCTION OF MACHINES AND AGRICULTURAL IMPLEMENTS

The manufacture of implements for tractor has been obtaining importance within the agricultural machinery subsector, which has given way to a process of import substitution and expansion of exports. Also, the quality of the manufactured implements has improved notoriously, though in some cases deficiencies associated with local design requirements, continue to exist. The participation of national raw materials in the production of agricultural implements has increased in the last years, and it is estimated that directly imported components represent only about 10 %, with a low import tax.

Till mid-seventies, the CIF prices of imported agricultural implements were similar to factory prices of nationally produced implements. Nevertheless, the nominal protection has superated, by an average of 30 %, which leads to believe that in those times such an import tax was not justified, since considering the transportation margin, national producers could compete with foreign goods.

During the second half of the seventies, as was mentioned before, Colombia maintained a policy of devaluation of the peso respect to the dollar, which did not compensate the increase of internal prices. This circumstance, when bearing in mind the domestic prices of the implements, allows to conclude that the present tariffs are valid, and they are lower than the average for the metal-mechanic industry, and are necessary for an adequate protection of the national industry. Anyway, as a result of the difficulties in the balance of payments, which is reflected in additional restrictions to imports, the industry of agricultural implements and the whole of the national industry, is enjoying nowadays an excessive protection, which in most cases is traduced practically into a prohibition of imports.

Whithin the enlarged automative programme of the Andean Group, Colombia, Peru and Venezuela were jointly awarded the manufacture of wheel tractors. It was assigned to Colombia exclusively the production of caterpillar track tractors. These assignments and others, like harvesters, which also belong to Colombia within the metal-mechanic programme, were never clearly defined and are actually being subjected to substantial rearrangements in the sectorial programmation within the Cartagena Agreement.

GOVERNMENT POLICY AND MECHANIZATION

The development programmes of the fifties awarded a particular emphasis to the mechanization of agriculture, which were partially modified between 1960-1970, when a greater relative importance was given to the variables concerning rural employment and income distribution. Within government policies, those concerning foreign trade have had the greatest influence in the agricultural mechanization process. External financiation for agricultural machinery (the first major disbursement was made in 1949) was clearly associated with an increase in tractor imports, and consequently, with the intensification of mechanized agriculture. Since mid-seventies, the government changed its priorities concerning foreign loans, resulting in a limitation of the allotments, so that local representatives has to recur to conventional financial sources in the manufacturing countries.

Generally, as was pointed before, the tariffs on tractors and other agricultural machinery have been low, arround 2 %, whilst those concerning implements and parts made locally, have been fixed, in order to favour the process of import substitution. The rate of exchange for tractor imports has been similar to that applied on all imports. During periods like the fifties and the first half of the sixties, when the rate of exchange was clearly over-valued, the low tariffs and ample external credit were combined with foreign exchange policies that explicitly favoured machinery imports. In the latter part of the seventies, and during the early eigthies, tariffs were not modified, but, a reduced external credit and the relative appreciation of the peso towards the dollar and other currencies, which could have stimulated the importation of agricultural machines, was checked by the rise of international prices and a reduction of the internal demand for tractors, as a consequence of the acute decrease in the growth of the agricultural sector.

Credit based on internal sources has been relatively subsidized in Colombia, not only for agricultural machinery, but also for various imports, and, generally, for all the activities relationed with agricultural production. Credit disponibility has fluctuated strongly, and it can be said that the government, in the particular case of machinery, has not recurred on credit to encourage its use in recent years. Thus, credit demand from farmers has been in accordance with the sector's growth, though a slight decrease in real terms can be observed in the past five years. On the other hand, machinery prices and credit conditions, particulary the terms concerning time and guaranties, have partially limited the capacity of small farmers to acquire machinery. Other facts that have influenced this phenomenon, are the land-property structure, the lack of resources of these farmers, and the absence in the market of machinery adequate to the particular conditions. The difficulties inherent to the channeling of credit to these small farmers, are evident, when it is observed that state institutions have mainly financed big proprietors. Also, it has not been possible to implement a credit system that favours the creation of specialized enterprises to service machinery. This would generate a greater efficiency in the existing stock, and wider accessibility for small and medium farmers.

Finally, internal sale prices of tractors have been controlled by the government, evolving according to international prices, since tariffs and marketing margins (estimated as 35 % approximately) have not suffered substantial modifications.

FINAL CONSIDERATIONS

The relationship between the internal price of machinery and agricultural products is one of the factors that influence the use of machinery. The price level of tractors compared to agricultural products has fluctuated without a clear tendency. During the 1950-1954 lapse this relationship evolved favourably for farmers, which was reflected in a parallel raise in tractor stock and imports.

During the 1955-1958 period the relationship became unfavourable, resulting in a decrease in imports and net addition of machinery stocks. Between 1959 and 1966, prices of agricultural products rose faster than machinery prices, but this situation was not reflected in a significative growth in tractor stocks. Probably, this phenomenon can be explained by the reduced disponibility of internal and external credits during the mentioned period.

Between 1967 and 1975 machinery prices increased compared to agricultural products. Nevertheless, the notorious volume of imports, which was made possible through an external credit, enabled to maintain and even slighlty increase the tractor stock till 1970. After this year and till 1975, the absence of foreign resources, the decrease in the internal government credits, and the increase of tractor prices with respect to agricultural products, were all associated in the small growth rate of machinery incorporations. The last seven years (1975-1982) have shown a greater deterioration in terms of tractor-agricultural products interchange as a result of higher international prices for machinery. As the restriction in foreign loans was maintained as a consequence of the accumulation of foreign currency reserves, and since internal credit resources were not used to stimulate the use of machinery, the relative increase in price compared to agricultural products was reflected in a virtual standstill in tractor stock and the agricultural mechanization process.

The present government policy favours public investments in agriculture. Investments that modify the trend in investigation and technology, in land and infrastructure recovery, in storage facilities, are being devised and executed. These investments, if accompanied by a proper political and economical climate for private enterprise, can generate an expansion of the agricultural frontier in the medium future, recovering the productive base of the sector, accompanied by an ensuing increase in the rhythm of machinery incorporation.

Nevertheless, the junctural handling of Colombia's economy, and the external conditions, do not seem to be the most appropriate for inducing high rates of growth in agriculture in the next years. The recovery of world economy will be moderate and excessively concentrated in the United States, the international rate of interest shall probably remain at high levels during the decade's first half, and the accessibility to foreign capital markets will be difficult, until banks recover their debt servicing ability in Latin-American countries. Thus, during the next years, the country will surely have to bear a growing deficit in its balance of payments and foreign exchange difficulties.

Additionally, the fiscal deficit and the necessity of financing it partially with monetary emissions, could lead, under certain circumstances, to a greater loss of foreign exchange reserves, or a revival of strong inflationary pressures. The narrow disponibility of foreign currency and the continuous crisis of certain sectors could also lead to an increase of protectionist policies and a more closed economy.

It is probable that in the future, prices of agricultural products (for the producer) will recover partially as a consequence of the reactivation of world economy, but the renewed pressure on costs caused by the acceleration of the devaluation of the peso, the high levels of protection, and the probable raise of internal inflation, can, progressively, discourage agricultural investments compared to other sectors of Colombia's economy.

Aspects of promoting mechanizations inputs as defined to strategic wheat production

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INTRODUCTION

Agricultural development has drawn more attention in the last few decades when food problems shot out very sharply to threaten the inhabitants of the globe. The shortage of food has tolled the bells of danger and famine catastrophies menaced human life. In response to this, many countries became much concerned and endeavoured to make all possible ways to feed their population and suffice them by all means. But due to irretreatable factors a considerable number of the third world countries failed to entirely recover and help themselves. Following this, the retardation in production has become a remarkable phenomenon in these countries, which resulted in the sufferings of famines.

In developed countries new approaches had been recognized to eleminate descrepancies in productivity and to highly improve agricultural production as a whole. Highly sophesticated technology had been followed to achieve the goals. On the other hand, developing countries could hardly follow suit if not at all, due to many factors that influenced their development plans, such as financial resources and support, which are always in the meagre side.

To divert from this shaky image in the track of development fulfilments, it is worth mentioning an example of a brighter effort of the Kingdom of Saudi Arabia to achieve more development in the sector of agriculture. Due to the wide expansions in the agriculture of the Kingdom in the last few years according to the very ambitiously declared policy towards self-sufficiency, a big number of the farmers opportuned this and worked for the development of their farms or bare lands. Dedication for such advancement was directed through more practical utilization of proper inputs, which are supported by the government in one way or the other. So more demand for agricultural machinery is activated and imports increased to satisfy the goals ahead.

Several seminars and workshops had been organized and papers been presented to deal with mechanization in many aspects. In this paper, however, attempt is made to spotlight how far it reached the aims in the Kingdom to become a tangible reality that wheat production materialized the drawn policy for fast self-sufficiency strategy. This is mainly attributed to the facilities applicable and in abundance.

AGRICULTURAL PRODUCTION

These lines are concentrated to the production of wheat, which has been counted for in the 5 year plans of the country in order to stabilize food production and support self-sufficiency. A number of farmers switched hence to the growing of wheat, depending on guaranteed marketing facilities, whereby each farmer delivers his product to the widely-spread siloes. This situation entailed dramatically very sharp an amazing increase of wheat farmers, hence resulting an attainable record rise in production (Table 1).

The development of wheat experimentation had been started in 1971 with simple trials on local varieties, when a survey was conducted to prove that production costs were much higher than the farmer could afford and hence meant a continuous loss to him. The programme was to tackle the work from different angles of attack:

- to develop varieties adaptable to the local conditions of each region;
- to apply modern agricultural inputs;
- to use farm machinery in complete mechanization;
- to facilitate marketing and storage;
- to raise productivity from about 1 tonne/ha to more than 3, in order to let it be more economically feasible.

MECHANIZATION OF WHEAT

Mechanization has been regarded as the key reason for the increase in total production and high rise in productivity per man-year. This is now a point which characterizes the agriculture of the Kingdom. Contrary to the current hypothesis that hidden costs of farm mechanization and related changes include the decline in farm population, this is significantly unattainable to the Kingdom at present. Many infrastructural benefits are offset to counter losses in the rural social shifts.

Table 1. Rise in production of wheat (tonnes).

Year	Production
1979	17 000
1980	33 000
1981	89 000
1982	239 000
1983	691 000

It is becoming obvious to feel the rush of machinery imports, which might reach the saturation point in certain types and makes, depending on certain factors related to mechanization of crops in the country:

- the encouragement and individual care, induced on the strategies of crop production, resulted in capable initiatives to cater for more expansions;
- the government is much concerned to assist farmers in anticipation to (a) subsidy in varying rates on farm machinery and engines, and (b) easy loan terms through the Saudi Agricultural Bank to establish their farms and machinery;
- scarcity, or exactly to say, unwillingness of the native labour to work in the field with machinery because it is not paying, and higher foreign labour costs;
- on the other hand, fuel is much cheaper than in any other developing country; so it can comparatively help lowering costs of production.

Wheat production attracted many farmers and a considerable number prepared feasibly studied projects, which contributed to the expansion in land use. It followed however, that implications to modern technology are superseded with respect to:

1. Indications on availability of irrigation water are of high concern of the authorities; in order to be on safe side, there is the inclination towards more use through economic applications. This is just in line with the fast installations of centre-pivot systems all over the wheat production areas. It is becoming a sort of challenge with nature to exploit all possible means to develop fertile lands on the fringes of the desert through the application of economic water systems.
2. The use of modern techniques in agricultural production has been practised in anticipation towards purchasing high-powered machinery. This tendency is characterized with projects in action. It is becoming normal to see big tractors of more than 200 hp rolling in the fields with relevant implements in most cases. Big combine harvesters are similarly operating during harvest times, which actually does not exceed a period of maximum of two months. Loss in yields is expected to be large if the period goes beyond this, due to climatic factors which affect the crop in the field and make it so dry that it can easily crack the seeds during thresing. Working round the clock is of no problem to the operator as all combines are air-conditioned and power-steered. Some have all facilities of easy life, such as radio.

The spreading of high-powered machinery is said to be attributed to the following:

1. It is assumed that high-powered tractors will reduce production costs in two ways. First, the tractors can achieve much better productivity per area; second they can reduce labour costs by appointing less labour during the season to carry out a certain operation.
2. High fuel consumption by the big tractors can be compensated for by the

lower prices of fuel, which is incomparable with other countries of the world.

Otherwise there are certain points worthy of recognition in the very way that big machinery can induce:

1. Wheat is grown only once in the year, and there is ample time to start and finish land preparation before the next season begins. The possibility to prepare fallow lands in the rotation can be noted and taken into consideration.
2. Initial capital investment on high-powered machinery can affect costing, if there is no maximum utilization of the machinery.
3. Repair and maintenance facilities are in most cases short, due to high-cost specialized and trained labour.
4. Other essential services display no presence in the scene, where some agents are not ready to service machinery which are not procured through them; and this is, by the way, happening very often.
5. The risk exists in case of any breakage during the peak of the season. Still smaller tractors are enlisted within the optimum force of machinery to work in other field duties.
6. In large farms, the difficulty of repair and maintenance is demolished, because each farm has its own workshop and force to carry out the jobs.

However, looking into the future of machinery imports in view of the present park, it is worth to note that there is always increase of machinery numbers to the inner markets. This in fact, does not reflect a clear picture to the exact types and makes and even the range of powers, but it is a pointer for the magnitude of imports dimensions. The numbers are indicated according to the state of sales in Table 2, and the state of imports at the different ports of the country in Table 3.

Table 2. Tractor and some implements sales. Source: Saudi Agric. Bank. (1982).

Item	1977	1978	1979	1980	1981	Total
tractors	820	2 380	2 348	2 274	5 277	13 097
combines	168	195	229	399	925	1 916
balers	24	38	70	79	258	469
sowing machines	10	15	57	107	355	594
trailers	51	116	298	573	1 836	2 874

Table 3. Tractor and some implements import. Source: Dept. of Agric. Engineering, MAW (1983).

Item	1978	1979	1980	1981	1982	Total
tractors	1 771	2 776	3 910	7 220	4 942	20 619
combines	29	21	78	381	638	1 147
balers	46	57	253	174	804	1 334
drills	23	160	66	663	754	1 666
mowers	268	684	673	51	95	1 771
trailers	248	494	1 211	1 594	1 696	5 243

From Table 3 it is clear that the tendency towards increase in farm machinery is greater in the last few years, and this is actually due to the tremendous development approaches to wheat production. This has affected the population of implements in the country in general. Notwithstanding, it can be concluded that the development of wheat production has become factual, and efforts are exerted to improve productivity. This achievement resulted in expectations to reach yields beyond self-sufficiency. The question remains at what costs does it stand. This has been already realized by the ministry of agriculture, and more intensive work is to be underway to study this with respect of categorizing and stabilizing the utilization of proper and suitable machinery.

Les formes de recherches et leurs résultats dans la promotion de la mécanisation agricole

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RÉSUMÉ

Traditionnellement on distingue plusieurs niveaux de recherche. Si la simple expérimentation permet le développement technologique et l'amélioration constante d'un matériel, il apparaît que la synthèse de travaux techniques et la modelisation qui peut en découler est génératrice de nouvelles voies.

Deux exemples sont donnés pour illustrer ce concept. L'un porte sur les principes de propulsion de machines agricoles. L'autre démontre l'amélioration significative des aptitudes à la locomotion grâce à la recherche fondamentale sur les pneumatiques.

Il est démontré que de nouvelles voies sont ouvertes et peuvent promouvoir une mécanisation rationnelle en exploitation agricole qui prend en compte les exigences agronomiques et permet des économies énergétiques. Les avantages sont donc à la fois biologiques et économiques.

L'expérimentation systématique du matériel agricole permet le développement technologique et l'amélioration constante des équipements. Cette technique scientifique s'avère particulièrement utile dans la définition des conditions optimales d'utilisation des matériels et permet d'expliquer par exemple les incidences économiques ou les raisons de l'adoption ou du rejet de ceux-ci par la pratique agricole.

Il faut reconnaître que des synthèses analytiques de semblables expérimentations sont l'exception alors qu'elles peuvent mettre en évidence certaines imprécisions ou d'importantes lacunes. Dès lors d'autres investigations et d'autres approches peuvent apporter les éléments nécessaires à de nouveaux progrès.

Les progrès en locomotion hors routes doivent tenir compte des exigences agronomiques, c'est-à-dire qu'ils sont liés à la pédologie, à l'hydrodynamique des sols et aux phytotechniques principalement, et dépendent des possibilités d'améliorer les modes d'exploitation de l'énergie motrice.

Deux types d'interventions majeures permettent d'envisager des améliorations. L'une porte sur l'utilisation des relations d'attelage et du contrôle de celui-ci. L'autre approfondit les connaissances en matière des pneumatiques agraires. La combinaison des deux améliorations accroît sensiblement l'aptitude à la locomotion hors routes et réduit les dommages aux sols vu la limitation possible des puissances motrices utilisées.

L'attelage trois points contrôlé hydrauliquement n'est généralement pas suffisamment exploité dans le but de parvenir aux améliorations énoncées plus haut. Les barres de l'attelage forment un système articulé dont tous les axes sont parallèles. Elles constituent un quadrilatère, muni d'articulations aux quatre sommets lorsqu'il est procédé à une projection dans le plan vertical longitudinal médian. La fixation de deux des points ne laisse qu'un seul degré de liberté, De plus, il s'agit d'un attelage actif, c'est-à-dire permettant le contrôle des accessoires attelés par voie de bielles et piston hydraulique. Les propriétés conférées aux relations entre les accessoires ou les équipements et le tracteur par suite de l'existence de cet interface autorisent une exploitation technique améliorant propulsion et/ou traction.

L'analyse des effets créés par des modifications systématiques dans la position et dans les dimensions des différentes pièces participant au système de relevage trois points assisté hydrauliquement fait apparaître que:

- les modifications mentionnées plus haut peuvent toujours amener une distribution des efforts dans les barres qui soit mieux appropriée pour appliquer des charges sur les roues;
- la localisation de l'attelage par rapport au bâti du tracteur influence la répartition des charges et est susceptible de favoriser l'aptitude à la traction tant des tracteurs à deux roues motrices que quatre roues motrices, mais bien évidemment de manières différentes;
- la position absolue d'un des éléments du système d'attelage est peu importante en regard du rôle que prend la position relative d'une des pièces par rapport à celle des autres;
- la distribution des efforts dans les divers éléments fait intervenir la géométrie de l'ensemble du système.

Il est dès lors constaté qu'une combinaison adéquate de deux systèmes hydrauliques de relevage placés en tandem peut contribuer à de meilleurs transferts de charges en statique et en dynamique, car ils procèdent des masses attelées, des grandeurs des efforts passant dans les barres et de leurs géométries respectives. L'analyse théorique au banc et sa transmission à l'ordinateur permet des approches intéressantes. Toutefois, l'expérimentation pratique est nécessaire pour l'acquisition des données et la vérification des résultats.

C'est ainsi qu'est né le pont auxiliaire moteur et que de nouvelles combinaisons d'essieux moteurs sont d'ores et déjà approchées. L'association d'un pont arrière de tracteur agricole équipé de son relevage à un tracteur deux ou quatre roues motrices via son propre système de relevage s'est révélé particulièrement efficace. Cette conception permet deux options principales, à savoir d'une part celle qui est expliquée ci-avant et d'autre part une version issue de la projection de l'ensemble des parties dans un plan vertical médian et permettant alors une réalisation d'une forme particulière de boggie. Les transferts repris dans les barres tiennent alors compte des charges, des efforts résultants du travail des outils et des couples appliqués aux roues pour vaincre ces résistances à l'avancement. En effet, la décharge de l'essieu avant du tracteur est consécutive à l'application d'une compression et de tractions dans les barres, fait intervenir l'asservissement hydraulique tant à l'essieu auxiliaire qu'à celui du tracteur lui-même. Il y a ainsi une double contribution à l'adhérence. De plus, le couple moteur à l'essieu auxiliaire transmet un couple dont le bras agit sur le relevage du tracteur et s'ajoute au premier transfert de charge enregistré à son essieu. Les essais effectués, tant sur piste expérimentale que sur champs, vérifient les gains obtenus en traction.

Il est dès lors logique de penser que dans une agriculture où la puissance 'moteur' requise en moyenne demeure limitée, il soit possible avec cet engin moyen de parvenir à des efforts de propulsion très élevés dans lesquelques périodes culturales où ceux-ci peuvent être requis. De la sorte, les investissements en matériels demeurent acceptables, les conditions mécaniques du travail sont meilleures et les façons culturales ou les opérations en exploitation sont garanties au point de vue agronomique. En effet, les risques de compactages localisés sont limités à ceux encourrus avec des équipements légers à moyens alors que les capacités de travail sont très élevées.

Les pneumatiques qui équipent tracteurs et équipements agricoles retiennent trop peu l'attention des utilisateurs, surtout lorsque les contingences énergétiques obligent d'entreprendre tout ce qui est possible, tant pour procéder à des économies de combustibles ou de carburants que pour conserver les propriétés culturales des sols.

Le pneu définit une enveloppe torique déformable dont la constitution spécifique possède des propriétés imposées par la pression de gonflage. Deux éléments principaux interviennent donc: la manufacture de l'enveloppe et la pression de gonflage. Dans les premiers temps d'une mise en charge un pneu s'affaisse plus qu'il ne s'élargit. Aussi des taux d'écrassement et d'aplatissement sont-ils déterminés pour être mis en rapport avec les surfaces de contact et les effets dans le sol.

Considérant les conditions de locomotion hors routes en agriculture, le pneu est placé à l'interface entre un ensemble rigide tel le tracteur agricole et un support plus ou moins meuble comme le sol. L'élément solide a évidemment divers comportements possibles par suite des relations d'attelage et de son évolution sur le terrain. Le pneu est manufacturé d'une certaine manière, ce qui lui confère une structure et des propriétés en raison de l'assemblage de nappes de fibres et de gommes et polymères. Le sol est un milieu granuleux possédant des réactions aux charges qui lui sont appliquées.

Tout pneu doit réaliser un équilibre entre l'élément tracteur ou partie rigide et le milieu sol. Le pneu agit sur le sol jusqu'à ce que les forces réactives apparaissant dans le milieu équilibrent chaque effort appliqué en tout lieu de la surface effective de contact définie par la bande de roulement. C'est pourquoi la manufacture est directement liée à la distribution des charges reçues de l'essieu via le voile et la jante de la roue. Il est vérifié que les compactages enregistrés en chaque lieu de la surface de contact expriment les actions de l'enveloppe.

La mise en graphique de ces compactages révèle diverses distributions comportant des pics bien marqués. Généralement, les pics les plus marqués se situent sous les barrettes à l'endroit de l'équateur et du milieu des portions latérales de la bande de roulement. C'est pourquoi l'hypothèse qui est avancée pour l'interprétation du diagramme de distribution des charges par la bande de roulement dans un sol retient que cela procède semblablement à la répartition des moments de flexion par une poutre sur appuis. La localisation des appuis par rapport à la longueur de la poutre est importante. Dans le cas du pneu cela correspond à la position des implantations des flancs sur la bande de roulement. Ainsi naît un profil 'camel shoe' (CS), dans lequel la largeur de jante est moindre que dans les versions actuelles pour une dimension donnée. De tels pneus ont été manufacturés expérimentalement et ont été mis en essais aux champs, sur piste expérimentale, à la ferme et en forêts. Ils vérifient les hypothèses avancées en cela qu'ils permettent une transmission de couples moteurs plus élevés qu'avec des pneus classiques, qu'ils réduisent les compactages localisés, que toute la largeur de la surface de contact devient effective et qu'ils assurent un meilleur confort. Les pneus CS reprennent les charges dans les matériaux qui les constituent ce qui les rend pratiquement indépendants des pressions de gonflage aux basses pressions classiques. Il apparaît également que le dessin de la bande de roulement et la présentation des barrettes soient moins importants qu'avec les manufactures actuelles. En tout état de cause les glissements enregistrés se révèlent toujours plus faibles.

CONCLUSIONS

La notion de transfert de charge sur tracteur agricole est connue, mais n'est que partiellement exploitée. Dans une optique de limiter les puissances moyennes utilisées en exploitation, il convient de répondre à certaines nécessités momentannées et périodiques de grands efforts de traction. La géométrie du système de barres qui compose un système de relevage permet une exploitation qui offre une possibilité d'améliorer signi-

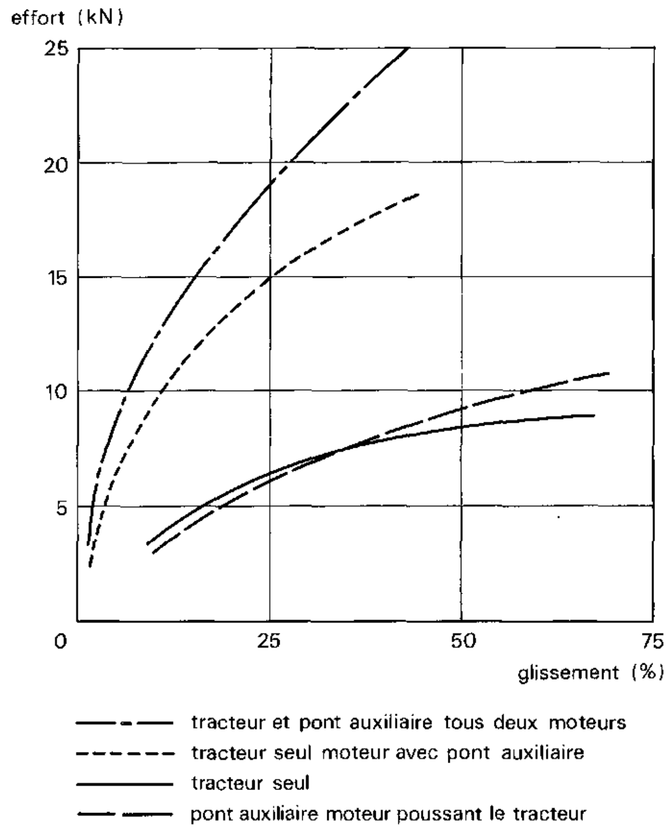

Figure 1. Enregistrements de glissement dans quelques systèmes de traction.

ficativement les capacités de travail. La combinaison des transferts de charges, d'efforts de travail et de couples moteurs entre accessoires et roues motrices via une bonne géométrie dans la triangulation des barres autorise une meilleure exploitation de l'adhérence sous les roues motrices et parvient ainsi à plus que doubler les capacités de traction. Partant de ce concept il est possible de réaliser un dispositif de demi essieu avec roues en tandem. La seconde roue se raccorde à la première via une triangulation de barres et réalisé cette exploitation des transferts tels que mentionnés pour parvenir aux économies souhaitées.

L'expérimentation des pneus agricoles permet d'en quantifier les caractéristiques physiques. L'observation des effets de ces pneus dans les sols autorise l'élaboration de modèles interprétatifs débouchant sur le concept 'camel shoe'. Celui-ci est un pneu à basse ou très basse pression de gonflage, présentant une largeur de jante moindre que celle de la bande de roulement. Les effets attendus de la théorie se confirment en pratique et font apparaître des économies importantes en ouvrant des perspectives de nouveaux développements.

La combinaison des résultats obtenus avec les ponts moteurs ou les roues montées en tandem et exploitant les propriétés d'attelage de systèmes trois points asservis hydrauliquement avec les améliorations apportées aux pneumatiques agraires permettent d'augurer favorablement quant à une limitation des puissances moteur et à leur utilisation optimale au bénéfice de l'agriculture et plus particulièrement de celle dont les moyens ou les terres sont pauvres, peu favorables ou peu importants en superficies et dont les productions sont diversifiées.

The agricultural machinery industry in the developed market economies

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UNIDO'S RECENT STUDY OF THE SECTOR

UNIDO's Division for Industrial Studies, Sectoral Studies Branch has prepared an appraisal of the current production and market situation for the world's major producers of agricultural machinery. It is issued in two volumes (UNIDO, 1983). The first one contains the main analysis and conclusions; the second one constitutes a statistical compendium containing all the supporting data. The study draws on a number of regional input documents. Two special surveys of the Latin-American and the African regions are issued separately (UNIDO, 1983b and c).

The global appraisal reviews the present situation in the agricultural machinery industry in the world and the major factors behind this situation. It presents both a short-term and longer-term market outlook for the major producers, including tentative projections of the apparent consumption of agricultural machinery for the years 1990 and 2000. The study discusses the response of the industry to the current market situation and the principal considerations behind possible industrialization strategies of the developing countries. The overview of the global production and trade is followed by regional summaries highlighting the specific situation and the main problems in each global region.

PRESENT PRODUCTION AND TRADE

The world's agricultural machinery industry is heavily concentrated in the hands of a few countries and in relatively few producers. The largest producer countries are the US, the USSR and Japan. In the developing countries only Brazil, Argentina, India and the Republic of Korea have significant domestic production of agricultural machinery (hand-tools and simple implements excepted). Mexico is emerging as a new important producer (Fig. 1).

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* The views and interpretations in this paper are those of the author and should not be attributed to UNIDO.

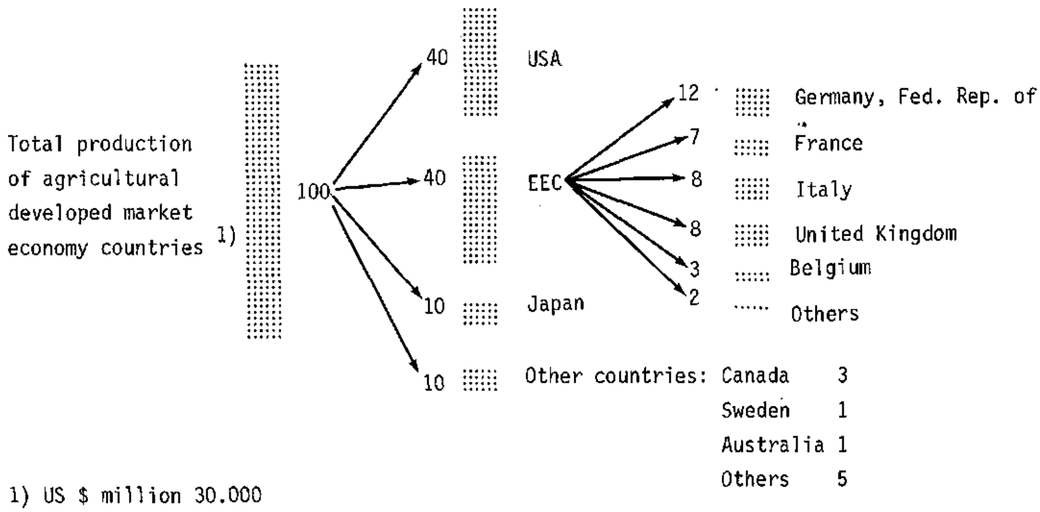

Figure 1. Production of agricultural machinery in developed market economies in 1980 (percentage distribution). Source: The Engineering Industries in OECD member countries, basic statistics, 1976-1978, OECD, Paris 1982 and UNIDO estimates.

There is no doubt about it that, globally, the agricultural machinery industry has experienced a severe recession for much of the current decade. This may have begun as early as 1977 or 1978, but became productionwise very serious around 1980/1981 for most major producers. The decline in international trade generally lagged the reduction in production by one year. Of course, there has been individual deviations from this overall pattern both in terms of producers and products, but most the market situation has been dismal (Fig. 2). Only very recently have some of the producers (mainly North-American) begun to show better profitability (Massey-Ferguson's net losses during the second quarter of this year are down to $ 11.3 million compared to $ 87 million in the corresponding period of 1982. However, the improvement in profitability now is due to paring back of costs, rather than to increased sales.) and the market outlook is expected to generally improve by 1984. One exception must be noted here. In 1981 Brazil managed to increase its exports to the other developing countries, while other exporters started to experience heavy declines in their overseas sales. In fact, judging from the most recent available trade figures, no major slump in the trading performance of the developing countries occurred in 1981 as compared to 1980. Globally, however, the developing countries' share in trade (and production) of agricultural machinery is so small that their comparatively good performance failed to brighten the global picture of the industry.

Because of the concentration of production, trade in agricultural machinery is substantial: approximately one third of the total world production is internationally traded. Therefore, too, production and exports

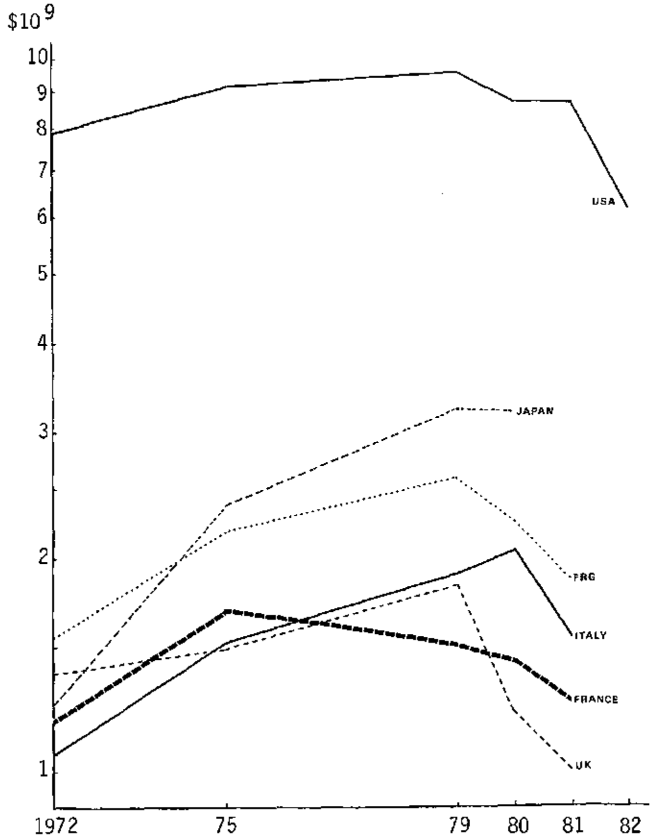

Figure 2. Production of agricultural machinery, at constant 1975 prices.

are heavily correlated. Of the total exports, nearly 80 % originates in the developed market economies; five countries alone export two thirds of this total. Some 80 % of the developing countries' exports go to other developing countries, the majority of this being intra-regional trade from Brazil to other Latin-American countries. The remaining 20 % is exported to the developed market economies. Thus, no exports to the centrally planned economies from the developing countries is registered.

The developing countries purchased one quarter of the world exports. More than 85 % of these imports came (in 1980) from the developed market economies, 11 % came from the centrally planned economies and the remaining 4 % from fellow developing countries. Brazil is the only net exporter of agricultural machinery among the developing countries.

REASONS FOR THE PRESENT MARKET SITUATION

The current market situation can be attributed to both domestic and international causes. On the domestic markets, among the major determinants are the worldwide recession, large crop production years further depressing already low farm commodity prices, increasing real prices for agricultural machinery, and an uncertain future of high interest rates and government support programmes. A prolongation of the usual machinery replacement cycle has not helped the machinery producers either. In some of the smaller countries, a further development of collective utilization and leasing of equipment has reduced the rate of growth in the demand for agricultural machinery.

Since a large portion of total agricultural machinery production in the developed market economies is exported, the external causes on the international markets are of great importance to this sector. Among the factors facing all or nearly all the exporting producers is foremost the worldwide recession, which has caused total trade to languish and protectionist measures to proliferate to protect jobs at home. Other major common factors include the problems with distribution, service and parts supply, which have not kept up with demand and have caused some disillusion among potential buyers. The deteriorating balance of payment situation in many of the developing market economies is causing difficulties for not only the exporters, but also for domestic producers, who often rely on imported parts (often engines) to a varying degree.

Because of the recent large relative movements in the foreign exchange rates, the producers in different countries face different difficulties. The American dollar is grossly over-valued with respect to the Japanese yen (by as much as 25 % according to some sources). The effect on the respective exports to each other and to third countries has been noticeable. Italian and Fed. Rep. German producers have maintained their competiveness through currency adjustments and their traditional export orientation in specialized equipment. In fact, the smaller and more specialized manufacturers seem to have weathered the recession better than the giants in this industry. The producers in the UK have actually improved their international position through the lowering of the value of the pound and a lower domestic inflation rate.

With respect to the markets in the developing countries, the major factors contributing to the depressed condition for the producers of agricultural machinery include:

- a deteriorating balance of payment situation, making especically hard currency (dollars) for the purchase of imports scarce;
- the increased debt burden in major importing countries, making further credit very expensive, or even unavailable;
- continuing low incomes of farmers and fragmentation of available farm land;
- unfavourable ocean rates, especially for North-American producers;
- national policies intentionally or unintentionally biased against domes-

tic agricultural production;

- the over-production of food in the developed market economies.

Although the latter two factors deserve further comments, as they are seldom, if ever, discussed in connection with the mechanization of agriculture in the developing countries, the briefness of the present paper does not allow such elaboration (UNIDO, 1981).

HOW THE PRODUCERS HAVE RESPONDED

In response to the general market situation, the producers of the developed market economies have been looking at their own cost, production, and distribution structure, rather than attempting to force increased sales on an unwilling market. This has meant lowering wage and salary bills, reducing inventories, improved manufacturing methods and lay-outs, tighter financial controls and relationships with suppliers, and in general various attempts at cutting costs by rationalization of the production. Responsibility for quality control has been transferred towards the suppliers of components. Research and development has been stepped up by at least some of the major producers. Many have been operating their plants at less than capacity and have consolidated their operations to increase operating efficiency and capital utilization.

Many production facilities have been temporarily or permanently closed. At one point early in 1983, a spokesman at the US Department of Commerce provided the following estimates of plant operating levels in terms of per cent of full capacity:

John Deere	less than 50 %
International Harvester	closed
Massey Ferguson	no longer produces tractors in North America
J.I. Case	closed 2 out of 3 months
Allis Chalmers	closed 2 out of 3 months
Ford	barely open.

Thus, tractor production in North America, in the last quarter of 1982, was probably at only 20 % of full capacity. The share of worldwide employment of major North-American producers employed in North America has steadily increased signalling a relative decline in overseas production. In fact, divestment of major interests in both European and Latin-American subsidiaries have taken place recently. The recession has forced the various manufacturers to further specialize their production and concentrate on the markets and products where they have a comparative advantage in terms of technology and foreign exchange rates.

North-American firms are selling agricultural equipment to other countries from their plants overseas to cushion against the effect of the high dollar and bring the production closer to the markets. For example, John Deere manufactures its 55-59 hp tractor line in West-Germany and markets to developing countries from there. Massey-Ferguson manufactures its medium and small (less than 100 hp) tractors in the United Kingdom and France. International Harvester manufactures in France, West-Germany, and the United Kingdom, and assembles in New Zealand, Australia, and Mexico. J.I. Case acquired a British firm that manufactures small tractors, to manufacture its 40-90 hp tractor line. Ford sells most of its tractors to customers outside North America from its European (France, Belgium, and the United Kingdom) and Brazilian plants. Not more than 5 % come from US plants. Other responses of North-American producers of agricultural machinery include increased purchases of parts from overseas subsidiaries and licensees. Finally, leading producers in all sectors have increased their political pressure on the Reagan Administration to do something about the dollar/yen disparity in particular.

THE POTENTIAL ROLE OF THE DEVELOPING COUNTRIES

Many of the firms in the developed market economies are now entering into joint-venture agreements with some developing countries. Certain innovative approaches, such as trade-and-barter schemes, that accept counter-trade in exchange for exports, are also tried out. In general, however, the developed countries' producers are not looking to solutions to their current problems with low demand that would involve the developing countries to any great extent. The product line produced in the developed countries for the developed country markets is so different from the machinery demanded in most developing countries that gearing up for those markets would involve major designing and re-tooling. This, in turn, would require major investments which the industry is in no shape to undertake now. Besides, the resulting production series would likely be too short to achieve customary economies of scale. For example, for the European producers, the demand of the developing countries for agricultural machinery represents only some 10 % of total production. The Japanese manufacturers constitute an exception in this respect. Their production lines (compact tractors, combines and equipment suited for rice cultivation) find receptive markets among the developing countries. Japan is also eyeing the emerging huge Chinese markets and it is trying hard to increase its sales to the oil exporting Middle East countries with which it runs a constant trade deficit.

Political and other unrest have made several traditional markets for the developed country producers of agricultural machinery less attractive in the eyes of these manufacturers. Government interventions in the markets, as well intended as they may be, are also seen by these producers as uncertainty factors and thus have a negative effect on their perception of the markets in these developing countries. The response has been an abrupt withdrawal from these markets, except for in the case of direct sales of individual lots of machinery against guaranteed payment.

Yet, population growth is outstripping food production in many developing countries. Where output has increased, it is often due largely to an expansion of the areas under cultivation. With the pressure of the growing populations on land, the traditional patterns of shifting cultivation, long fallow periods, manual farming using only primitive implements, and litte use of fertilizers, are becoming increasingly inappropriate. Over the past decade, it has been recognized that labour constraints are a key obstacle to agricultural progress, but development strategies have not fully reflected this insight. Rather, the increase of the productivity of land through fertilizers and improved seeds has been stressed. Clearly, however, more emphasis should now be placed on increasing the productivity of labour through the greater use of farm implements, animal and machine-powered cultivation, grain harvesting and processing equipment, and other equipment aimed at freeing labour for other tasks.

THE SHORT-TERM OUTLOOK ON SELECTED MARKETS

1982 was the sixth year of decline in worldwide farm and industrial machine sales. Overall world demand for farm machinery in 1983 is expected to remain near the depressed level of 1982. There seems to be a continuing trend toward higher horsepower tractors, because of government development purchases and a trend toward larger farms.

In North-America, continuing low grain prices, substantial reduction in acreage, and an uncertain future of still high interest rates, will cause capital outlays for agricultural machinery to remain near the depressed levels of 1982. However, US retail sales of tractors are expected to increase in 1983 and 1984.

Western-European sales of farm machinery is expected to increase in 1983 slightly above the 1982 level. In Australia, farm machinery sales will remain weak throughout 1983. In Japan there is a trend towards larger tractors, but local manufacturing is gradually replacing imports.

In Argentina, farm machinery sales increased nearly 50 % in 1982 from the very depressed level of 1981. Further improvement is, however, expected to be limited. In Brazil, despite the government's Strategic Development Plan, farm machinery sales in 1983 are likely to remain near depressed 1982 levels. In Mexico, severe national financial problems will continue to limit farm machinery sales in 1983. In Turkey, farm machinery sales increased significantly in 1981 and 1982 and should be stable or slightly higher in 1983. The Middle East oil producing countries are expected to remain a relatively strong market for agricultural tractors. Government priorities are likely to affect sales levels. Political unrest and war in the region will continue to limit the interest of industrialized country producers in these markets. Other developing countries experience deteriorating financial situations, but stable oil prices and stable to rising raw materials prices contribute to an expectation of farm machinery demand in 1983 near the 1982 level.

The long-term outlook for the worldwide demand for agricultural machinery will depend on increased agricultural production through the substitution of modern machinery for hard labour and draught-animals. However, improved storage facilities could yield equal or better results in terms of the amount of agricultural products reaching the consumer. Government priorities may therefore favour improved storage facilities over agricultural machinery.

The technical requirements for agricultural machines in the coming years can be summarized as follows (for a full discussion see FAO/ECE, 1981):

- more capacity per unit in countries with large farms (in particular the US and the centrally planned economies);
- small flexible and inexpensive machines for small farms;
- increased reliability and less maintenance;
- less damages and losses resulting from use of machinery;
- special equipment for slopes and heavy or sandy soils;
- increased use of equipment suited for reduced tillage and non-tillage farming practices;
- improved transmissions and hydraulics to match engine and ground speeds to load;
- increased use of front-wheel or four-wheel drive to reduce tire slip and power loss, and to improve fuel economy;
- electronic or microprocessor-controlled devices and sensors to permit more accurate control over implement precision;
- more comfort and safety for the operators;
- better machines for harvesting and handling of vulnerable crops;
- more standardization in components;
- more attention to environmental damage.

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Design criteria of farm machinery from management point of view

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ABSTRACT

Well-designed farm machinery may not be acceptable by the farm manager as it may lack management aspects like reliability, ergonomic considerations, and simplicity, among other things. A good machine should be designed not only from the view-point of sound engineering principles, but also should be taken care of the aspects in which a farm manager is interested. This paper discusses such aspects which must be taken into consideration in designing a farm machine in order to satisfy a farm manager.

INTRODUCTION

Design (Gregory, 1966) is concerned with making things that people want; with building-up patterns which have value. It involves creative thinking, but people see only the end-products and tend to think of design as an operation strongly related to material things. Thus, the designers will have to design and make machines or things that are acceptable to the people, the users. If a design fails to satisfy its users, it fails as a design. Therefore, if a farm machinery designer wants his design to satisfy a farmer or a farm manager, the design has to incorporate his needs and views on the intended machine.

MACHINE MANAGEMENT

According to Cuplin (1975) good farm machinery management is concerned with: (a) choice of a set of equipment as per needs of the farmer; (b) employment of sound operating techniques for using both the individual machines and the matched set of equipment under a machinery system; (c) attention to detailed setting and adjustment (of the machines) to suit soil, crop, and the environmental conditions, and (d) a well-planned system of maintenance and repairs of equipment, to ensure that all the equipment are always in good working order. Thus, the farm manager will be interested to buy the machines which are simple to operate, maintain and manoeuvre without asking for the services of highly skilled technicians. At the same time, the farm manager will desire that the selected machines have high reliability and also should be of high performance both in quantity and quality.

DESIGN CRITERIA

To meet the needs of a farm manager the machine designer should design the machine on the basis of the following criteria: design to standards, design for high machine performance, for matching power capacity, for manoeuvrability, for simplicity of production, operation and maintenance, design with ergonomic considerations, design for improvement, for economy, for reliability and quality, and design for safety.

Design to standards

Standardization means conforming to specifications and rules which have been agreed upon, laid down and are widely accepted. For example, the power take-off (pto) shaft of a tractor has two standard speeds, viz. of 540 and 1 000 r.p.m. Thus, anything which uses the pto as a source of power, should be designed keeping the above speeds in mind, otherwise one would have to buy additional drives, which would make the machinery more costly than it should have been.

Standardization also provides an easy language of communication between the farm manager (purchaser), the manufacturer and the designer. A wise farm manager will want to purchase a set of standardized tools (if available) to meet his farming needs.

With the standardization, some parts may be designed which may be interchangeable. Highly interchangeable standardized components like wheels, frames, handle bars, chains, tubes, bolts and nuts, for example, have made repairs and maintenance, even in remote areas, very easy (Zachariah, 1977). The design of parts should be such that a minimum number of tools need to be handled in its servicing or maintenance.

Design for high machine performance

The performance of an agricultural machine is measured by the rate and quality at which the operations are accomplished (Hunt, 1973). Timeliness of operation is a very important factor, which should be duly considered in the selection of the machine. The farm manager needs to select the machine whose capacity matches his total needs, so as to carry out his operations on time. There is no need for him to select a machine which has capacity far more than his needs. The quality of work should be such that it is acceptable to the farmer's needs or specific standards.

Design for matching power capacity

The ultimate aim of any equipment is to give maximum efficiency. The equipment should have a matching power unit, so that there is no wastage of power. Some machines may be self-propelled, meaning that they have their own power units, others use a prime mover. The designer should give the specifications of the prime mover so that the farm manager can procure them. The designer should strive to design different machinery which can use the same prime mover, so that a farm manager need not have different set of prime movers for different machinery. For example, a farmer having land of 10 ha will want to have a tractor of 26 kW. He will desire that most of his equipment needing prime movers, may be operated by this tractor, so that his investment can be minimal.

Design for manoeuvrability

Having to buy one machine for each operation or purpose is economically unsound. It would be a lot of saving, both in initial and variable cost, if one machine could handle all the farming operations in the farm. Since this may not be possible, the designer should consider many other purposes or functions for which the machine could be used. For example, a planter may be designed which, by making minor manipulations, can be used as a seed drill or a broadcaster. A multi-crops reaper which can reap wheat, rice and barley, may be preferred to the reaper meant for reaping wheat only.

Design for simplicity of production, operation and maintenance

In general, the simplest design that meets the specifications should be used. Also, the number of parts should be kept to a minimum, because the design with less parts will mean less sophistication, and therefore, will need fewer highly-skilled operators and servicemen. It would also require lesser time for maintenance and there will be lesser breakdowns (Turner, 1966).

Design with ergonomic considerations

Shaekel (1966) defined ergonomics as the study of the relationship between man and his occupation, equipment and environment, and particularly, the application of anatomical and physiological knowledge to the problems arising therefrom. He goes further to say that designers mostly concern themselves with improving the mechanical, electrical and other performance aspects of their machines, and most of the time forget the efficiency and performance of the total system of which their machine is a part.

In a man-machine system, the important thing is how the machine works in conjunction with the operator who uses it day after day in his routine work. Errors of operation due to fatigue can be greatly avoided by incorporating ergonomic considerations in design. The design should incorporate good spacing for easy movement of operators' hands, legs, eyes and body as a whole. Deafening sounds and high-intensity lighting tend to reduce operators' sense of hearing and vision, and excessive exposure to heat and radiation have serious side-effects on the operator. Posture during work and the manner of working have a considerable effect on the operator in terms of causing unnecessary fatigue, health hazards, waist pain, backache, blisters, bent shoulders and spines, and early arrival of the signs of old age and/or loss of efficiency in terms of output.

For the man-machine compatibility to be attained the designer should study the anthropometric data of the likely user population, so as to develop design criteria with the operator in mind (Wagami, 1983).

Design for improvement

While considering the replacement of a machine, a manager will want to know if the new machine will perform better than the one he has (Wagami and Mittal, 1981). The design should have a basic improvement on the performance of the earlier machine to warrant its acceptability. This basic improvement should be such as to improve the manager's economic production, in terms of performance and ease of operation, so that the jobs may be done in time.

Design for economy

Economic consideration in design should include the use of cheap available materials for the components. Also high performance efficiency of the machine will entail low operating expenses in terms of fuel, lubricant, etc. Economy in terms of design considerations will also include standardization of components for interchangeability, high machinery performance, matching power capacity, reliability, manoeuvrability and simplicity of production, operation and maintenance.

Design for reliability and quality

For a product to be reliable it should look right, work right and last for the specified life span. For it to be of good quality, it has to conform to the specifications at all times. Overall reliability of a machine is a function of the reliabilities of the individual machine components. The more the number of components, the higher must be the reliability of individual components. In other words, the large number of components will require high efficiency, resulting in high cost. Thus, the components should be kept to a minimum number (Corney, 1966).

Design for safety

One can think of safety in machine design as incorporating in the design precautions or protections against possible body injuries by the machine's moving parts or by the flying-off of parts of the material. Relevant safety standards should be strictly adhered to at all stages of the design.

CONCLUSIONS

Machines and equipment are designed to meet the specific requirements of the farm manager. The designer needs to study the manager's view-points, so as to incorporate these criteria in his design. This will go a long way towards fulfilling the manager's needs and will also help advertise the equipment speedily, as it will be widely acceptable.

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Nécessité d'une coopération des fabriques de matériel agricole en région sahélienne

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BREF HISTORIQUE

Au début des années 60, une usine de fabrication de matériel agricole a été créée au Sénégal pour répondre aux besoins en matériel de culture attelée à traction animale. Bien que cette usine la Siscoma fut agrandie à plusieurs reprises, son importante capacité de production était, à la fin des années 70, absorbée à 85 % par le marché national Sénégalais.

Suite à des questions économiques, générales et propres à l'entreprise, la Siscoma ralentit ses activités en 1979, pour être momentanément fermée en 1980. Pendant cette période, l'option traction animale pour la culture en région sahélienne s'est étendue à la plupart des pays de l'Afrique de l'Ouest, spécialement dans les pays francophones.

L'usine Sénégalaise devant répondre en premier lieu aux besoins internes du Pays, ne put pas toujours faire face, tant en quantité qu'en délai, aux demandes qui lui parvenaient des pays de la sous-région. Lorsque s'est ajoutée à cela la fermeture momentanée, mais indéterminée de l'usine Siscoma de Pout, des unités nationales qui s'étaient créées entretemps dans d'autres pays sahéliens se sont agrandies et multipliées.

Actuellement, il existe des unités de fabrication de divers matériels agricoles dans plusieurs pays de la sous-région, à savoir le Bénin, la Côte d'Ivoire, la Haute-Volta, le Mali, le Niger, le Sénégal, le Togo. Les programmes de fabrication de ces unités ont été déterminés en fonction des besoins et des possibilités nationales, et dans le cadre d'études et de projets totalement indépendants et organisés, en général avec l'appui d'assistances nationales ou étrangères différentes et non-coordonnées.

D'une façon générale, aucune de ces usines ne fabrique la gamme complète de matériel de culture attelée à traction animale, et dépend pour ses approvisionnements, non seulement de matières premières, mais surtout de pièces semi-finies en provenance des pays industrialisés.

SISMAR

Devant les besoins présents et futurs du monde rural en matériel agricole au Sénégal comme dans les pays de la sous-région, il était indispensable que l'important centre industriel créé par la Siscoma à Pout ne soit pas désaffecté. Dès l'arrêt de production de l'usine Siscoma, le gouvernement sénégalais entama des démarches auprès de sociétés étrangères et nationales pour mettre sur pied une nouvelle entreprise destinée à reprendre ces activités.

En novembre 1981 fut ainsi créée, à l'initiative du gouvernement sénégalais, la Société Industrielle Sahélienne de Mécaniques, de Matériels Agricoles et de Représentations (SISMAR), avec des partenaires privés et publics, sénégalais et belges. Comme mentionné dans le protocole d'accord de base de la création de la société, l'objet principal de l'entreprise était de mettre ses moyens techniques de création et production au service du monde rural de la région sahélienne.

Dès le début de 1982, l'usine de Pout fut remise en activité en partant de la gamme importante de matériel de culture et de traitement des récoltes de l'ex-Siscoma. Cette gamme de matériel était déjà bien connue et appréciée des paysans dans la plupart des pays de la sous-région, et même sur d'autres continents, qui ont acquis des exemplaires de ces équipements pour les adapter et les fabriquer localement.

Par suite de la suppression de l'organisme central d'encadrement au Sénégal et de l'arrêt momentané du programme national d'assistance en matériel aux paysans, la Sismar put immédiatement mettre ses unités de production au service du développement agricole dans les autres pays de la sous-région.

Quoique la gamme Siscoma fut déjà très étendue, la Sismar s'est attachée depuis sa création, à compléter cette gamme par une étude sur différents prototypes, particulièrement dans le domaine de traitement des récoltes, tels que les moulins, batteuses, décortiqueuses, cribles et tarares, et cela en coordination ou suivant les indications d'organismes de recherche pure en agriculture.

Malgré l'extension de la gamme dans le matériel agricole, les potentialités de Sismar ne sont pas utilisées au maximum des capacités et dès lors, des diversifications sont envisagées dans d'autres domaines liés généralement à l'agriculture, tels que des remorques, citernes, mais aussi des éoliennes et équipements de pompage.

Il est important de noter que les outils de production, installés à Pout, permettent de réaliser localement la totalité des pièces rentrant dans le matériel de culture attelée et de traitement des récoltes jusque et y compris des pièces forgées qui sont actuellement importées de l'étranger par les autres unités de production de la sous-région.

Bien que les investissements en machines de Sismar soient assez récents on peut considérer sur un plan simplement comptable et financier que l'ensemble industriel de Pout est pratiquement amortis et constitue donc un bien de production installé et appartenant non seulement à la vie économique du Sénégal mais aussi à l'ensemble des pays de la sous-région, qui devraient l'utiliser et le valoriser au maximum de ses capacités dans le cadre des communautés inter-africaines comme la CEAO ou la CEDEAO.

BESOINS EN MATÉRIEL ET UNITÉS DE PRODUCTION

Si dans chacun des pays de la région sahélienne, le développement de la culture attelée évolue d'une façon propre et qui tient compte des politiques agricoles nationales, des conditions climatiques et humaines, de l'expérience déjà acquise en matière de culture attelée, de la situation quant à la vulgarisation agricole ainsi que des disponibilités en animaux de trait, il y a cependant une analogie très grande entre les équipements et matériel utilisés dans l'ensemble de la zône sahélienne pour la culture des mêmes céréales. Dans l'ensemble, on constate que les résultats espérés d'une motorisation intensive de la culture dans ces régions n'ont pas été atteints, et, compte tenu des facteurs mentionnés ci-dessus, la tendance est actuellement plus vers une extension de la culture attelée qui devrait permettre à un plus grand nombre de familles de subvenir à leurs besoins propres et de s'assurer un certain revenu au-delà du minimum de la subsistance.

Dans l'avenir, les besoins en matériel agricole, particulièrement pour les conditions spécifiques de culture en sous-région sahélienne, devront être assurés par une production locale qui est mieux à même de s'adapter aux besoins des agriculteurs dans les conditions réelles qu'ils connaissent, plutôt que de devoir utiliser des équipements standards produits et conçus dans des pays industrialisés pour couvrir des marchés beaucoup plus vastes que ceux de la région sahélienne. Il est donc nécessaire que les évolutions des conditions de culture résultant des phénomènes météorologique telles que la progression de la désertification ou l'accroissement des périodes de sécherresse, soient suivies sur place par les instituts de recherche agronomique en liaison directe avec les producteurs du matériel agricole à qui il incombe d'apporter constamment les améliorations nécessaires à leur fabrication pour áider les agriculteurs de leur pays à conserver et si possible améliorer le niveau ou la qualité de production.

Si l'on consulte la carte de la sous-région, on est frappé par les vastes étendues de ces territoires qui incite à croire à l'existences d'un vaste marché de produits pouvant être fabriqués en série. Par contre, comparé à la population rurale de chacun des états, les besoins en machinisme agricole qui en résultent, ne permettent pas de couvrir les frais de gestion et de production d'unités multiples et séparées de fabrications en grande série.

Pour les sept pays mentionnés précédemment et qui possèdent chacun une unité de production en machinisme agricole, il faut noter que la population totale n'est que de 40 millions d'habitants pour une superficie de territoires de 3 500 000 km².

La souhaitable indépendance technique des pays de la sous-région pour couvrir ces besoins en matériel de culture attelée et de traitement des récoltes ne pourra s'obtenir au niveau de chacun des pays séparément qui resteront toujours dépendants d'assistances et de subventions internationales. Par contre, une concertation et mise en commun des outils de production existant dans cette région sahélienne donnerait à l'ensemble des pays et par là à chacun d'eux une position autonome de production.

POLITIQUE DE COORDINATION

Nous pensons qu'une politique de coordination devrait être élaborée en commun par une étroite concertation entre les producteurs de matériel agricole qui, en premier lieu, mettraient en commun leurs connaissances et expériences et étudieraient les moyens de mieux valoriser leur capacité propre de production. Par après, lorsq'une concertation et coordination auront été établies à ce niveau, elles pourraient être étendues aux organismes de recherche fondamentale en agronomie qui pourraient obtenir l'assistance de l'organisation des producteurs pour la mise au point avec eux des nouveaux équipements et prototypes permettant de promouvoir le développement du monde rural qui est indispensable au développement de cette région de l'Afrique.

La politique de coordination des producteurs de machinisme agricole en Afrique sahélienne pourrait porter notamment sur les questions suivantes:

- l'uniformisation et la normalisation des matériels et produits, étant entendu que par normalisation nous ne désignons pas une quelconque standardisation impérative mais bien une analogie technique des éléments produits permettant une fabrication à moindre coût de séries de pièces identiques entrant dans des ensembles différents et restant totalement adaptées aux besoins et habitudes traditionnels des agriculteurs;
- une spécialisation des unités de production en fonction de leurs possibilités de fabrication pour valoriser au maximum les moyens de production existants en accroissant la valeur ajoutée de la production africaine au profit d'une réduction globale des coûts de production et par là du coût des produits finis pour les utilisateurs;
- une étude concertée pour assurer la complémentarité des investissements et réduire ceux nécessaires aux produits pouvant déjà être fabriqués dans certaines unités de la sous-région de façon à utiliser les moyens disponibles pour créer des investissements assurant un élargissement de la gamme des fabrications;
- une concertation sur le plan des études et conceptions de matériels nouveaux ou simplement à améliorer pourrait être utilement établie en s'appuyant sur un ou plusieurs bureaux centraux existant dans certaines entreprises et qui pourraient constituer une source d'informations techniques

pour les unités de la sous-région.

Il ne s'agit pas de préconiser l'abandon des moyens existants de certains pays, mais plutôt, d'en permettre une meilleure utilisation dans le cadre d'un renforcement et d'une coordination au niveau de l'ensemble des unités concernées. Ce bureau d'études commun central sur lequel s'appuyeraient au niveau régional les différentes unités de production, permettrait d'orienter et de servir d'appui au programme d'études, non seulement pour la mise en fabrication de matériels existants déjà dans l'une ou l'autre production, mais aussi pour la conception des nouveaux produits et l'étude de divers prototypes.

Comme la Sismar, l'a déjà fait pour certaines entreprises dans la sous-région avec lesquelles elle coopère, elle pourrait mettre son Centre de Formation à disposition, dans l'usine de Pout, pour une formation en usine africaine des ouvriers, maîtrise, et cadres des autres unités de production. Ce Centre de Formation pourrait ainsi devenir un centre de concertation complémentaire pour recherche et études dans le cadre du machinisme agricole. Si la proposition rencontrait un avis favorable auprès des responsables du machinisme agricole dans la sous-région, nous, Sismar, sommes ouverts à toutes rencontres et concertations qui pourraient être organisées de façon à discuter de ces questions dans l'intérêt global de l'ensemble de la sous-région.

Mechanization for small-scale farmers in the north east of Brazil

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INTRODUCTION

Brazil is the largest country in Latin America, and fifth largest in the world in territorial expanse. In the country (8.5 million km^2 or 3.3 million square miles) distances from the west to the east as well as from the north to the south exceed 4 000 km. Its 120 million inhabitants are unevenly spread over its five regions, with most of them concentrated in the southeast and along the coast. Especially in the southern states of the federal republic of Brazil, it is a modern industrial country, with also a sophisticated agriculture.

In the central part of the country, Brazil has a savanne landscape of about 180 million ha. Here large-scale programmes of reclamation for agricultural production are in progress. In the future this part of Brazil will look more or less like the Mid-West of the USA. Due to new methods in weed control one can grow dry rice here in a crop rotation. It probably will make Brazil also one of the biggest rice producing countries.

The northeast is a semi-arid region of 1.5 million km^2, with 35 million inhabitants. Especially outside the costal zone the region is known as a very dry area.

REFORMATION OF THE REGION

Irrigate (large parts of) the semi-arid northeast with water of the rivers and the region will get a new and much better future in agricultural aspect. This is the summary of an idea, which is already 100 years old. Nowadays, with modern techniques, the Brazilian government realizes this large and grande project step by step.

The major possibilities for irrigation in the northeast of Brazil are based on the use of water of the river São Francisco. The river, velho Chico, which is old São Francisco has its 2 700 km long way from Bela Horizonte to the sea in the northeast near Penedo in between Salvatore and Recife. For hydro-electrical sources dams are also made in the São Francisco river. Well-known is the Paulo Alfonso hydro-electrical plant, the third biggest of Brazil.

One of the development agencies in the north-east region is the Companhia de Desenvolvimento do Vale do São Francisco (CODEVASF). With support of the United Nations they reformate the valleys along the river São Francisco. This is done project for project, with technical assistancy of a team of specialists of the Food and Agricultural Organization (FAO) of the United Nations, and financial help of the World Bank.

In 1967 the São Francisco Superintendency (SUVALE) started to select priority areas for irrigation and agricultural development in the north-east. Since 1974 the activities are taken over by CODEVASF. CODEVASF operates like a private-sector development company, with planning, coordinating and executive functions. It acts on behalf of the ministry of the interior as the leading federal development agency in the São Francisco valley. It has to promote the economic development and utilization of the natural resources of the valley, principally its water and soils. 'A river commands progress' is a slogan used by CODEVASF to summerize that the modifications in the water regime also can stimulate the region's agriculture. CODEVASF has selected priority areas at ten points along the river, and with a total area of more than 10 000 km^2.

ACTIVITIES OF CODEVASF/FAO

Traditionally in the region one could find a small number of very big farms with extensive agriculture and a large number of small subsistent farmers, especially on the land flooded at that time normally at least once a year. Now CODEVASF has given the regions a better infra-structure, while polders with drainage and irrigation facilities are created as well as small villages with schools and medical centres.

The project area for the consultancy is located in the Fourth District, the Lower São Francisco Valley in the State of Alagoas and Sergipe. In the lower São Francisco Valley the main economic activity is the production of rice. CODEVASF undertakes here an Intergrated Development Programme. The first phase of this programme is an Emergency Plan for the Protection of 17 000 ha of floodable lowland downstream of the village Propria, where the agriculture utilization of about 10 000 ha of irrigated rice will be done in polders by pumping systems. This will permit the irrigation and drainage of the lowland at any time, independant of the differences in the river water table. It makes it possible to harvest two crops of rice a year.

Of the 10 000 ha polders planned, more than 5 000 ha is already in use by farmers. At present the average rice yield per harvest is only 2 500 kg. The total area of the Integrated Programme in the Lower São Francisco Valley is 270 000 ha, covering 33 000 ha of lowland. This lowland, in Brazil called 'varzeas', will be put under protection by means of irrigation programmes at small-farm level. On the borders of the polders are areas of land available for horticulture and agriculture with sprinkler irrigation or for dry land farming.

FARMING IN THE PROJECT AREA

The history of the region

The regional farmers lived for hundreds of years traditionally with flooding the varzeas. This was more or less controlled by small dykes, about 1 m high, they had prepared. The small slopes in the varzeas and the dykes at several levels gave them the opportunity to manage the natural drying process on the parcels. Based on this system, they could start to plant rice around April and to harvest around September, spreading their planting and harvest time somewhat. In the lower parts of the varzeas they combined at that time rice growing with fishing. This fish came to the varzeas when they were flooded. For the farmers these floods not only gave the water required, but also some fertilizing by sediments.

The present situation

Now dams regulize the São Francisco river. Because of the possible increase in flow, the varzeas had to be protected. The CODEVASF activities, supported by the FAO and the World Bank, include realizing more or less permanent irrigation opportunities in the varzeas. This is carried out by making dykes, pumping stations and irrigation canals for serving opportunities to flood the fields (or in some cases to irrigate them by sprinkler systems).

Because of the high number of farmers and other labourers available in the region, and hardly other employment possible, small-scale farming must be accepted. The farmers in the region are mainly poor and the vast majority does not have any form of mechanization. One of the main intentions of the CODEVASF/FAO in this region is to get the farmers that far in their management that they produce two rice crops yearly on a small irrigation farm of only 3.5 ha, while they or others can grow crops like maize, cassava, beans, etc., on not-floodeable land. At present almost 85 % of the relevant (older) residents are illiterate. Most of them where in the past farmer or fisherman, some worked as shareholder, some just as labourer.

CODEVASF needed a couple of years to reconstruct the polders and to prepare the new irrigation facilities. During that time the farmers had no land or smaller areas. Some of them worked part time or in a full job for contractors, preparing their new polders.

The exploration of the new polders in their new form is based on individual irrigatable parcels, surrounded by soil dams. The parcels have a different size, but in general, they are very small (average field size only 25 m x 130 m = 3 250 m^2, 26 % of the fields no more than 20 m x 60 m = 1 200 m^2). Most parcels are not square, as the farmers made or modified their soil dykes within the fields according to the slope in the landscape. This small and various size of the parcels proves to be a serious handicap for optimal mechanization.

The irrigation system is based on concrete canals and in some cases completed to individual fields by soil ditches. So in this new situation the farmer has the opportunity to get water at the time of the year he wants and to grow two crops of rice yearly (in principle even five rice crops in two years is possible). The farmer, however, has to put more management in his rice culture. Because of the fact that all soil dams are not really tight, he has to plan wet and dry periods. He sometimes also has to make agreements on irrigation with his neighbours.

At present CODEVASF staff act as managers in the projects. In the first phase of the exploration of the new polders by the farmers, CODEVASF helps them with soil tillage and threshing too. CODEVASF needed heavy machinery for the reconstruction work. They have, beside of the tractors available, land construction and levelling machines, but also agricultural machines. This agricultural machinery park, such as disc ploughs, disc harrows and rotavators, are now in use to help the farmer to prepare his rice field. In general this is done under wet conditions. CODEVASF is for this agricultural contractor activity equipped with tractors up to 82.5 kW (110 hp). On wet land they use tractors of about 60 kW (80 hp) and soil tillage implements suitable for this type of tractors.

Farming in the future

CODEVASF has managers and further staff in each of the projects. CODEVASF also manage the pumping stations and the irrigation. It is, however, the intention to transfer the organization of the projects in farmers cooperatives. The idea include not only the direction of the polders and selling and buying of products for the farmers, but also cooperative drying, storage and milling capacity for some agricultural products, especially rice.

In this context it can be a normal proces to stop CODEVASF' contractor work too. This, however, only is possible if another solution is available, at least for the soil tillage work and for threshing. In this frame two lines of mechanization are possible and studied in the consultancy, one based on rather heavy machines in the hands of cooperatives or contractors, and one based on small machines for multi-farm use, or just for farm use.

MECHANIZATION POSSIBLE

Soil tillage experiments

In good cooperation with CODEVASF in experiments in 1982 and 1983 possible soil tillage methods were analysed in the project region to demonstrate their value for practice. Some results are summarized here:

1. On inundated land the disc plough works acceptable when there is no more than a few centimeters water. With a 60 kW (80 hp) tractor the capacity is 1 ha/4 hours. With the disc harrow on the same tractor we tested one, two or three passes with one week intervals. It was not possible to reach enough soil penetration or a good quality tillage. In a combination of first ploughing and two passes of a disc harrow the result is good. It cost however as much time as with a combination of one pass ploughing and one pass rotavating, namely alle together 6.4 hours/ha. Two times rotavating with a 60 kW (80 hp) tractor was also good. It however only cost 4.8 hours/ha. With a 2 m working width rotavator tested, the time needed for two passes (and resulting in excellent work) was only 3.0 hours/ha.
2. With a tractor of 27 kW (36 hp) one pass ploughing cost 5.2 hours/ha, one pass rotavating 4.1 hours/ha. With both implements the quality of the work was good. A combination of ploughing, later followed by rotavating gave excellent results and cost 9.3 hours/ha.
3. With the two-wheeled tractor of 9.75 kW (13 hp) the work of the rotavator was good (7.7 hours/ha; one pass). A combination of ploughing and rotavating gave excellent results and cost 19 hours/ha.
4. Also on dry land it is possible to reach with a plough a tillage depth of about 20 cm and a good quality. With a 3 disc plough on a 60 kW (80 hp) the time cost was 3.6 hours/ha. With a 60 kW (80 hp) tractor in inundated land and in dry land one pass with a disc harrow, however, only cost about 1.1 hours/ha (plough c. 4 h, rotavator 1.5-2.4 hours/ha). This difference in time-consumption explains the interest in practice for disc harrowing. In dry conditions, in which in general a disc harrow is used, tillage depth mostly is no more than about 10 cm. The effect in weed control and in decomposition of organic material is of no importance. Also after ploughing, when the disc harrow was used for a second pass, the result was not very good, due to an uneven surface.

Method of soil tillage advised

The method of soil tillage advised, based on the experiments and other experiences, is at first one pass with a plough (prefereable a mould-board plough) to a depth of about 20 cm, done on dry land. This has to be followed by inundation and, in at least a week after the first pass, by one pass with a rotavator. When the land is not dry at harvest and at the first soil tillage, but only under a few centimeters water, ploughing is still possible and advised. With more water two passes of a rotavator are an alternative. A soil tillage depth of about 20 cm is a necessaty:
- to get a good incorporation of harvest residues and weeds, which is favourable for a rapid decomposition of this organic material;
- to get in the second pass the 15-20 cm puddled mud (mixture of soil and water, rich on air), wished for rice growing.

The soil finally has to be completely level, which is a difference of no more than 2-3 cm. Furthermore there ought to be no weeds on or in the surface layer.

Possible levels of mechanization

For the agricultural mechanization in the reformed areas of tropical Brazil are possibilities at several levels. To get the farmer optimal involved and responsible in his crop production, mechanization at the level of (groups of) farmers (cooperatives) is advised. Because of the small farm size of only 3,5 ha, split-up on average in 12 fields (average size 25 m x 130 m = 3 250 m^2) small-scale mechanization is favourite. The smallest mechanization possible is based on animal traction (0,5 ha of the farm is in this case necessary for animal feeding). This adapted mechanization is available in Brazil. With small-scale mechanization and tractors, about 0,5 hp/ha (0,375 k/ha) is necessary.

With tractors the smallest level possible, based on the Brazilian market, is the use of Brazilian two-wheeled tractors of about 13 hp (9,75 kW). One tractor in this case should be used by 4 farmers. For the use of this type of tractor the driver has to walk in the mud and has to have power for turning the tractor. On this tractor also a small swath harvester is possible.

Small-scale mechanization with four-wheeled tractors cost about 1/3 more than with two-wheeled tractors. Also the capacity is somewhat higher, while the work for the tractor driver is much easier. Brazil has small four-wheeled tractors (two-wheel driven) of about 16 hp (12 kW). The axles of the tractor wheels, however, are at present not sealed for the use in water and mud, which is a disadvantage.

Medium-scale mechanization is possible with the use of tractors of, for instance, about 36 hp (24 kW). Available is a two-wheel driven type, adapted for the use in inundated land with sealed axles. This tractor, furthermore, has a light weight (2 100 kg) and a small track distance (120 cm). Because of the capacity it has to be used by 9-14 farmers). The price is about 172 % of that of the 16 hp small four-wheeled tractor and about 240 % of that of the 13 hp two-wheeled tractor (the capacity, however, is 300 % more, while only one tractor driver is needed). Large-scale mechanization has to be avoided.

Implements for small and medium-scale mechanization are available on the Brazilian market. In conformity to the general advise for soil tillage a plough and a rotavator are necessary. For two-wheeled tractors, as well as for small four-wheeled ploughs, there is a one-body mould-board or disc plough and a rotavator of 75-80 cm working width. For the medium-size tractor of 36 hp a 3-disc plough and a rotavator of 125 cm working width are on the market.

With the two-wheeled tractor also a rice transplanter (not available in Brazil) and a swath harvester are possible. The engines of the 16 hp tractor and of the medium-size tractor of 36 hp can be used for the stationary threshers, as in use in the region.

One pass ploughing and one pass rotavating cost with the 27 kW/36 hp tractor 8-10 hours (one day) per hectare. With in between each growing period two month for soil preparation a capacity of c. 45 ha is calculated.

Also the mechanization of transplanting rice, harvest and transport is possible. Rice transplanting in handwork has a lot of disadvantages. Using machines for planting rice in rows also offers possibilities for mechanical weed control.

For mechanical harvest a small combine harvester, based on a type of a thresher that is already in use in the region, seems to be a good start. The capacity, is with two man 3-4 hours/ha (1 000-1 500 kg rice). In this capacity the transport of the sacks is not included.

INTRODUCTION OF SMALL-SCALE MECHANIZATION

To protect the own industry, Brazil has import limitations. Most international companies have factories in Brazil. Almost all types of tractors and implements are available on the Brazilian market. In an agreement with the French institute Centre d'Etudes et d'Expérmimentation de Machinerie Agricole Tropicale (CEEMAT) they also produce implements for animal traction.

The distribution network for agricultural machinery is well-developed. The missing thing is education and training in machinery use, especially for small farmers and farm workers.

The farmer in the project area has at present mainly no agricultural machines. His know-how about their use is low. The introduction of small-scale mechanization therefore has to be supported by instruction, training and the availability of workshops in the villages.

Special credits can stimulate a type of mechanization desired. A guarantee for profit, however, hardly can be given. This is the weakest point. Good management within the cooperatives and a priority for the eduction of the farmer are key-factors.

Economic evaluation of tractor ownership and utilization in South-Sulawesi, Indonesia

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ABSTRACT

At prevailing prices, four-wheeled minitractors are unlikely to generate a positive return on investment. Investments in tractors are not financially sound, and the situation will become worse if tractor numbers increase and are concentrated in a limited area.

Several remedial measures can be suggested. First, increase the area per tractor served or capacity utilization by limiting the concentration of tractors. The economics of tractor use indicate that given a finite area, a high tractor population provides the potential for a short turnaround period for land preparation. Secondly, an inventory of all available power sources (manual and animal) used for land preparation should be made before introducing additional power. Third, official custom rates are misleading as a basis for computing costs and returns. An increase in the custom rate for tractors does not make economic sense, since alternative power sources are available at equal or lower cost. Customers can shift from using tractors if they feel tractor custom rates are unreasonably high. Another alternative is make tractors worth-while by increasing utilization for transportation and cultivating, not only irrigated lowland, but also rainfed dryland field.

Lastly, the government can give serious consideration to use of domestically produced machinery which increases the domestic value added, are more servicable, easier to operate and have a lower initial investment cost.

INTRODUCTION

The number of tractors in South-Sulawesi, Indonesia, has increased steadily from 25 units in 1974 to 1 658 in 1981, although these are concentrated in only a few districts. The increased number and concentration of tractors in turn has created concern that expanded competition for the limited contract market would decrease tractor utilization below an economically viable level. The extent of the market for on-farm and custom services bears directly on the profitability of tractor ownership. This paper analyses the economic aspects of tractor ownership and utilization to provide guidelines for future policy in this area.

OBJECTIVES

The general aim of the study is to investigate the private and social justification for use of tractors in South-Sulawesi. The specific objectives are:

- to determine the pattern of tractor ownership and the costs, benefits and break-even levels of tractor operation;
- to assess the optimal number of tractors given assumed conditions of initial investment and operating costs, capacity and the cost of alternatives;
- to determine factors affecting adoption and use of tractors;
- to assess the social profitability of tractor ownership and use.

Sampling procedure

Among the 23 districts in South-Sulawesi, Pinrang and Sidrap districts were selected as research sites. Factors leading to the choice of this area were: (a) tractors have been used there for several years; the first machine was purchased in 1969 and the number reached 508 in 1979, representing 40 % of the total tractors in South-Sulawesi; (b) the districts are predominantly rice areas, with good irrigation and wide-spread adoption of HYVs of rice and other crops.

Based on the concentration of tractors, eight villages in the two districts were selected as sample areas; 149 tractor owners in the eight villages were included. Respondents were grouped according to the year the tractor was purchased. Five stratification or vintage groups, consisting of 10 tractors each, were randomly chosen, based on the year of purchase and level of operation from 1975 to 1979. From the five vintage groups, four groups were further delineated for analysis. They were the 1975 and 1976 vintage groups, the average of the entire 50 tractor sample (1975 to 1979) and the 1982 (newest) group. The observed receipts and expenses were employed in the case of the first three groups. For the 1982 group, we applied 1982 prices to the entire tractor group.

Methodology

Discounting techniques were used to estimate: (1) the private (financial) profitability of tractor ownership and use; (2) the magnitude of changes in a specific variable necessary to reverse a decision among alternatives (sensitivity analysis), and (3) the social profitability of mechanized land preparation.

ECONOMICS OF MACHINERY USE

Evaluation of machinery ownership and use to determine the optimal tractor number for a finite area has important implications for mechanization policy and research. Consider that (1) the length of time required to complete a particular task in a given area is determined by the capacity and the number of machines available in the area, (2) the number of machines which can be operated at an economically viable level is determined by the cost structure and the prevailing custom rate, (3) the custom rate for a machine cannot be higher than the rate for alternative sources of power (human and animal), (4) custom rates for machines are low or maintained at a reduced level by the low cost of alternative power sources, (5) low custom-hire rates require that machines operate over a larger area to be economically viable, hence the number of machines in a given area is low and, (6) when the number of machines in the area is low, the time taken to complete the task is longer.

The implication is that the timeliness advantages of mechanization will not be achieved in practice until the cost of alternative power rises. The minimum number of hectares of machine operation required to break-even can be derived by calculating the maximum net present value (NPV) of the machine services over time (Table 1).

SOCIAL PROFITABILITY ANALYSIS

From the individual farmer's point of view, market prices determine private (financial) profitability. Shadow-prices are used in social (economic) analysis to measure the true value of goods to society. The financial analysis requires use of market prices and social analysis requires adoption of shadow-prices. The difference between the prices are caused by: (a) distortions in market prices make observed prices diverge from the real

Table 1. Revenues, costs and profits for tractors.

Revenue = area served (ha) x custom rate (Rp/ha)	=	R_1
Salvage value = 10 % of initial cost	=	R_2
		TR
Expenses		
fixed cost (initial cost)	=	C_1
variable cost		
fuel = liter/ha x price (Rp/l) x area served (ha/year)	=	C_2
oil = liter/ha x price (Rp/l) x area served (ha/year)	=	C_3
driver = average wage (Rp/ha x area served (ha/year)	=	C_4
repair and maintenance = average cost (Rp/ha) x area served (ha/year)	=	C_5
		TC
Profit (net benefit) = TR - TC		

scarcity value of production factors to the economy, and (b) market prices do not represent the socio-economic policy and objectives of the government.

In this paper shadow-prices are derived for: (a) tractor prices and services, (b) diesel fuel and oil, (c) labour and capital and, (d) the exchange rate. The net social profitability concept (NSP) is used to measure the net gains (losses) associated with economic activities when all commodity outputs produced and material inputs employed are evaluated at their social opportunity costs (through the use of shadow-prices).

Output of tractor ownership is the earnings from cultivation activities on the owner's farm and off-farm. Factors of production (inputs) used are the tractor, labour, capital, diesel and oil. The net benefit or cost to the rest of the economy, is assumed to be zero. The social analysis of tractors is derived from the utilization pattern for the average of the entire tractor group using 1979 prices.

RESULTS

The main factor affecting increased adoption of 4-wheeled minitractors in the study area was increased demand for custom work. Fig. 1 and 2 show that tractors have become very popular, as indicated by their increased utilization for land preparation.

Demand for tractor loans from government banks for purchase of tractors increased markedly up to 1979. The interest rate (12 %) was very low compared to the 20-30 % rate of other lending agencies.

Tractor owners are usually farmers or traders, have greater assets and are more educated compared with non-owners or non-mechanized farmers in the same area. To cultivate their own land was the most common reason (44 %) given for the purchase of a tractor. The benefits associated with tractor ownership were the potential for timely planting (29 %), followed by better land preparation (25 %) and reduced hired labour requirements (25 %). Only 10 % believed the tractor increased yield or reduced drudgery.

For the fifty sample tractors, 70 operators/drivers were employed. Most had only 1 to 2 years of experience in tractor driving, and were without any formal training in tractor use. The major reasons for being a tractor driver was to obtain a higher wage (44 %). Most were engaged in agriculture (88 %).

Figure 3 shows the tractor utilization for own and off-farm or custom land preparation. The total area served was larger in the wet than in the dry season and the annual hectareage shows a decline since the initial year of operation. This is due to declining capacity utilization and the increasing number of tractors in the area, which made competition keen. Own farm area served (13 %) is smaller than the area of custom work (87 %).

Table 2 indicates the profitability of tractor ownership and use. None

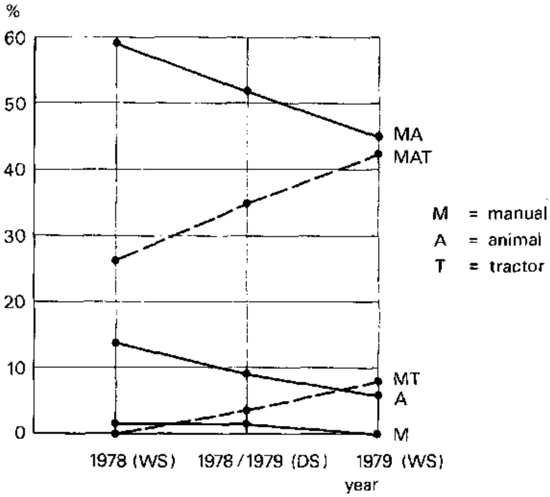

Figure 1. Power types for land preparation (household Census of 1 367 farms) in Pinrang and Sidrap Districts, South-Sulawesi, Indonesia.

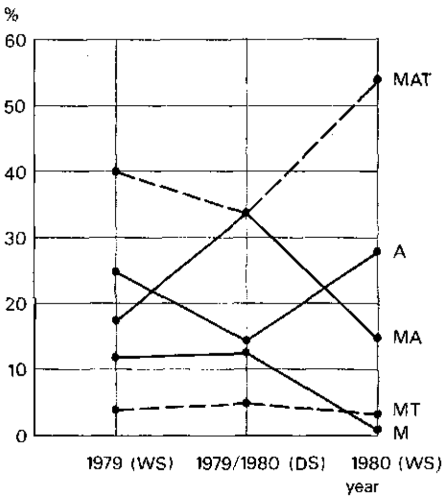

Figure 2. Power types for land preparation (Survey of 260 farms) in Pinrang and Sidrap, South-Sulawesi, Indonesia.

of the four groups were profitable, as indicated by BCR's less than one, a negative NPV and an IRR less than the opportunity cost of capital, with the exception of the 1982 group, and then only if the official custom rate is used. Analysis shows all tractor groups were under-utilized. At existing custom rates and capacity utilization, the minimum BEP was not achieved. Low custom rates were charged because low-cost alternatives (manual and

Table 2. Profitability analysis: BCR, NPV, IRR and BEP of 4-wheeled minitractors, South-Sulawesi 1975-1982.

	1975	1976	Entire group 75-79		1982 prices*	
			5 years	6 years	5 years	6 years
number of observations	10	10	150		150	
BCR (12 % disc.)	0.81	0.97	0.79	0.81	1.15 (0.93)	1.24 (0.99)
NPV (12 %, Rp x 1 000)	-539	-87.6	-743	-700	1 157 (-523)	1 893 (-24)
IRR (12 %)	<1	10.5	<1		18.4 (7.9)	20.0 (11.9)
area served (ha)						
break-even	60.37	55.19	62.79	54.64	38.07 (55.25)	33.12 (48.07)
actual	46.38	54.24	51.70		51.70	
custom rate (Rp)						
break-even	18 141	16 750	18 300	16 752	37 371	34 603
actual	15 439	16 586	16 194		45 000 (36 000)	

* Figures in parentheses refer to a 20 % custom rate reduction.

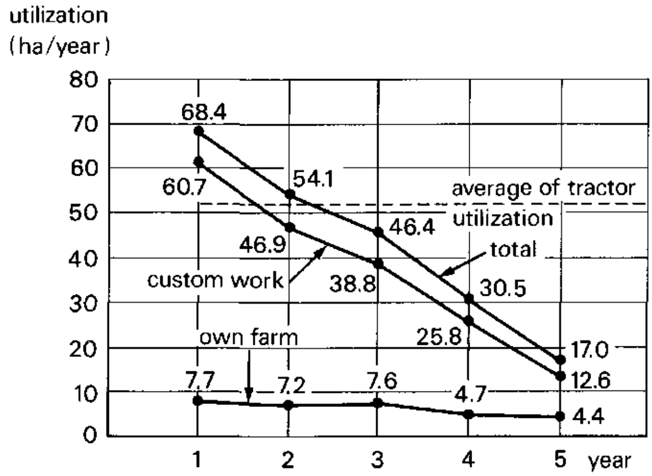

Figure 3. Four-wheeled minitractor utilization in Pinrang and Sidrap districts, South-Sulawesi, Indonesia.

animal) were available. The BEP can only be attained by maintaining the offical custom rate or by increasing annual utilization (area served).

The sensitivity analysis shows that changes in the contract rate results in large changes in the BCR, NPV and IRR. A 10 % increase in the contract rate will increase the BCR, NPV and IRR by 10, 73 and 23 %, respectively. A reduction in the contract rate has a very adverse impact on the BCR, NPV and IRR (Table 3). The NPV in particular is highly sensitive to capacity utilization and/or economic life.

Table 3. Sensitivity analysis: elasticities of BCR, NPV, and IRR with respect to stated parameters, using 1982 prices for average of entire group.

Parameter	BCR[1]	NPV[1]	IRR
capacity utilization	0.052	0.469	0.004
initial tractor price	-0.052	-0.367	-0.085
contract rate[2]	0.096 (-0.191)	0.726 (-1.452)	0.229 (-0.656)
interest (disc.) rate [3]	0.226	-1.629	-
economic life	0.078	0.636	0.154 (-0.13)[4]
economic life and capital utilization	0.048	0.327	-0.023
economic life and price	-0.048	-0.224	-0.026
economic life and contract rate	0.097	0.507	0.236

[1] Discount rate at 12 %.
[2] A 20 % custom rate reduction in parentheses. Assume a 10 % increase in the three first parameters and one year of economic life in the last four parameters.
[3] A 150 % increase in interest rate from 12-30 %.
[4] Elasticity of economic life to break-even area. The elasticities are defined as dy/dx and indicate the % change of the y-coefficient to a 10 % change (increase) in the relevant parameter x).

In South-Sulawesi, for a 100 ha area, the optimal tractor number is 3.0 units. With this tractor population, it requires 75 days per season to complete land preparation with an 8-hour work day and 2.5 days/ha. The custom rate would need to be Rp 20 000/ha to make it worth-wile for the tractors to complete land preparation within a two month period. Reducing the interval for land preparation requires an increase in the number of tractors and the custom rate. The tractor custom rate will not, however, be higher than alternative manual and animal power since farmers (customers) can switch to a competing power source (Table 4).

Table 4. Economics of machinery use, with given area and existing costs of operation.

	Average entire group[1]			1982 prices[2]			
	1	2	3	1	2	3	4
custom rate[3] (Rp. x 1 000 ha)	16.2	20 (25)	36	36	40 (50)	45	50
operating level for BE							
days/year	168 (248)	130 (130)	55 (83)	148 (218)	123 (128)	103 (150)	88
ha/machine/year	67 (99)	48 (52)	22 (33)	59 (87)	49 (51)	41 (60)	35
operating level on 1 000 ha at BE							
machine/1 000 ha	30 (20)	42 (38)	91 (61)	34 (23)	41 (39)	49 (33)	57
days to complete operations	75 (124)	60 (65)	28 (41)	74 (109)	61 (64)	51 (75)	44

[1] Tractor price Rp. 2 516 000/unit.
[2] Tractor price Rp. 4 500 000/unit.
[3] Figures in parentheses refer to unsubsidized capital cost (30 % r).

Comparative performance of selected village level grain grinding devices under dry milling condition

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ABSTRACT

Four milling devices, namely grinding stone, mortar-pestle, hand-cranked 'melon'-grinder, and a small 1.5 kW power-operated 'pepper'-grinder were compared in terms of capacity, fineness of flour, operational features and cost, keeping village level grain milling in view.

Traditionally, the grinding stones and mortar-pestle are more commonly used. The study revealed that the commonly available melon-grinders and pepper-grinders presently used mostly for melon and pepper grinding respectively, can be introduced for milling of sorghum grains.

The pepper-grinder gave an output of about 21 kg/h (dry milling), which gives a large advantage over the 1 kg/h output of mortar-pestle arrangement. Use of a melon-grinder gave an output of 4 kg/h, giving a 400 % increase over the mortar-pestle system.

INTRODUCTION

Grain milling is a trade term used relative to reduction of grain into flour. In Nigeria, various recipe demand two types of milling, namely dry and wet milling. For example, dry milling is done to produce flour for preparing a dish known as 'tuwo', whereas wet milling is done to prepare a recipe known as 'akamu' in the northern parts of Nigeria.

A feasibility study among the housewives in some villages in Zaria Local Government revealed that about 60 % of the housewives use traditional manual methods, viz. grinding stones and mortar-pestle, whereas the remainder uses both manual as well as power-operated (4-5 kW) burr mills, installed in villages on commercial basis. The study also revealed that some grinding equipment like melon- and pepper-grinders may have potential but have not been introduced into the villages yet (IAR, 1978).

This project was undertaken with the following objectives in view:

- to make a comparative analysis of selected milling devices which can be used at village level under dry milling conditions;
- to assess the economics and operational difficulties of the selected

milling devices.

The four milling devices selected for the study were: grinding stones, mortar-pestle, melon-grinder, and pepper-grinder. These were selected being the ones most commonly used for various milling operations.

DESCRIPTION OF SELECTED MILLING DEVICES

- Grinding stone. A stone, preferably of igneous rock origin, is carved out in a slab shape. Another small stone is carved out having an oblong shape with round ends. The material to be ground is placed on the slab and the shear force is applied by means of the companion stone. The surface of the slab is made rough for increased shear force (Fig. 1).
- Mortar-pestle. This device (Fig. 2) also has two components. The mortar (a wooden bowl in which the grain is crushed) and the pestle (a wooden rod with thick ends used for pounding or crushing the grain) are the two components of this device. Milling is achieved by impact force.
- Melon-grinder. The melon-grinder (Fig. 3) is a hand-operated burr mill which can be fixed on a bench or table. It consists of a pair of rough plates; one is stationary and the other rotates. The material meant for grinding is fed in between the plates. Size reduction takes place by crushing and shaering. Probably it assumed the popular trade name as 'melon'-grinder because it was used first to grind melon.
- Pepper-grinder. The pepper-grinder (Fig. 4) is a power-operated burr mill, and the principle of operation of this grinder is the same as that of the melon-grinder, except that it requires a 1.5 kW electric motor or any other equivalent power unit. It assumed its trade name 'pepper'-grinder probably because it was first used for grinding pepper together with other vegetables. This grinder is smaller in size and is also portable in comparison to the village mills installed in villages on commercial basis.

MATERIALS AND METHODS

- Selection of material. Sorghum (variety LS187) grains were used as test materials, because of sorghum being a staple food in Nigerian diet.
- Standardization of local sieve. Consumers at present do not have any parameter to characterize the quality of the end product. The quality of the flour is judged mainly by local sieves. Whatever material passes through the sieve is acceptable to the consumers and whatever can not pass through this sieve is either reground or is used for animal feed or discarded. The local sieve was selected according to the experience of the consumers, and it was decided to standardize the local sieve with respect to standard Tyler sieves. A sample weighing 250 g was passed through the local sieve and the percentage of the material which passed through the sieve was recorded. An equal quantity of the same sample was passed through

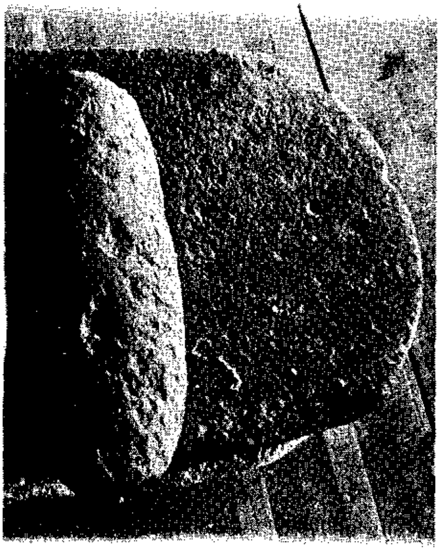

Figure 1. Slab and companion stone.

Figure 2. A woman with mortar and pestle.

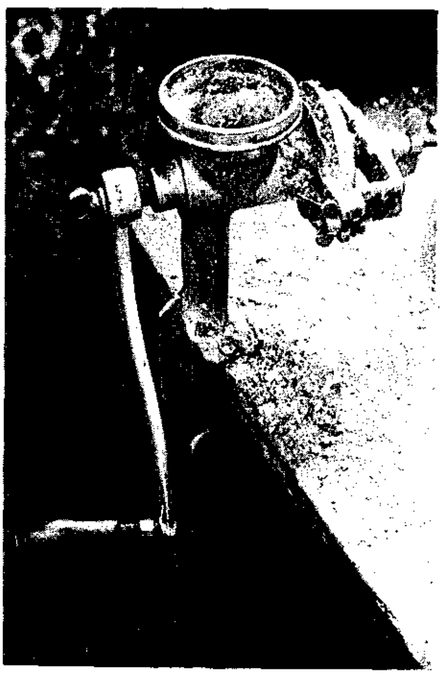

Figure 3. A hand-operated burr mill ('melon'-grinder).

Figure 4. A power-operated burr mill ('pepper'-grinder).

the standard Tyler sieves, having sieves of 3/8", 4, 8, 14, 28, 48, 100 mesh and pan. The percentage of the material which was retained on each sieve was recorded.

- Dry milling test. A known quantity of material was ground by each milling device and passed through the Tyler sieves and also through the local sieve. Two parameters were determined: (a) fineness modulus, and (b) uniformity index (Perry & Henderson, 1966; Mittal et al., 1981). Temperature rise in the case of each milling device was also monitored using a thermometer.

RESULTS AND DISCUSSION

- Standardization of the local sieve. The test results are summarized in Table 1. On the basis of these results the local sieve was characterized to be falling between 28 and 48 mesh, having size openings ranging from 0.29 to 0.59 mm.
- Milling. Table 2 contains the data for the analysis of finesess modulus, uniformity index and average particle diameter of sorghum grain milled by grinding stones. Similar parameters were also obtained for other milling devices. Table 3 shows the summary of the test results. The average diameter of the ground particles was minimum in the case of pepper-grinder (0.411 mm) and was maximum in the case of mortar-pestle (0.705 mm). The smallest percentage of milled flour passed through the local sieve in the case of mortar-pestle, which is also reflected by uniformity index. The rise in temperature during milling was found to be maximum in the case of pepper-grinder (14.1 °C) and minimum in the case of grinding stones (2.5 °C). It is not known whether the rise in temperature has a favourable or adverse effect on the quality of the final product. However, it is believed that high temperatures contribute to decomposition of the ground material, especially if the moisture content is also high.

COST ANALYSIS

It is assumed that the service life of all the milling devices is 5 years, after which the salvage value for all the milling devices except for pepper-grinder will be zero (Mittal et al., 1981). It is estimated that the salvage value of pepper-grinder will be 10 %. Annual usage of all the milling devices is assumed to be 500 hours. Pepper-grinder will require about 10 % of the purchase price for repair and maintenance, 1 % of purchase price for insurance and some added cost for power/fuel and relatively skilled operator.
Table 4 summarizes the cost analysis for these milling devices. It can be seen from Table 4 that the cost of grinding 1 tonne of sorghum is lowest if

Table 1. Standardization data of local sieve and Tyler sieves.

Parameter	Mesh	Size of sieve opening	Grinding stones		Mortar-pestle		Melon-grinder		Pepper-grinder	
			material retained on Tyler sieve	cummu-lative sum	material retained on Tyler sieve	cummu-lative sum	material retained on Tyler sieve	cummu-lative sum	material retained on Tyler sieve	cummu-lative sum
		(mm)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
material retained on Tyler sieve	3/8"	9.42	0	0	0	0	0	0	0	0
	4	4.7	0	0	0	0	0	0	0	0
	8	2.36	1.51	1.51	21.24	21.24	0.08	0.08	0	0
	14	1.17	26.35	27.86	95.06	116.30	12.44	12.52	2.8	2.8
	28	0.59	51.78	79.64	33.22	149.52	82.15	94.67	111.76	114.56
	48	0.295	88.77	168.41	34.73	184.25	81.57	176.24	48.67	163.33
	100	0.147	71.57	239.92	48.36	232.61	72.12	248.36	50.57	213.3
	pan		11.35	251.25	22.71	255.32	5.77	254.15	31.30	245.1
material retained on local sieve	-	-	-	147.12	-	100.19	-	132.72	-	138.23
percentage of material retained local sieve	-	-	-	58.55	-	39.24	-	52.23	-	55.42

Table 2. Analysis of fineness modulus and uniformity index of sorghum grains milled by grinding stones.

Mesh	Size opening (mm)	Percentage of material retained on the Tyler sieve (R)	Assigned number (N)	Product (N x R)	Classification of sieves	Sum of percentage of material retained on group of sieves (ΣR)	$\frac{\Sigma R}{10}$	Nearest whole number of $\frac{\Sigma R}{10}$
3/8"	9.42	0	7	0				
4	4.7	0	6	0	coarse	0.6	0.06	0
8	2.36	0.6	5	3.0				
14	1.17	10.6	4	42.4	medium	31.2	3.12	3
28	0.59	20.6	3	61.80				
48	0.295	35.2	2	70.40				
100	0.147	28.5	1	28.5	fine	68.2	6.82	7
pan	-	4.5	0	0				
		100		203.1				

$$\text{Fineness modulus} = \frac{\Sigma (N \times R)}{100} = \frac{203.1}{100} = 2.03$$

Uniformity index = 0 : 3 : 7.

Table 3. Dry milling performance data for the milling devices using sorghum grain at 6 % m.c. (d.b.).

Milling device	Capacity (kg/h)	Percentage of flour passed through local sieve	Fineness modulus (M_f)	Uniformity index*	Average diameter (D**) (mm)	Temperature rise during milling (°C)
grinding stone	2.86	58.55	2.03	0:3:7	0.434	2.5
mortar-pestle	1.05	39.24	2.76	1:5:4	0.705	3.1
melon-grinder	4.11	52.23	2.09	0:4:6	0.443	6.4
pepper-grinder	21.71	55.42	1.98	0:5:5	0.411	14.1

* Uniformity index refers to the proportions coarse: medium: fine.

** Average diameter of flour particles (D; in mm) = 0.104×2^{M_f}

Table 4. Summary of the cost analysis of milling devices.

Milling device	Purchase price* (₦)	Capacity (kg/h)	Total cost per year (₦)	Cost per ton (₦)
grinding stones	5	2.86	151.15	106.0
mortar-pestle	15	1.05	153.45	292.0
melon-grinder	30	4.11	157.90	76.8
pepper-grinder	500	21.71	406.50	37.4

* In 1983 1 ₦ = US$ 1.30.

ground by the pepper-grinder (₦37.4) and is highest if ground by the mortar-pestle (₦292). (In 1983 1 ₦ = US$ 1.30).

OPERATIONAL DIFFICULTIES

The melon-grinder is a simple device and a housewife can be trained to use the grinder and to clean the burrs. The pepper-grinder is already widely used for tomato paste making. Its usage can be demonstrated. The village artisan can repair and maintain the grinder. The pepper-grinder should give less operational difficulties in comparison to the traditional (4-5 kW) burr mills already working in the villages.

CONCLUSIONS

The traditional milling devices, namely grinding stones and mortar-pestle are labour-intensive and costly in the long run. The 'melon'-grinder and 'pepper'-grinder are improved devices in terms of labour economy and quality of the flour. The 'melon'- and 'pepper'-grinders turn out to be cheaper in the long run.

The cost of milling a unit tonne of sorghum was found to be the lowest (₦37.40) in the case of pepper-grinder and was highest (₦292) in case of mortar and pestle. However, the purchase price of the 'pepper'-grinder could be rather too high for an individual ownership but may be rented on custom or cooperative basis.

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Planning the demand for agricultural machinery

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INTRODUCTION

In planning future development of low income countries the agricultural sector is an important component of such planning. The reason is that agricultural development is essential to meet the increasing demand for food and to increase the economic position of the rural population. In this planning a key question is the needs for technology, indicated as capital resources for land clearing and land improvement, agricultural production as well as the processing and marketing of agricultural produce.

In this paper we primarily refer to the required technology for agricultural production involved in planning agricultural production projects. We discuss the various steps that have to be taken in preparing a prognosis of the future agricultural mechanization requirements, including the many assumptions to be defined. Also a practical example of a prognosis is presented: a prediction of the farm machinery market in Mali for the period 1981-2000.

THE PROCEDURE OF AGRICULTURAL MECHANIZATION PLANNING

In planning future development of agricultural mechanization a number of consecutive steps have to be taken.

Step 1

At first it is necessary to formulate the objectives and goals in terms of an increased agricultural production. This information will be derived from food strategy studies, national development plans and other sources of information that describe the demand of agricultural produce as well as the possibilities to meet this demand. It is of great importance when such planning documents also describe the actions to be taken in land development, land improvement, irrigation, soil conservation, seed production, fertilizer production, etc. These plans are based on the available resources, required for improved production, taking into consideration the agro-ecological conditions, the man-power capacity and many other factors involved.

Step 2

The next step is to collect information from the various agricultural regions what changes in the major farming systems from the actions mentioned under step 1 will take place in terms of: number of farms, size of the farms, cropping patterns, yield levels, required farm inputs and outputs. Through this procedure is it possible to get understanding about what changes on mechanization of farming level will be required to realize the planned production. This phase of the planning includes the identification of the existing operating methods in farm work: the tools and implements applied, the available energy sources and the relation between the demand and the supply of man-power.

Step 3

The next step is to determine changes in the farm operating methods and the farm inventory of tools and implements. Based on the results of agricultural mechanization studies and equipment tests, acquainted from local institutes or from elsewhere, the mechanization planner is supposed to indicate what improvements and changes of technology have to be installed. This step in the planning operation requires a broad and thorough experience of the planner, especially of his judgement capacity to select those types of farm equipment available on the (world-)market that fits best to the specific needs of the agricultural farming system and farm region considered. Often this will include recommendations to the government or other authorities to introduce still unknown implements in the region and to conduct practice-oriented tests and training. In the planning it is recommended to promote such innovations.

In selecting the appropriate type and level of agricultural mechanization special attention should be given to changes of the employment level in the rural areas. The employment level of the rural population in low-income countries is usually a matter of concern and the undesirable high rate of urbanization in many countries is the result of it. Agricultural mechanization in low-income countries can have an adverse effect on employment if not properly applied. By definition a machine is a labour-saving device. In the industrialized countries only through mechanization of agriculture the required man-power for industry could be made available. So its effect has been very positive. In labour-intensive farming systems this effect may also be considered as positive when by mechanization undesirable labour peaks can be reduced and operations can be performed better on time. The overall effect in countries with a high level of labour supply, however, should be aimed at an increase of the rural employment as a result of more intensive production systems and improved quality of farm operations.

Step 4

For each of the agricultural regions of a country the requirements of agricultural machinery has to be planned and the results be compiled to data for the country as a whole. The demand of agricultural machinery is influenced by several factors: change in number and size of farms; changes in the equipment inventory, the standards for replacement, and the speed with which innovations take place. For each of these factors assumptions have to be set that are based on the prevailing conditions. The result of the planning exercise is an estimate of the annual requirements of the major categories of farm implements for a certain country or other area unit.

Once this step is taken yet another step can be considered. That is how the supply of the equipment will be achieved as well as which supporting sources are needed to arrive at the planned level of agricultural mechanization including a sufficient degree of effectiveness: such as research and education in agricultural mechanization, financing, selecting the most effective use of machinery, the required spare part and repair services supply, etc.

Information on the future market of agricultural machinery in low-income countries is only limited available. One reason for this is that the statistical data often lack. In our opinion it is desirable to concentrate more of the efforts of agricultural engineers and others to find ways to extend and to improve information. It is essential for solving the world problems of food supply, and these problems can only be solved when sufficient attention is given to an appropriate supply of energy and implements for agricultural production.

AN EXAMPLE OF PLANNING: MALI

Early 1983 the authors of this paper have visited Mali to make an estimate of the required number of agricultural implements in Mali for the five year periods 1981-1996, 1986-1991 and further up to the year 2000. This information was asked for by the government of The Netherlands as an activity in its cooperation with the government of Mali and others, a.o. the World Bank. Three objectives were involved in this mission:

- to indicate which numbers of implements were needed to increase agricultural production in Mali;
- to justify assistance of the agricultural machinery manufacturing industry in Mali;
- to give assistance to an extension of research, testing and training in agricultural mechanization in Mali.

A detailed report including the forecast of the needs for agricultural implements as well as two plans of operations and financial budgets for an extension of research, testing and evaluation is on its way to be presented to the authorities mentioned before. In this paper we will concentrate on the methods of planning we have applied and only briefly we will discuss obtained results.

SOME STATISTICS OF MALI

General

situated in West-Africa, East of Senegal
size: 1.24 million km^2
population: 7.5 million (estimate 1982); 85 % rural
rate of urbanization per annum: 5.5 %
G.N.P. per capita (1981): US $ 114.-
national export (1980): 86.5 million Malinese Francs (250 MF = 1 Dutch Guilder = US$ 0.3); estimate for 1985: 109.4 billion MF
national import (1980): 183.8 billion MF; estimate for 1985: 214.5 billion MF (estimates 1985 on 1980 price level)
the import/export ratio is increasing

Agriculture

cropping area: 2.0 million ha
irrigation: 10 % of the cultivated area
rainfall: from less than 300 mm p.a. in the north to 1 300 mm p.a. in the utmost south
crop production (1978/1979)
grains: 1.2 million tonnes
cotton: 0.12 million tonnes
peanuts: 0.10 million tonnes

Since 1978/1979 the production of cotton and peanuts (both export/crops) is decreasing; grain production is increasing, especially maize.
number of food crop farms (1981): 490 000
number of other farms (livestock, fish): 160 000
average size of farm family: approx. 9
estimated size of cow herd (1980): 6.0 million
estimated number of working animals: 0.45 million (1982)

Agricultural equipment (1978)

ploughs for animal traction	129 000
multi-purpose toolbar for animal traction	58 000
carts for animal traction	78 000
seed drills for animal traction	16 000
harrows for animal traction	12 000

hoes for animal traction	16 000
knapsack sprayers	43 600
wheeled tactors	450
crawler tractors	465
tractor ploughs	303
tractor trailers	361
motorized sprayers	251
tractor seed drills	150
water pumps	1 430
motorized threshers	290

Hand-tools usually on the farms: hand hoes for tillage and weeding, sickles, knives, forks, scoops, etc. The total numbers in use are unknown.

The agricultural development of Mali

For the period 1981-1986 the government of Mali has prepared a five-year development plan based on food strategy studies conducted by the EC and others. For each of the seven regions of Mali detailed development plans have recently been described, indicating the projected increase of cropping acreages, changes in cropping systems and crop yields. Detailed data are also given on land clearing, land improvement, irrigation schemes, etc.

It is estimated that the grain production will increase from 1.2 million tonnes in 1981 to 1.7 million tonnes in 1986, 2.2 million tonnes in 1991 and 2.7 million tonnes in 2000. The degree of self-sufficiency will raise from 72 % in 1982 to 92 % in 1986 and 100 % in the year 2000. In the food strategy studies for Mali the following standards are applied: average daily food intake of 10.26 MJ energy value; 70 % of it in grains (21 % rice) and 30 % in fish, meat, eggs and other non-grains. In the plans it is assumed that the grain/non-grain ratio will not change. To meet this demand the cultivated area as well as the average yield levels will increase.

From the point of view of required farm equipment two facts are important:

- a change of the number of farm units;
- the percentage of farms that are equipped with farm equipment.

The future number of farms is influenced by the land development programme, the increase of the population, and the trend of urbanization. In Table 1 is given the estimated number of food producing farms based on the present rate of growth of the population of 2.6 % p.a. and two different rates of urbanization: 4.0 and 5.5 % p.a. In case of a reduced urbanization the average farm size will decrease from 4.0 to 3.6 ha.

Farming in Mali is predominantly family farming. During the seventies there has been a rather steady increase of the use of implements for animal traction. Oxen are the prevailing source of energy. About 50 % of the farms is linked with a regional semi-government organization for the distribution

Table 1. Number of food producing farms during the period 1981-2000 for two rates of urbanization: 4.0 and 5.5 % p.a. and a population growth of 2.6 % p.a.

Cultivated area (x 1 000 ha)		4.0 %	5.5 %
1981	2 000	490 000	490 000
1986	2 120	550 000	540 000
1991	2 340	640 000	585 000
2000	2 520	715 000	640 000

of farm materials for marketing and extension (the so called farms encadrées). In general these farms are on a higher business level than the others, e.g. in 1981 were 227 000 (46 % of all farms) equipped with a plough or a multi-purpose toolbar; for the farms encadrée this was 72 %, and for the others 27 %.

In planning the needs for agricultural implements it is necessary to distinguish between requirements for replacement and requirements for expansion. The replacement standard is influenced by the intensity of use and the level of capital and repair costs of the implements. For each category of implements the economic lifetime has been estimated (Table 2). In the prognosis the expected change of technology as a result of the introduction of improved implements and changed farm practices has to be incorporated. As an illustration three of such changes are briefly explained:

1. In one of the irrigation schemes of the Office du Niger a rehabilitation programme is in execution that enables the individual farmers to improve their farming operations and to achieve higher yields. Improved equipment for land levelling and tillage has been introduced successfully. In cooperation with foreign industry during the period 1982-1983 about 1500

Table 2. Projected requirement for agricultural implements in Mali during the period 1981-2000. Lifetime 20 years (toolbar: 16), 4.0 % urbanization (x 1 000). Percentage of farms equipped in 1981 and 2000.

Implement	Percentage	1974/1981	1982/1986	1987/1991	1992/2000
ploughs/toolbars	55 (46)*	16.2	16.3	20.3	24.0
seed drills	25 (9)	5.0	7.5	14.0	18.0
harrows	50 (4)	1.3	2.5	2.5	3.0
land levellers	- **(0)	-	0.3	1.3	2.0
hoes	- **(3)	-	0.3	1.3	2.0
carts	55 (20)	8.0	16.3	20.3	24.0
		30.5	43.2	59.7	73.0
Oxen (8 years worklife)	55		34.6	39.0	49.3

* Percentage of farms equipped in 1981.
** Only in certain areas.

improved oxen ploughs have been made available to the farmer with success. In 1984 this will be continued.

2. In Mali large stationary threshers, operated by the 'Offices' carry out threshing. High costs and high product losses are involved in this system. It is expected that small and medium-size threshers, operated by the farmers, will replace the large threshers.

3. For dry land farming in southern Mali, with cotton as the most important cashcrop, some years ago about 80 small four-wheeled tractors of a tool-carrier type have been introduced mainly to farmers that are far above the average size (20 ha and more). A further introduction of farm tractors will depend on the capital cost ratio of tractors and work animals. However, as Mali has a rapidly growing farming population, a large size cow herd and much experience in working with animals, the authors do not expect a remarkable tractorization during the planned period.

In the planning procedure various scenario's were applied:

- rate of urbanization of 5.5 and 4.0 %;
- lifetime of the implements, e.g. ploughs, 10, 15 or 20 years;
- the percentage of the farms equipped with a plough or toolbar and a pair of oxen: 46, 55 and 65 %.

In Table 2 is given the average requirement of some important groups of implements, mainly oxen-drawn equipment for a rate of urbanization of 4,0 % p.a. and a lifetime of 20 years (toolbar: 16). The percentage of farms equipped with implements and the average sales for 1974/1981 are also given.

For rice threshing it is expected that for the three periods an average annual number of threshers is required of 56, 138 and 210 machines. The prognoses has been limited to the categories mentioned. As already noticed we do not expect a substantial change in tractorization. Except for land improvement schemes and some large scale operations, it is evident that the average farmer will continue to use animals for work. The large breeding stock of cows in Mali will be able to provide sufficient oxen for work.

Local manufacturing

Mali has one industrial type agricultural machinery manufacturer, the Société Malienne d'Étude et de Construction de Matériel Agricole (SMECMA), located at the capital Bamako. It is a semi-governmental company with permanent working force of about 200. Since its foundation in 1974, an annual average of 36 000 implements with a total value of FM 2.0 billion has been produced, mainly ploughs, toolbars, carts, harrows, seeders, hoes and tractor trailers. The average added value by SMECMA was about 30 %. In 1981 and 1982 there was some recession, like in other West-African countries and outside Africa.

In the past some agricultural implements have been imported, mostly from Senegal. The average value of the import during the period 1974-1982 was about 10 % of total annual sales.

From Table 2 we can conclude that in order to fulfil the planned production goals for the three projected periods the demand of agricultural implements will be increasing. From an average demand during the period 1974-1982 of 30 0000 implements this demand will increase to approximately 40 000, 50 000 and 70 000 implements per annum. From this it can be concluded that it is justified to extend the facilities for manufacturing in Mali. However, three conditions should be considered:

- by introduction of improved and new manufacturing technology the locally added value and the manufacturing quality should be increased;
- the industry should be enabled to produce newly developed improved implements such as ploughs, toolbars, seeders and threshers;
- export of farm equipment should be promoted; both export as well as import depend on the government policies in the region, as well as the strength of competition from abroad.

Blacksmith training

In Mali here are about 200 blacksmith workshops involved in repair services and spare part supply. Because of their vital role in rural mechanization, it is important that training programmes and credit facilities for inventory improvements should get full attention. It was noticed that in 1983 such a training project was in operation.

CONCLUSION

The example of agricultural mechanization planning for Mali demonstrates the complexity of planning of future required technology. The quality of the results is never better than the quality of the assumptions incorporated in the planning exercise. By changing factors such as the expected lifetime of equipment, the figures will be changed. The value of such a planning procedure, however, is that the influence of such changes can be evaluated better than without the use of a quantitative analysis.

As soon as the report is distributed, it is planned to discuss it with the local authorities in Mali and to revise it when necessary.

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Mechanization of small-scale peanut farming in the Caribbean

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INTRODUCTION

In this paper I am presenting the pioneering work carried out by the Caribbean Agriculture Research and Development Institute (CARDI) in agricultural engineering aspects, more specifically research and development in the areas of crop production and primary processing at farm level. Major part of the work was carried out under the European Development Fund sponsored Peanut Production Technology Project. Though the Project functioned in five territories of Belize, Antigua-Barbuda, St. Vincent and St. Kitts, the paper is presented more in relation to St. Kitts.

CARDI is a regional organization which was established in 1975, to serve the agricultural research and development needs of the twelve member countries of the English speaking Caribbean Community (CARICOM): Belize, Guyana, Jamaica, Antigua, Montserrat, St. Kitts-Nevis, Dominica, St. Lucia, Barbados, St. Vincent, Grenada, and Trinidad and Tobago. The Institute's funding comes from a core budget which is provided by the member countries and from project funds. Donor agencies currently funding projects include the USAID, EDF of the European Economic Community, IDRC Canada, Caribbean Development Bank, CIDA, UNDP, FAO of the UN Overseas Development Administration (UK) and Barclay's Bank International.

Peanuts have been cultivated in the West Indies for long on a small scale. Subsequently, in islands like St. Kitts, it was grown on a large scale up to 500 acres in late 1970 by the National Agricultural Corporation on land that became fallow between two crops of sugar-cane, and as a result the small farmers' annual crop of fractions of acres dwindled. The very small-scale operation perhaps never needed to be mechanized. The large-scale operation was carried out with modern heavy tractors, and tractor-mounted planters, plant protection equipment and digger-shakers. But inter-cultivation and threshing were never mechanized and were left to be done with hand labour, more to provide employment during the slack season when there is no cane cutting and crushing. The cost of production was of secondary importance. In the large-scale sector also acreage got reduced to less than 100 acres in 1982. The 1982 cost of production figures/acre, in East Caribbean Dollars (EC $), were:

land preparation	168/acre
cost of seed plus shelling	220
planting (mechanical)	97
pre-emergence insect control	46
manual weed control (long handled hoe, plus pulling weeds out by hand)	302
insects and diseases control (4 applications including material)	205
digging and de-poding	243
cleaning, selecting and bagging (by hand)	207
total	488/acre

The average yield in St. Kitts over the last three years was 1 159 lbs/acre and the price per pound of peanut fixed by the Central Marketing Corporation is EC $ 2.40, bringing in total returns and net profit of EC $ 2 781.6 and EC $ 1 293.6 per acre, respectively. The small-scale operator's marging of profit must be less as the labour requirement is much higher.

The annual production in the CARICOM is little over 1 000 tonnes; imports from extra-regional sources are about 6 000 tonnes, and the internal market is therefore vast. The council of ministers of agriculture of ECCM has recently passed a resolution emphasizing the production and processing of peanut in the Less-Developed Countries (LDC's) of the Caribbean. In his annual report for 1981 Dr Haque, project leader, states: "Taking into account the strength and weaknesses of Caribbean agriculture, no other crop has as much potential or is as versatile as peanut, both for small-scale and large-scale production" (CARDI, 1981). The market value of the main crop of the Caribbean, namely sugar-cane, has come down to about a third of what it was a few decades ago, whereas peanut has forged ahead in value about three times in the recent past and has become the highly sought-after snack-food material.

THE CALL FOR SMALL-SCALE MECHANIZATION

It is expected that the bulk of the short-fall in peanut production will be met by the small-scale sector. The situation has changed, and to make a living comparable to other professions, a small peanut farmer has to cultivate at least 5 acres of the crop. Due to lack of attractiveness of farming the average age of farmers has been steadily going up with the younger generations migrating to other islands and other professions. "Farmers have pointed out that the non-availability of labour, particularly for harvesting, is the greatest bottle-neck. If the harvesting is prolonged the deterioration of peanut progresses. They further pointed out that it is difficult to manage more than one acre of peanut at one time without the help of machines" (CARDI, 1979). Similar is the case with lack of drying facilities in territories where there is incessant rainfall during the harvesting season.

Main constraints

The problem areas with respect to small-scale farming are:

- land preparation;
- planting;
- weeding and moulding;
- harvesting, and
- threshing.

Present level of mechanization

Sample surveys conducted by the author in different territories, including the larger ones, show that the total investment in agricultural tools and equipment per unit area farmed is low, compared with many other professions and other aspects of life of the farm family. The tools possessed are all hand-tools and those farmers are even not aware of the existence of wheeled manual implements, leaving aside small power-operated equipment (Table 1).

Past efforts in research and development for small-scale farming

Under CARDI: development and fabrication of treadle-operated peanut thresher by Mr. Jocelyn Grant, agricultural engineer, Jamaica.

Under the National Agricultural Corporation: (1) adaptation of the Hunt type metal, rocking type peanut sheller for local requirements of faster operation and cleaning arrangement; capacity: 27 kg/h, compared with 35-45 kg/8 hour day by a hand-picker; (2) design, fabrication and introduction of wooden crop drying trays for different crops; capacity: 200 lbs/h;

Table 1. Implements and tools on a typical 3-acre farm (Island St. Vincent)

Implement/ tool	Number of units	Cost per unit	Total cost* (EC $)
long handled hoe	1		15
4-pronged digging fork	1		110
cutlass	2	10	20
long handled rake	1		35
hand trowel	2	10	20
total	7		200

* Cost of farm implements per acre: EC $ 66.7.

12 trays stacked one above the other can hold 1 t approx.; cost EC $ 200/ tray, approx.

Strategy required

There is urgent need to improve the power utilization efficiency of existing manual power and also to introduce additional power, both mobile and stationary. Accordingly, work was taken up under two systems, namely manual and 2-wheeled tractor system.

MANUAL SYSTEM

Land preparation: development of the CARDI manual digger

The 4-pronged digging fork is the implement in common use for loosening the soil for planting. It is an efficient and modern implement, suitable especially for sloping areas. However, by virtue of the bending posture from which it has to be worked, and also because the main parts of the body which come into play are the hands and the back and not the legs, it is tiring and strenuous to work with it for sustained periods. The CARDI Manual Digger is a U-shaped digging tool which overcomes most of the drawbacks of the digging fork in land preparation work. The main force which has to be applied to push the implement into the soil, comes from the considerably stronger leg muscles, and only the lighter soil-breaking force comes from the hand and abdominal muscles. The design of the implement is such that the strength from the entire body can be harnessed in its working. It is a development from implements like the Grelinette of France and other similar implements existing in the US and other parts of the world. The Grelinette is considered to be 10 times faster than conventional tools for soil working.

Some of the developments carried out on the existing designs are:

- materials of construction and fabrication techniques were changed to available sources in the Caribbean;
- the spacing between the tines was reduced for the heavier soils of the region;
- the two end-tines were made removable to make it suitable for different conditions and workers of different strength;
- the bevel-angle at the tip of the tine was reduced from 25° to 15° for easier penetration in harder soils;
- the main frame was fabricated from 1 3/8" bore automobile muffler pipes, instead of the standard hollow rectangular section;
- as 7/16" high carbon steel rod could not be obtained in the island, the tines were fabricated of ½" D. M.S. rod.

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The force required to penetrate into the soil is:

area of cross-section of one tine	0.196 square inch;
area of cross-section of six tines	1.178 square inch;
average unit draught of sandy loam soils	5 psi (sandy or silt loams range);
total penetration force required	5 x 1.78 - 5.89 lbs.

Use of 7/16" high carbon steel round rods will reduce the force required for penetration by over 23 %. Preliminary trials have shown about 50 % more capacity in land preparation and harvesting root crops, compared with the fork. The implement may have special significance under West Indies conditions in weed control, especially deep-seated weeds like nut grass.

Planting

Farmers in the region plant peanut by the 'chipping process'. In this method small pits are made with the long handled hoe of about 6½" width, while the worker moves sideways. About 2-3" space is left between two adjacent chips. Following chipping the seeds are dropped by hand from the standing posture and they may land at any part of the length of a particular chip. Dropping the seed and covering it with the foot are carried out by the same person.

Drawbacks are many in the above method; foremost that the planting is far from being in clean lines, to facilitate use of row-crop implements for the subsequent operations, thereby increasing the cost of production of the crop greatly. Besides, the seed-to-seed spacing within the row can vary from a minimum of 3" to 16". As the average spacing will be about 9.5" the plant population will be half of about 80 000 plants per acre recommended by CARDI at a seed spacing of about 4.5". In short, the planting method is the crucial of operations, which sets the drudgery-tempo and high cost of production for the following operations.

Design and development of the CARDI Tyre Dibbler. Automatic push-type planters for manual operation or 2-wheeled tractors applicable to the variety of peanut or type of soil conditions need not always be available to every farmer, and they are also quite expensive. A wheel hoe or cultivator is more of a possibility on the farms, as they are simple and versatile. Dibblers of many types have been available in different parts of the world, but they are all independent implements and thereby expensive. The CARDI Tyre Dibbler is a concept by which many common wheeled implements can be converted into dibblers by mounting a metal tyre, having dibbling spikes over the existing wheel. It could help in planting peanut in straight lines, at proper depth and at optimum plant spacing. It can form a good Intermediate Technology between the prevalent chipping method and modern push-type automatic planters.

Application of the principle on existing wheeled implements. The Planet Junior wheel hoe. A tyre was fabricated in 3/16" x 2" M.S. flat to fit around the 15" diameter wheel of the implement and was bolted on to the wheel. The eleven spikes were of 3/4" diameter and 2" length, and they were tack-welded on the tyre radially, to achieve 4½" hole-spacing. A row marker of standard design, used in commercial push type planters, was attached to the hoe, completing its conversion into a dibbler. A simple frame had to be prepared for accomodating the length of the spikes.

The big wheel hoe. This is a gardening implement marketed by M/S Sears Roebuck of USA. A simpler and lighter version of this is also marketed by some firms in India. For the soil conditions of the West Indies the hoe was modified and made heavier and sturdier by the Belize centre of CARDI. An attempt was made to convert it into a dibbler, using the CARDI tyre dibbler principle, details of the materials used being the same as for the Planet Junior wheel hoe. The CARDI Dual row marker was attached to the hoe, to complete it as a dibbler.

Field trials. Trials were conducted at St. Kitts and St. Vincent, especially on the North Caroline variety of peanut, which has seed dimensions of 0.478" (major diameter) and 0.875" (length). Common push-type planters do not have suitable seed plates to accomodate such large seeds. The dibbling attachment gave holes of 1-1½" depth under optimum soil moisture conditions. The hole distance was 4½", and therefore it can be used to plant crops at seed distances of 4½" and its multiples. The row marker can give row spacings up to 24". It reduced labour requirement for planting peanut to about a third, compared with the chipping method.

Identification of automatic push-type planters. After extensive varietal trials, carried out under the guidance of Dr S.Q. Haque, programme leader, Peanut Programme, and Dr Don Walmsley, project coordinator, European Development Fund Peanut Technology Development Project, CARDI recommended two varieties of peanut for cultivation in the region, viz. the traditionally-grown small-kernelled Tennessee Red (TR) and the new-comer, the larger-kernelled North Carolina 2 (NC 2). The length and major diameter the seeds are: 0.55" and 0.35" (Tennessee Red) and 0.478" and 0.875" (North Carolina 2). In this investigation an effort was made to locate suitable walking planters for the two varieties.

Planter for Tennessee Red. The engineering characteristics of several designs were carefully examined and two units of the Precision Garden Seeder, Model 1001B, manufactured by M/S Earthway Products Inc. (Bristol, Indiana) were procured as prototypes. Of the 6 standard seed plates supplied, the plate meant for peas of part No. 1002-18 was tried out for planting Tennessee Red. Of the 12 seed cells the alternate ones were closed with masking tape, to get suitable seed-to-seed distance, which was 5½", compared with the 4" optimum recommended by CARDI. The row spacing was kept at 16", according to which the seeding rate was 75.63 lbs/acre, and the possible plant population was 71 280 per acre. The average speed of travel was 1.94 miles/h. Accordingly it will take 12.75 hours for one man to plant one acre of peanut at 16" row spacing with the machine, compared with the 96 man-hours required for the chipping method.

Planter for North Carolina 2 variety. Efforts were made to develop a metal seed plate with seed cells large enough to accomodate the N.C. 2 seed. Simultaneously the manufacturers supplied a special seed plate by inserting three additional seed cells in their standard plate of No. 1002-27 for Lima beans. In laboratory and field trials, carried out with both the above plates, it was observed that though the plates were able to meter the seed, the seed delivery tube of the planter got choked, due to the large size of the kernel, and this approach had to be abandoned.

Subsequently, a unit of the precision sowing machine 'Gombei', model HS-300, manufactured by M/S Mukai Kogyo, Inc. (Osaka, Japan) and marketed by M/S INPAG Inc. USA was procured. Its design characteristics are:

- seed metering system	by a link belt conveyor cassette and an endless belt conveyor cassette
- power transmission	shaft and bevel plastic gears
- furrow opener	shoe type
- seed covering device	spring-loaded pressing plates
- row marker	yes
- versatility	suitable for a.o. peanut, corns, rice, beans, sorghum, peas, spinach, buckwheat, wheat, burdock, white raddish, onions, carrots, turnip, cabbage, lettuce
- cost	US $ 141.60
- weight	6.5 kg

Link belt No. 26138 is observed to plant N.C. 2 satisfactorily. At a row spacing of 18" it will take 11.33 hours for a single person to cover 1 acre, walking at an average speed of 1.94 miles/h. The seed will need grading to ensure uniform sowing, as ungraded seed gave muliple seed metering.

The suppliers have recommended link seed belt No. 20107 for Tennessee Red, which is to be procured and tried.

CARDI dual row marker for walking planters. This row marker was developed as an accessory for attachment to push-type tyre dibblers, developed from wheel cultivators, etc. Row markers available in commercial planters need to be lifted by hand and re-engaged on the planting side at the end of each row by the operator, which involves additional effort and loss of valuable time. This investigation was an effort to design a row marker which can be engaged by the operator without having to physically turn it over by hand. The simple device consists of a V-shaped ½" bore conduit pipe pivoted at the inside of the V, which is of 115°. There are two marker fingers on two arms, instead of the one in conventional row markers, which can be fixed at desired length away from the middle. The row marker, which is free to swing to both left and rigth sides, works on the principle of the first lever, and can be engaged by the operator simply by tilting the whole implement towards the side desired. The extent of tilt will depend upon the weight of the marking fingers.

Gap filling or supplying in planting. This is an operation workers generally shun, perhaps because it is an odd type of job, and often it gets postponed and ultimately abandoned, being late, affecting the final plant population and thereby the yield profoundly. In trials, carried out at St. Kitts with some models of Jab Planters, it is observed that this secondary operation can be go done conveniently (Table 2).

One or two units of all the six push-type weeders (Table 3) were procured early and given extensive trials on different crops, especially peanut (both varieties). They have also been tried at the CARDI Antigua and St. Vincent Centres. Under optimum soil moisture conditions and while the weeds are not too high, one man could cover on the average 3/8 of an acre, in a 6½ h working day, or in other words it will take 17.33 man-hours to cover 1 acre. All the trials in St. Kitts were carried out on crops planted

Table 2. Different Jab-type planters procured and tried

	Manufacturer/ supplier	Cost (US $)
Jab Type Planter Model HP-SBA	Allan Machine Co., Ames, Iowa	63
Spade Potato Planter, Model 7000	Earthway Products, Inc., Bristol, Indiana	20

Table 3. Identification of push-type weeders for the manual system.

	Manufacturer/ supplier	Cost (US $)
Cult-A-Eze Garden Cultivator Model 6000-B tools: slicing hoe furrow plough 5-tined cultivator mould-board and hilling plough	Earthway Products Inc. USA	43
High-Wheel Cultivator cutting tools: seed furrow shovel mould-board plough 5-shovel cultivator	CARDI, Belize	(BH $ 110)
Big-Wheel Cultivator Model 1501A cutting points seed furrow shovel mould-board plough 5-shovel cultivator	Sears Roebuck USA	43.99
Planet Junior Garden Plough Model No. 19 6555X cutting point: Sweep Model 39999	D.H.Tilmor Co. Inc., Hinesburg	75
Garden Tender 1411A Model cutting points: scuffle knife furrow shovel and row marker 5 cultivating shovels rotary hoe with 40 cutting points	Cumberland General Store, USA	42.81
Ro-Ho cutting points: scuffle knife 5 cultivating shovels rotary hoe with 40 hoe points	Rowe Enterprises Inc., Cincinnati, Ohio	20.50

or sown on the flat.

As to performance and workers' preference-wise their placement will be as:

No. 1 position: Cult-A-Eze Garden Cultivator, Model 6000-B

No. 2 position: Planet Junior Garden Plough, Model 19 6555X

No. 3 position: a. Garden Tender, Model 1411A

b. Ro-Ho

No. 4 position: Bigh-Wheel Cultivator, Model 1501A

No. 5 position: High-Wheel Cultivator, CARDI, Belize.

Between Garden Tender and Ro-Ho, the former is built sturdier and has the additional feature of a seed-furrow opener and row marker, and is preferable, though double expensive. Between the Big-Wheel Cultivator, supplied by M/S Sears Roebuck, and the High-Wheel Cultivator, developed at CARDI, Belize, the former was better-balanced, lighter and considerably easier to work with, the area coverage being about twice as much, compared with the latter. There was excessive clearance between the axle and hub of the latter, and the workers found it difficult to hold it upright during work. It was also much heavier (2.6 lbs against 13 lbs of the Sears model). The Sears model was also a folding type for easier transportation to other fields.

Harvesting

Harvesting is one of the five, constraints which at present makes peanut cultivation unattractive. The practice followed is that of just pulling out by hand. Firstly, it is expensive with respect to labour. Secondly, the cut-off percentage of good quality kernels is higher than usually expected. To a great extent cut-off percentage depends directly on the top soil-moisture content. If a farmer is fortunate enough to have had a crust-softening-shower on the previous night, he can expect a considerably higher recovery, and on the consecutive day, when the crust would have hardened back, he may lose an additional 5 % or so.

Cutt-off losses are observed to take place in two ways, namely while the tap-root along with some nuts come out, some of the individual nuts are left in the soil, either without the pegs or along with the pegs. The other type of cut-off loss is total, that is the tap-root along with all the nuts remain in the soil and only the stems break and come off at the root joint. Plants having equal number of nuts below, but having weaker stems by themselves or by partial drying up due to late harvesting, are observed to fail in latter manner. In a recent survey it was observed in St. Kitts that 2 out of every 10 plants (or 20 % of the plants) failed so. It is a common sight to see harvested fields fully covered with freshly sprouted plants in a few days time, giving the impression that the field has been replanted!

The total cut-off losses from both aspects is observed to be about 10 % under average soil-moisture conditions. In certain islands, like St. Vincent, pulling out by hand is immediately followed by digging with a hand trowel at the particular plant site to recover the rest of the pods. Another approach is allowing interested people to research out the lost pods and then handing over a certain percentage of it to the farmer, which is usually 50 %. Both these methods call for additional man-hours in harvesting.

I have not come across any study using penetrometer readings to arrive at a curve giving soil crust hardness versus percentage cut-off losses, which may be worth making. The above indicates the real need for suitable digging tools in order to make a larger recovery. Accordingly, efforts were made to design and develop suitable harvesters, both for manual and 2-wheeled tractor operation.

Manual digger. Improving the utilization efficiency of manual power in this operation can form an important factor in small-scale peanut farming in the Caribbean, where much of the land is in higher degrees of slope. Tools which are good for loosening the soil in land preparation, should also form satisfactory peanut digging tools, as the principle involved is similar. Accordingly, the 4-pronged fork, in common use for land preparation, is also a tool used for digging. However, due to its limited width, it can dig only one or two plants planted at the recommended row spacing of about 4". Therefore the CARDI Manual Digger, mentioned earlier in this paper, was tried out for peanut digging. As the soil crust was hard on the day, the outer two tines of the digger were removed. It was observed that the digger was 25 % faster than the digging fork.

The tines of the diggig fork are continuously tapering, while those of the digger have only a bevel cutting end at an angle of 20°. Further efforts as such are in progress on improving the shape of the tines. It was also observed that werever the crust was hard, the tines cut through the soil and emerged out without uprooting the plant. The reason for this could be that the digger tines are round, whereas the fork tines are square taper.

TWO-WHEELED TRACTOR SYSTEM

Design of CARDI 2-wheeled tractor toolbar

The 8 hp Howard Dragon from the UK was one of the tractors considered under the 2-wheeled tractor system. It has several factors in its favour for peanut cultivation, and thereby its adoption in the Caribbean. It is, however, not provided with a toolbar for attaching drawbar-type implements, such as shovel cultivators, digging blades, etc.

A 22" long toolbar, made of ½" x 1½" T-section along with 2 U-clamps of simple design, was therefore designed and fabricated. The hitch arrangement to the tractor was developed. The toolbar has a series of slots at both its ends to which drawbar-type implements could be easily clamped, and used. The clamps provide for depth-adjustment without any special tools. The design is based on the 'Sine Hoe' toolbar, designed by Mr Gene Nolle of France.

Selection of planter for 2-wheeled tractors

Seeder fertilizer (Garden Tractor Mount), Model No. 9000B. Though the unit is primarily meant for small 4-wheeled tractors in the States, as its features seemed interesting with reference to peanut planting, a unit was procured and evaluated. The results obtained so far have been most promising.

Broad specifications:

number of rows	1
furrow openers	shoe type, depth-adjustable
number of seed plates	7 to plant more than 20 varieties vegetable seed
hopper capacities	seed: 1 quart
	fertilizer: 25 lbs
cost	US $ 184
weight	36 lbs

Calibration. None of the 6 seed plates supplied was meant for peanut. Plate No. 9010-8 meant for peas, and plate No. 9010-4 meant for Baby Limas were selected for NC 2 and TR, respectively. The averages of 15 consecutive seed spacings for the two plates were 4.47" and 5.55", respectively.
Field trial. After preliminary trials 6 rows each of NC 2 and TR were planted, the length of the rows being 152'. Based on the time taken, it will take almost 9 man-hours and tractor-hours to plant an acre. The Howard Dragon was run in the first gear and throttle setting was kept at half. At higher throttle positions there was tendency for the seeds to collect in the seed delivery tube and ultimately bring about full choking of the metering mechanism.

Interculture
Design of 2-tined cultivator. Weeding by hand, which is the current practice even in large-scale cultivation, is one of the expensive cultural operations that reduce the percentage of returns to the farmer. The narrowest rotavator available for the Howard Dragon tractor is of 18" width. The row spacing recommended by CARDI is also 18" and the rotavator cannot naturally be applied. Therefore a 2-tined cultivator attachment for the CARDI 2-wheeled tractor toolbar was developed. It was equipped with 7"-size duck-foot shovels, and could take other common types of cutting points, such as sweeps, hillers, etc.

Field trials show that equipped with 10" sweep points the cultivator can cover about 12-13" of the cultivable inter-row space, leaving only the intra-row space between the plants to be attended to with hand-tools, like the long handled hoe, reducing the man-hour requirement for weeding to about a third.

Narrow slasher rotors on light-weight 2-wheeled tractor (Wolsely Cadet, 3 hp, Model AC3409):

narrow slasher rotors	Model No. 2547
width	9½"
cost	Br. pounds 17.55 (1 Br. pound = EC $ 4.00).

The Cadet is a light-weight (89 lbs) baby 2-wheeled tractor without different gears. Weeding of peanut rows was carried out with the narrow rotor which has all the 8 blades inward facing to avoid damage to crops. The tractor was run at full throttle speed. Ground speed obtained was about 1.5 miles/h; depth of cut 2½", and width covered 13-14" out of the 18" inter-row space between the lines. The field capacity obtained was coverage of 1 acre in 8.25 hours. Accordingly it will take 8.25 man-hours per acre.

After the narrow slasher rotor operation, further 1-2" on each side was cut with the Hi-wheel hoe (Sears Roebuck), Model 1501A, fitted with the mould-board plough part No. 10219. This astride-row cultivation requires 17 man-hours per acre.

The above two operations together covered 15" space between the rows, leaving only 1½" on each side of the plant line. The intra-row cultivation may have to be covered either by long handled Dutch hoe or by hand trowels.

Harvesting

CARDI U-type peanut digger. For digging with the 2-wheeled tractor, an U-shaped digging tool having a cutting blade of 5" width and 12" length was designed and fabricated. It can be mounted on the 2-wheeled tractor toolbar developed. In field trials conducted, it was observed that it can cut to a depth of 10" or more, and it cuts the tap root and pulverizes the soil slice cut out, enabling the plants to be lifted off by hand easily. In harvesting NC 2 at 1.5' row spacing, the rate of working obtained has shown that it will take 12.28 man-hours as well as machine-hours to harvest one acre with the blade working with the 8 hp Howard Dragon tractor, digging 1 row at a time. Digging with the blade reduced the cut-off percentage to almost nil, compared with about 10 % losses in pulling out by hand without loosening with any digging tool. After digging with the blade, lifting the plants by hand was also much less strenuous, thereby increasing the area coverage by human labour.

The digging blade performs better in moulded crop. In crop with long vines, sometimes observed to be up to 48" long, there was binding on the two standards of the blade, to clear which the digging had to be stopped. Perhaps addition of two disc coulters ahead of the standards could be of assistance.

Another problem observed was in controlling the tractor, especially in highly uneven surface. There was tendency for it to swerve towards the sides, and excessive force was required on the part of the operator to keep it on track. Unevenness also made it difficult to attain uniform depth of cut. With some experience the operator was, however, able to come to more steady operation after working for about 1 000 foot length.

Trials were also held to cut the haulm first with the Howard Dragon mower and then dig with the blade. This was not quite successful, as the huge volume of vines had to be removed row by row prior to digging, and also because the mower had cut too close to the ground and not enough length of the stem was left for pulling out the plant. Perhaps this approach will be successful if the haulm is cut at proper height and left to dry for one or two days prior to digging, especially in crops which have excessive vegetative growth.

'T'-type peanut digger. One unit of the digger was imported from Japan for trials. It is of an interesting cantilever design, having only one standard, made of 1½" bore steel pipe and a blade of 20" length. The digger was received with an Universal Hitch for 2-wheeled tractors. For hitching it to the Howard Dragon tractor an adapter Hitch was developed of ¼" x 2" x 4" built-up MS Channel and a ½" D. 5" long bolt. The ½" D. 6" long handle was put in a ferrule, to enable the operator to install and remove the implement by hand.

Performance evaluation. The digger was used to harvest 4 rows each of TR at 16" row spacing and NC 2 at 18" row spacing. The Howard Dragon tractor was run at full throttle and in the first gear. The rows were 256' long. The NC 2 required 10 398 man-hours and machine-hours per acre, and the TR 13.29 man-hours and machine-hours per acre.

Threshing

Design and development of the CARDI-35 thresher. The prevalent practice in West Indies for depoding is pulling the pods out by hand, even where large acreages are involved, and in this operation hand labour is uneconomical. Threshing is usually done along with harvest to avoid losses during sun-curing from rain, monkeys, rodents, pigs, birds, pilferage and lastly from shattering due to trampling during picking. Because of the excessive bulk and weight of the crop, it cannot be transported to the farmstead and hand-picking also means long hours of work for women and children in the scorching sun.

Available devices, such as comb threshers, and pedal and treadle drive peanut threshers, are of low capacity and also may not be acceptable to the farmers under present-day circumstances when they are used to fairly high level of modernization in most other spheres of day to day life. Commercial power threshers, available from various sources, are suitable mainly for sun-cured crop and are also large and expensive. Besides, high-level automation may not be acceptable, in the first place for fear of unemployment.

After consideration of the problems faced by the farmers, the design and development of a low-hp semi-automatic thresher was taken up. Specifications:

length, width, height	54" x 48" x 48"
power source	3 hp gasoline engine/2-wheeled tractor
power transmission	B-section V-belts
number of persons required	3 to 4

road transportation	on semi-pneumatic rubber wheel under-carriage, removable for field operation
threshing cylinder	18.75" diameter, 32" long
on-field shifting	with 1 fixed and 2 folding handles
fuel consumption	about ¼ gallon/h of operation
blower	centrifugal, rotor 11.75" diameter, 31.25" long

The machine has a drum-like threshing cylinder with four flatslat-type threshing members. The slanting hopper-cum-concave board has a curved section concentric to the cylinder, to provide ample effective threshing surface. At full throttle engine speed of 3 000 r.p.m. the cylinder speed is 250 r.p.m., providing 1 000 threshing strokes per minute. The periferal velocity of the cylinder is 1 227 f.p.m., and it has been kept low to reduce breakage in fresh wet nuts, and also from the safety angle, as it is a handfed machine. The blower is 4-bladed and runs at about 1 500 r.p.m.. A chaffer made of steel flat strips is provided to permit only the pods to fall through into the collection tray. The chaff, leaves, etc., retained by the chaffer, are blown out by the fan blast. To keep down cost the cylinder beater was given up, and in place, two adjustable baffle plates, one right after the cylinder and the other at the chaff delivery end, have been provided to prevent the pods from being hit out. The conventional oscillating-type cleaning shoe has also been avoided for the same reason. The cylinder cover is exactly half of a standard lubrication oil drum. A belt guard is provided. Freshly dug and properly-heaped crop is picked up and the pod end is inserted into the 33" long hopper in small bunches by hand. Three or even four persons may feed the machine simultaneously to utilize the full width of the throat for maximum efficiency. The bunches are turned to and fro for the cylinder to knock off all the pods. The vines are then pulled back and thrown out. The green vines are not wasted, as in sun-cured threshing, and can be used as animal feed, mulch, compost or silage.

The threshing efficiency is almost 100 % and breakage and shelling losses are less than 1 %. About 2 % of the nuts get hit out by the cylinder, because of the absence of the cylinder beater. About half to one acre of peanut crop can be threshed in a working day of 8 hours by 3 or 4 persons, with an output of half to one tonne of wet pods, depending upon the yield. The output is related to feeding efficiency, by the utilization of the whole length of the throat and rapid feeding with minimum loss of time.

The machine costs about EC $ 900, the engine about EC $ 600 and the under-carriage about EC $ 100, bringing the total cost to about EC $ 1 700. A farmer going in for CARDI's 2-wheeled Tractor System will be able to run the machine conveniently on the field from the PTO V-pulley of his tractor and avoid expenditure on a separate gasoline engine. At farmsteads it can be operated with a 2 hp single-phase electric motor from the house current.

Sustained field trials have been conducted on the machine in three territories, namely Belize, St. Kitts and Nevis, and the performance of the machine has been observed to be satisfactory by small-scale farmers, who may have had to employ labour at high cost for hand threshing.

At present six units of the machine are under fabrication as prototypes for wider trials in different islands. CARDI may patent the machine and may also take up the machine through its sister organization, the Caribbean Industrial Research Institute, Trinidad, for global distribution, for the benefit of small peanut farmers in developing countries.

Drying

Drying and aerating threshed peanut pods are serious problems in territories like Belize, where considerable rain losses, both qualitative and quantitative, take place.

Wooden crop drying trays. These trays, developed some years back, have been in regular use by NACO and the CARDI in St. Kitts, and forms an efficient system, if stacked properly. However, no arrangement has so far been developed either for quickly covering them during rain or for moving the stack under a roof. Preliminary surveys have been carried out on moving roof type cocoa driers in islands like Trinidad and St. Vincent. Details of a solar rice drier, developed at the Asian Institute of Technology by Dr R.H.B. Exell, have also been collected, and it is planned, as discussed with the scientists at the TPI, London, to combine the solar drying shed idea with the wooden crop drying trays. An agricultural wastes burning drier, using old lubrication oil drums, has been developed and installed at CARDI, Belize.

Peanut shelling. A hand-operated peanut sheller was introduced on peanut farms in Belize. A local workshop was contracted to fabricate it. It has substantially reduced labour requirements for shelling. In trials, carried out on the machine for shelling the Tennessee Red variety, it's output was 51.62 lbs of pods per hour. Accordingly, it will take 139.53 man-hours to shell 1 tonne (2 240 lbs) of dry pods, 2 persons working at a time.

Winnowing. A wooden hand-operated winnower (Beaumont, 1981) was fabricated for cleaning of peanut pods, and shelled mixture of kernels and chaff. The main parts are:

- winnower body;
- wind case;
- saddle;
- fan;
- large chute;
- chute;
- table assembly, and

- drive assembly.

The materials of construction are: items (1) through wood, and (8) through metal. Concerning constructional details and operation, the unit is made up of three distinct components: the body, the wind case and fan. The winnower is operated by turning the drive handle which rotates the fan, forcing air into the wind case. The machine is mainly for threshed and decorticated material, i.e. for finer materials. Decorticated material is fed into the wind case, where the lighter pieces of shell or husk are blown out, and heavier kernel falls down to be collected separatively. The winnower is operated by one person.

Cleaning and sorting. For metering out seed uniformly automatic planters, both manually pushed and tractor-operated ones, require uniform size seed. This work is at present carried out by hand and is a very time-consuming process. A sieve was prepared by drilling out holes of 3/8" diameter in a 28 gauge alluminium sheet, as suitable sieve material was not available in the island. The dimensions of the screen are 20" x 20" and 4" depth. The screen was fitted in a wooden trough with 19" long handles, and can be operated by two persons. It is suitable for the TR variety seed, and can sieve out all substandard kernels and dirt. Very little hand-picking was required only to remove broken and too large seeds larger than the average size. In preliminary trials, a 500 g sample was sieved in just 26 seconds. The sieve frame is so made that other sieves for grading and cleaning, as well as those for washing crop materials, can be inserted in it as required.

CARDI ENGINEERING KITS FOR SMALL FARMERS

Based on the new designs evolved, and implements identified from different parts of the world, procured, evaluated and suitably modified for West Indies conditions, the following are CARDI's Engineering Kits, around which detailed Engineering Tech-packs will be evolved. Two systems are considered, namely the Manual System and the 2-wheeled Tractor System. The Kits show new additions, over and above existing implements, which are expected to reduce man-hour requirement significantly, especially in the main constraint areas (Tables 4 and 5).

Table 4. Manual system.

Operation	Name of implement	Cost (EC $)
crop production area		
land preparation	CARDI Manual Digger	100.00
planting	Earthway Precision Seeder	
	(planting TR only, or	108.68
	Gombei Seeder (TR and NC 2)	384.71
gap filling planting	Earthway Jab Planter	54.34
weeding and moulding	Earthway Cult-A-Eze	116.83
peanut digging	CARDI Manual Digger	---
primary processing area		
threshing	CARDI-35 Thresher (optional)	1 600.00
shelling	wooden sheller, Belize design	203.77
crop drying	wooden drying-tray (3 Nos.)	600.00
grading seed	wooden frame sieves (2 sizes)	100.00
total with Earthway seeder and thresher		2 883.62
total with Earthway seeder without thresher		1 283.62
total with Gombei seeder and thresher		3 159.65
total with Gombei seeder without thresher		1 559.65

Table 5. Two-wheeled tractor system.

Operation	Name of implement	Cost (EC $)*
crop production area		
land preparation	Wolseley Titan GT, 7 hp tractor with attachments	2 000.00
planting	Earthway Garden Tractor Planter	499.91
gap filling planting	Earthway Jab Planter (3)	162.02
weeding and moulding	Wolseley Titan GT	---
peanut digging	1-row Vibratory Digger, Japan, or	358.45
	1-row CARDI U-type Digger	100.00
primary processing area		
threshing	CARDI-35 Thresher**	1 000.00
shelling	wooden sheller, Belize	203.77
crop drying	wooden drying tray (6)	1 200.00
grading seed	wooden frame sieves (2 sizes)	100.00
total with Vibratory Digger		6 524.15
total with CARDI U-type Digger		5 265.70

* The cost of the implements does not include freight, insurance, handling charges, etc. (US $ 1.00 = EC $ 2.7169).
** The thresher can be operated with the tractor.

ACKNOWLEDGEMENTS

I express my deep sense of gratitude to the Authorities of CARDI, Mr J.A. Bergasse, Executive Director, Dr S. Parasram, Director, Research and Development, Dr S.Q. Hague, Leader, Peanut Programme, and

Dr Don Walmsley, Project Coordinator, Peanut Project, in providing me with the opportunity and unlimited freedom of action in this most challenging of work for the Caribbean. I am also very grateful to Dr A. Moens, Chairman, Scientific Committee and Dr H. Lems, Chairman Organizing Committee for inviting me to present this paper, before the international forum, of distinguished agricultural engineers.

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Analysis of the agricultural machinery and implements industry in Latin America

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INTRODUCTION

There are many great differences between Latin-American countries as regards climate, soil, topography, types of agricultural production, farm size, market size, and development level. Therefore, there are also great differences between their respective agricultural machinery and implements industry. The main feature is the difference in technological sophistication among the countries of the region. The available information about the production and the foreign trade for the three biggest countries of the region (Argentina, Brazil and Mexico) and for two countries members of the Andean Group (Colombia and Venezuela) cover approx. 85 % of the agricultural equipment in Latin America. In general, all the countries of the region produce hand-tools, but those with a higher technological content are manufactured only by the big countries (Argentina, Brazil and Mexico), while there is an intermediate position for countries like Colombia and Venezuela, which produce and export some types, but are net importers especially of power and tractor equipment. The small countries of the Central America and Caribbean region (with the exception of Cuba) are net importers of most of the agricultural machinery and implements.

From 1960 to 1976 the agricultural machinery and implements industry in Latin-American countries experienced a self-sustained development with high levels of growth. Thus, from 1962 to 1976 the tractors industry increased the production from 18 567 units in the first year to 100 951 units in 1976, which represented an average rate of growth of 12.9 % yearly; the rest of the industry grew at an average of 7.0 % yearly in the same period.

In the last seven years (1976-1982) there has been a fall in the production level as a consequence of the international economic development and in some countries also because of internal problems. The production of tractors, measured in physical units produced, decreased at an average rate of 10.8 % yearly, and the other component of the branch decreased at an average of 9.2 % yearly, in both cases (Table 1). Two parts of this industry are distinguished in the following, e.g. the manufacture of tractors, and the manufacture of other agricultural machinery and implements other

Table 1. Production of agricultural machinery and implements in Latin America, 1962-1982 (units). Sources: 1962-1980 Yearbook of Industrial Statistics; Commodity Production Data, New York, different issues.

Items	1962	1967	1970	1976	1980	1982[1]
tractors[2]	18 567	19 475	28 787	100 951	78 128	50 663
of which						
Argentina	10 981	9 664	10 642	24 098	3 658	3 889
Brazil	7 586	6 219	14 029	65 279	57 975	32 246
Mexico		3 592	4 116	11 574	16 495	14 528
agricultural machinery and implements other than tractors[3]	137 960	212 812	469 328	354 612	217 025	198 000

[1] Figures for tractors from national sources; for other machinery Secretariat estimates.
[2] Tractors of 10 hp and over, other than industrial and road tractors.
[3] Cultivators, scarifiers, weeders, hoes, etc., harrows, ploughs, seeders, planters and transplanters, combine harvester-threshers, mowers (animal, tractor-operated and self-propelled), rakes and treshing machines.

than tractors.

THE MANUFACTURE OF TRACTORS

Tractor manufacture is considered as part of the automotive industry at national and regional levels as far as capital investment regulations and industrial promotion policy is concerned. The tractor industry represents the most important component of the agricultural machinery and implements output in Latin America. Tractors accounted for 57 % of the agricultural machinery produced in Argentina, 64 % in Brazil and in Mexico 69 %, in 1978.

About 20 % of Latin America's tractors are in Argentina alone, and another 38 % in Brazil and 14 % in Mexico. The number of tractors in relation to cultivated area also varies sharply among the different countries. Cuba emerges as the Latin-American country whose agriculture is most intensively tractorized. In Costa Rica, Uruguay and Venezuela there are 10-15 tractors for every 1 000 ha. At the other extreme, tractor use is almost negligible in Bolivia and Haiti. Taking the region as a whole, it will be seen that tractor use is higher in Latin America than in other developing regions of the world. The regional average of 5 tractors for 1 000 ha of cultivated land compares with that of 1.5 tractors in Africa and 2.2 in the Far East in 1980.

The tractor industry in Latin America has the following main characteristics:

- tractor manufacturers are generally subsidiaries of transnational corporations or joint-ventures with domestic companies working under a license system. There are a few domestic manufacturers of tractors, but there is a trend to concentration of the production to the 5 or 6 bigger companies. The strong price competition, the capital investment requirements, marketing and research, the need of standardization, training, sales promotion, etc., has concentrated production to the large companies in the same way as the production of cars and trucks;

- the location of the manufacturing is close to the main cities, due to the need of skilled workers and labour force in general;
- the production, because of scale requirements, is mainly located to the large Latin-American countries, Argentina, Brazil and Mexico;
- generally, enterprises manufacture only one product: tractors, although in some cases the tractor factory is a separate branch of a large company that manufactures other products in the same country;
- production is based on technology transfer from developed countries;
- production needs large amounts of capital investment;
- tractor manufacturing needs as a minimum 500 persons employed in the factory;
- the tractor industry in the Latin-American countries needs protection through high import tariffs, import license restrictions, etc.;
- there is a high degree of domestic production of components and parts, almost 100 % in Argentina and Brazil, and a 70 % in Mexico.

MANUFACTURES OF AGRICULTURAL MACHINERY AND IMPLEMENTS OTHER THAN TRACTORS

Hand-tools and simple machinery and implements are produced in all Latin-American countries except in some small countries. As far as harvesting equipment is concerned, the situation is rather different, because the technology is more complex. The main producer of self-propelled harvesters is Argentina, but Brazil also produces this type of machinery. Chile, Colombia and Mexico have some stationery threshing machines. The harvester-threshers fleet in Latin America was 128 723 units, and Argentina, Brazil and Mexico have a fleet of this equipment of 95 000 units, or 73.8 % of the region: 44 000 units in Argentina; 36 000 units in Brazil, and 15 000 units in Mexico.

This subsector has some characteristics which are entirely different from that of production of tractors, e.g.:

- Production is located in small towns, near the farms. This fact allows for constant experiments, technical adaption to the farmers needs and modernizations of designs of machinery, implements and accessories.
- Approximately 80 % of the manufacturers have less than 50 persons employed, including administrative staff, workers and technicians. Only 5 % of the companies have 330-500 total employees.
- More than 80 % of the manufacturers have their own designs for machinery and implements, which means no technology transfer expenses.
- There is an industrial tradition in this sector. The labour force has

been working in the same company for many years, some of them are in the third generation since its foundation. For example, in one enterprise in a small town, in the province of Cordoba, Argentina, more than 100 persons working are descendants of the founder's family.

- The number of manufacturers is much greater, e.g. there are in Argentina today 5 factories of tractors, but approximately 600 manufacturers of other agricultural machinery and implements.
- Another important characteristic of this sector is its great versatility, that permits it to adapt to different climates, different soils and different sizes of the farms and types of exploitation. In many Latin-American countries, there are different kinds of climate in the same country: tropical, subtropical and temperate.
- The agricultural machinery and implements with their accessories are designed in such a way that with few changes they can be used in different functions and conditions. This flexibility reduces the cost of investment for users.

TOTAL TRADE OF AGRICULTURAL MACHINERY AND IMPLEMENTS

Total Latin-American imports of agricultural machinery reached US $ 650 million in 1981, at constant 1975 prices, up from US $ 445 million in 1971 (Table 2). This represents an annual real growth rate of 3.9 %. Total exports rose to US $ 146 million in 1981, up from US $ 15 million ten years earlier, representing an annual growth rate of 25.8 %. Thus, although imports still exceed exports by a factor of nearly 4.5, exports grew at a much faster pace than imports. Even more remarkable is the indication that the recent recession appears to have affected imports much more severely than exports, which nearly all remained in 1981 at about the 1980 levels, or even increased slightly for some product groups, whereas imports in all product categories decreased dramatically.

An analysis of the composition of the kinds of agricultural machinery products, imported and exported by the region, shows that the tractor industry represents a high percentage all through. The tractor imports in the total imports of agricultural machinery have decreased from 68.0 % in 1971 to 61.1 % in 1981, whereas the tractor exports have increased from 41.1 % in 1971 to 70.4 % in 1978 and 79.8 % in 1981.

The most salient conclusion is that although Latin America remains a net importer of agricultural machinery and implements, the situation has substantially changed between 1971 and 1981. Between 1971 and 1975 the trade ratio dropped from 30.1 to 11.2, i.e. in 1971 the region imported 30 times more than it exported agricultural machinery, in 1975 imports were 11 times higher than exports and in 1981 only 4.4 times higher. The most significant change has occured in the tractor industry with a trade ratio declining from 49.9 in 1971 to 12.5 in 1975 and to 3.4 in 1981.

Table 2. Latin-American imports and exports of agricultural machinery and implements share of the Region in World Trade 1971 and 1975-1981, in constant 1975 US $ millions[1]. Source: UNIDO Data Bank.

SITC Rev. I	Description	1971	1975	1976	1977	1978	1979	1980	1981
7121/2/5/9	agricultural machinery and implements (total)								
	imports US $ millions	444.8	916.2	654.4	690.1	646.8	682.4	871.6	650.1
	share in world imports	10.2	10.9	7.8	8.9	8.5	8.2	10.2	10.5
	exports US $ millions	14.8	82.0	55.1	94.4	113.5	130.0	145.6	146.4
	share in world exports	0.4	1.0	0.6	1.2	1.5	1.5	1.8	2.4
7121	cultivating machinery								
	imports US $ millions	26.9	51.0	41.6	35.6	39.6	47.3	57.0	48.1
	share in world imports	8.4	7.2	6.2	5.3	6.0	6.4	7.6	7.1
	exports US $ millions	2.4	11.9	9.0	11.8	9.6	11.7	13.9	10.1
	share in world exports	0.8	1.7	1.4	1.8	1.5	1.6	1.6	1.5
7122	harvesting machinery								
	imports US $ millions	94.8	231.1	125.4	132.2	116.6	116.8	214.1	176.8
	share in world imports	7.7	8.4	5.1	6.3	5.3	4.8	7.3	9.6
	exports US $ millions	5.6	19.9	18.1	16.3	14.6	12.0	14.4	17.4
	share in world exports	0.4	0.7	0.7	0.8	0.7	0.5	0.5	1.0
7125	tractors non-road								
	imports US $ millions	302.6	603.4	442.2	484.7	455.6	467.5	536.4	396.9
	share in world imports	13.2	13.7	9.9	10.9	9.7	10.9	11.6	11.9
	exports US $ millions	6.1	48.4	26.0	63.5	84.4	104.0	114.6	116.8
	share in world exports	0.3	1.1	0.3	1.4	1.8	2.4	2.5	3.5
7129	agricultural machinery and appliances NES								
	imports US $ millions	20.5	30.7	45.2	37.6	35.0	55.8	64.1	28.3
	share in world imports	7.0	8.3	6.7	8.6	7.4	7.7	9.5	7.8
	exports US $ millions	0.7	1.8	2.0	2.8	4.9	2.3	2.7	2.1
	share in world exports	0.3	0.5	0.5	0.7	1.2	0.5	0.4	0.6

[1] Deflated by the export price index of agricultural machinery and implements, published in the Monthly Bulletin Statistics, United Nations, New York, February 1983, p. XXX.

A general remark should be made regarding this fast evolution of the tractor industry. In the region's import substitution policy, the tractor industry has played a very important role, particularly in countries with great potential markets, such as Argentina, Brazil and Mexico. The policies adopted consist of high levels of customs protection, taxes, incentives and policies to promote linkages industries such as production of tyres, motors, spare parts, etc. In this first phase the production was for domestic use. As a second step, in the middle 60's, an outward-strategy or promotion of exports of the manufacturing sectors was initiated, which implied penetration of new markets, in the first place other countries in Latin America. This has been supported by measures such as tax incentives, arrangements through which import duties are not levied on the condition that the imported inputs are used solely in exports of final products, barter arrangements and free zones for setting up assembly industries.

MAIN FACTORS LIMITING THE DEVELOPMENT OF THE AGRICULTURAL MACHINERY AND IMPLEMENTS SECTOR IN LATIN AMERICA

Among the causes common to the whole region are the following:

- instability of the economic policies and the regulations which affect industry, production and the investment climate;
- lack of adequate marketing surveys;
- lack of adequate standardization of production;
- lack of adequate planning of production;
- lack of adequate capital investment policy;
- lack of adequate infrastructure of transport and communication;
- lack of cooperation between export producers to reduce the marketing costs;
- instability of the local currencies in many Latin-American countries, including the three more developed, Argentina, Brazil and Mexico, which has caused a continuous increase in the costs of raw materials, parts and components, affecting the final cost of machinery and implements, and hindering production and trading;
- short series of production, with the only exception of Brazil, which does not permit scale economies;
- lack of a Latin-American network of technical and commercial information on agricultural machinery and implements industry;
- excessive number of manufacturers of agricultural machinery and implements and the resulting excessive number of different models of same machinery or implement.

In addition to the above mentioned causes of slow development of this industry, the following factors are prominent in the less-developed Latin-American countries:

- small market size, that does not permit a rentable production and does not justify the investment required to manufacture tractors and power agricultural machinery, highly dependent on scale economies;

- low technological level that does not permit the sophistication required to compete in the foreign markets;
- dependance on import of some products, parts and components as gears, transmissions, valves, bearing, wheels, axes, pumps, etc.;
- low horizontal integration, also due to the low development level;
- monocultural structure of the agriculture production in some less-developed countries, that hinders the product diversification; in many cases the use of agricultural implements is reduced to a few ones, due to the rigidity of partial crops (coffee, for example);
- lack of institutional technical assistance and training.

MAIN POSSIBILITIES FOR EXPANDING THE LATIN-AMERICAN AGRICULTURAL MACHINERY AND IMPLEMENTS INDUSTRY

In order to accelerate the development of the agricultural machinery and implements industry in Latin America, bearing in mind the main constraints to an increase in production and trading, the following recommendations could be formulated. It will be necessary:

- to standardize the production of agricultural machinery and implements through adequate national, regional and international cooperation (national and regional institutions of technical standards together with similar institutions of the developed countries can help the sector to reach the necessary standardization);
- to raise the presently very low level of capacity utilization to improve true economic viability;
- to promote cooperation of manufacturers of agricultural machinery at national levels in order to reduce marketing costs and to have a competitive export package;
- to establish a Latin-American network of technical and commercial information on agricultural machinery and implements industry in order to improve production and sales;
- to promote an adequate technology transfer to the less-developed countries through international cooperation;
- to improve the horizontal integration through regional agreements and international cooperation (sectorial meetings of manufacturers can help this purpose);
- to promote national and regional seminars and training courses with participation of users or potential users of agricultural machinery and implements, especially in the less-developed countries;
- to promote in the less-developed countries national institutions of technical assistance in agricultural machinery, similar to those existing in the more-developed countries of the region;

- to make farming itself more profitable, thus encouraging increased productivity through higher levels of mechanization. (This can take place through a variety of schemes such as long-term tax incentives and buy-back schemes, subsidized loans, export incentives, etc.). A sensible agricultural pricing policy, however, requires political will that is often against the short-term interest of the (politically powerful) urban masses.

Pneumatic injector for deep placement of urea in wetland rice soils

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ABSTRACT

For deep placement of urea in wetland rice soils a pneumatic injector has been developed. The injector is constructed from strong synthetic materials and is hand-carried and hand-operated. The injector is about 1 m long and weighs about 2.5 kg when empty, and about 4 kg when filled with fertilizer. Accurate quantities of prills and granules, up to 8 mm diameter, can be deep-placed. The success of injection was demonstrated in a field trial, where injected urea resulted in higher rice yields than broadcast urea. The time has come to gain more field experience and to test the farmers' acceptance.

INTRODUCTION

The efficiency of nitrogen fertilization of wetland rice can be strongly increased, sometimes even doubled, by deep-placing instead of broadcasting urea (e.g. Craswell & Vlek, 1982; De Datta & Craswell, 1982; IRRI, 1977; Partohardjono et al., 1981; Rao & Prasad, 1982). The objective of deep placement is to get the urea into the reduced zone, beyond contact with the floodwater. There have been developments to deep-place urea mudballs, urea briquettes or urea supergranules by hand (Pillai, 1982). To lighten this task research was started to develop deep-placement applicators. At present there are applicators in different stages of development from China (Liu Chung-Chu, 1982) and from the International Rice Research Institute (IRRI), the Philippines (Bockhop & Cochran, 1983; Khan, 1983) as well as from The Netherlands. This paper describes the technical development and agronomic test results of the Dutch urea applicator in the period 1980-1983.

* Seconded by the Agricultural Bureau of the Netherlands Fertilizer Industry (LBNM).

OBJECTIVES

At the request of the Agricultural Bureau of the Netherlands Fertilizer Industry (LBNM), the Department of Agricultural Engineering of the Agricultural University at Wageningen has developed a deep-placement applicator for the small rice farmer. The primary requirements were: simple, cheap and hand-operated. The first choice to be made was between band and point placement. Point placement was preferred because:

- most small rice farmers do no transplant rice in straight rows as is necessary for band placement;
- the condition of the soil is less important, i.e. point placement is rather insensitive to the presence of plant residues or clods. Band placement applicators require well-prepared soils;
- it is easier to keep the urea out of contact with the floodwater in case of the small holes made by point placement than in the case of the furrows made by band placement.

Thereafter the following requisites were drawn up:

- light weight, so that the applicator can be easily carried to the field and during application;
- sturdy, non-corrosive, with little need for maintenance;
- able to apply urea prills and granules with diameters up to 8 mm (urea supergranules were not considered because they are not commonly available and because they are apt to block the discharge tube);
- able to place at different depths;
- equipped with an accurate metering device which can be easily set to different rates of application.

CONSTRUCTION

It was decided to opt for an injector, constructed from strong synthetic materials. At first it was tried to deep-place mechanically. This did not work, because the mud blocked the discharge tube. This led to the concept of pneumatic application of the fertilizer, based on the principle of a bicycle pump. Figure 1 shows a schematic presentation of the pneumatic injector.

OPERATION

The injector is operated as follows:

1. The 2-litre bottle of the hopper is filled with fertilizer and then screwed onto the injector, whilst the apparatus is kept upside down. The total weight of the injector, when full, is about 4 kg.
2. The injector is held with both hands, one hand on the handle, the other at the upper part of the compression pipe.

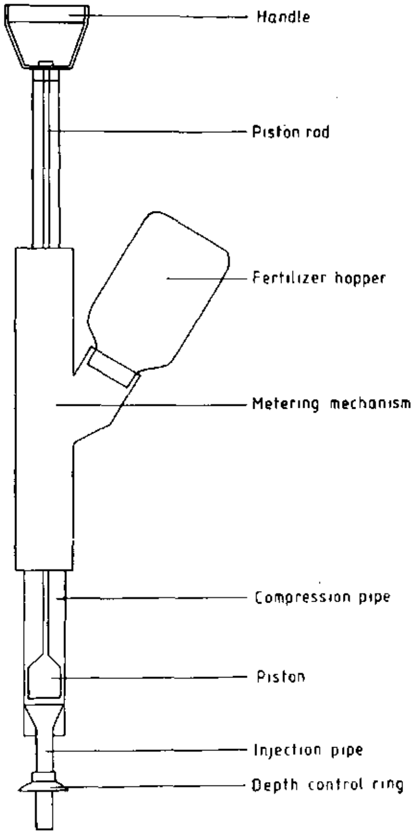

Figure 1. Schematic presentation of the hand-operated pneumatic injector, developed in The Netherlands. The injector is about 1 m long, and weighs about 2,5 kg when empty, and about 4 kg when filled with fertilizer. The compression pipe is transparant, so that the fertilizer flow can be checked.

3. The apparatus is positioned at about 30° from the vertical and the injection pipe is inserted equidistant from four rice hills. The depth of injection can be controlled with the depth control ring.
4. The handle is pulled up into top position and the desired quantity of fertilizer is metered out. This quantity drops through the compression pipe on the mud in the injection pipe.
5. The handle is pushed down and the fertilizer is discharged into the soil by the compressed air.
6. The injector is taken out and is inserted equidistant from the next four hills, and so on.

At a rate of 100 kg urea prills per ha a refill of the hopper is needed every 150 m^2. In a planting pattern of 20 cm x 20 cm there are 250 000 rice hills/ha. With one injection per four hills this means 62 500 injections/ ha. According to a field test at IRRI, the Philippines, it took 90 minutes to inject 624 m^2. This means that it would take about 24 hours to inject 1 ha. According to a field test at Malang, Indonesia, the pressure needed for discharging the fertilizer, was 1-3 kg per stroke.

METERING TESTS

The metering mechanism of the injector is readily accessible and the rate of application can be adjusted with a screw. The intended and actual rates of application are in good agreement as is demonstrated by the low standard errors and the rather small variations (Table 1). The smaller the urea particles and the lower the rate, the smaller the variation.

QUICK TESTS WITHOUT PLANTS (GREENHOUSE)

A quick method to test the effectiveness of injection is to determine the urea-N concentration of the floodwater after fertilizer application. The higher the urea-N concentration, the greater the chance of nitrogen losses through volatilization as shown by an increased concentration of ammoniacal N and a higher pH of the floodwater.

Tests were carried out in the greenhouse under simulated tropical conditions. A first test was carried out at the Institute for Soil Fertility, Haren, The Netherlands. Two urea grades, prills and granules (with a diameter of 5-8 mm), were point-placed at 0, -3 and -8 cm, respectively. Figure 2 shows the change in urea-N concentration of the floodwater from day 0 to day 7. It is clear that the highest urea-N concentrations were recorded following placement at the soil surface. It was satisfactory to inject granules, but not prills, to -3 cm. Good results were obtained with

Table 1. Metering test. Intended and actual quantities of different forms of urea after applications of 2.0 and 3.5 g per stroke. These rates of application correspond with 57.5 and 100.7 kg N/ha, respectively.

Form of urea	Intended rate (g)	Actual average rage (g)	Standard error	Minimum actual rate (g)	Maximum actual rate (g)
prills	2.00	1.90	0.011	1.88	1.92
1.9 mm	3.50	3.44	0.017	3.41	3.48
granules	2.00	2.00	0.020	1.95	2.06
2.1 mm	3.50	3.46	0.030	3.39	3.52
granules	2.00	1.88	0.027	1.82	1.94
2.9 mm	3.50	3.52	0.039	3.43	3.62
granules	2.00	2.13	0.180	1.14	2.42
5-8 mm	3.50	3.35	0.185	3.03	3.76

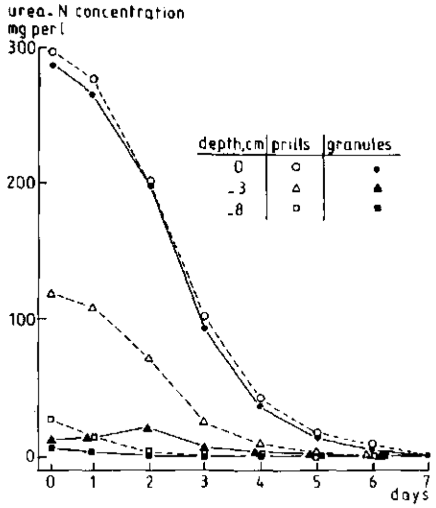

Figure 2. Change in urea-N concentration of floodwater with time after injection of prills (with a diameter of 1.9 mm) and granules (with a diameter of 5-8 mm) at different soil depths

injection of either prills or granules to -8 cm. Sometimes the prills, but not the granules, stuck to the injection pipe.

A second test was carried out at the International Fertilizer Development Centre (IFDC), USA (Table 2). The urea-N concentration of the floodwater was much lower after injection than after broadcasting. Injection of granules (with a diameter of 5-8 mm) and supergranules appear to be more effective than injection of prills. It is interesting to note that hand-placement and injection of supergranules gave similar results (Table 2).

YIELD TEST (FIELD)

At Malang, Indonesia, a field trial was conducted to compare the effect of urea injected one week after transplanting with that of urea broadcast in three split applications (a quarter one week after transplanting, a half dose at first weeding, a quarter at panicle initiation). Urea was applied at different rates, as prills or as granules (with a diameter of 5-8 mm). The success of injection is shown in Fig. 3: at 50-100 kg N/ha the yield with injected urea was up to about 1 t higher than that with broadcast urea. Also, it took less urea when injected than when broadcast to obtain the same yield. For instance, a yield of about 5 t/ha was obtained with 100 kg N broadcast, in comparison with 50-60 kg N injected. These results show that injected urea is more effective than broadcast urea. It should be noted that with injection the highest rates of application resulted in higher yields, but also in a higher proportion of green grain.

Table 2. Urea-N concentration of floodwater about 4 hours after application of 86 kg N/ha. Average values for treatments on drained or flooded soils at time of application, with or without closure of deep-placement holes, at 3, 7 or 14 days after puddling

Method of application	Form of urea	Diameter (mm)		Urea-N (mg per l)
broadcasting	prills	about	1	344
injection -8 cm	prills	about	1	113
	granules		5-8	61
	supergranules (1 g)	about	12	23
hand-placement -8 cm	supergranules (1 g)	about	12	26

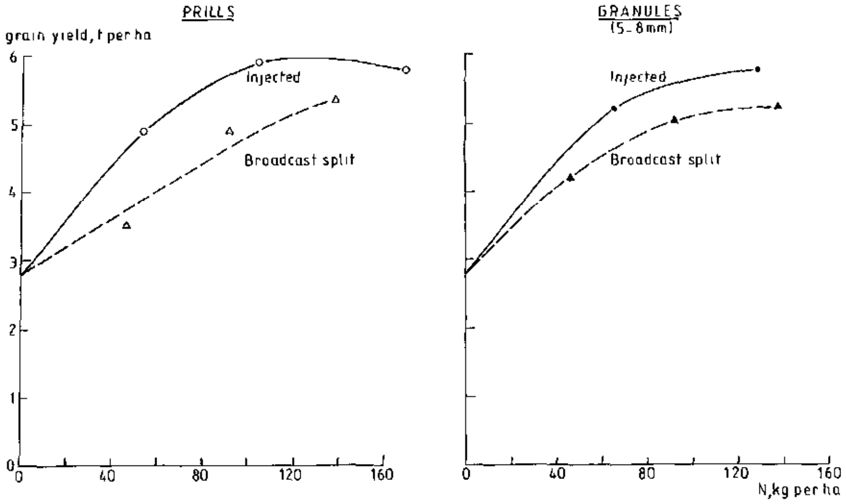

Figure 3. Rice yield as affected by rate and method of application of urea as prills and as granules (with a diameter of 5-8 mm). Rice grain at 13-14 % dry matter. Hand-drawn curves.

CONCLUSIONS

The results have shown that the concept of pneumatic injection is sound. The main advantages are that the injector can apply different kinds of urea and that the rate can be easily varied. The time has come to gain more field experience and to test the farmers acceptance.

ACKNOWLEDGEMENTS

We thank Homeco, Dieren, and the Technical and Physical Engineering Research Service, Wageningen, for constructing prototypes of the injector.

We also thank the Staff of IRRI, the Philippines, for doing some tests, the Director of IFDC, USA, for making greenhouse trials possible, and the Staff of the Brawijaja University at Malang, Indonesia, in particular Ir. A.A. Wanders, for carrying out the field trial.

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Some aspects of agricultural mechanization in Indonesia

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INTRODUCTION

Indonesia, an archipelago located in South East Asia, consists of thousands of islands distributed around the equator and dominantly influenced by a monsoon climate. The eastern part of Indonesia is relatively dry, while the western part is relatively wet, with an average rainfall of 3 000 mm per year, distributed into dry and rainy seasons. Due to bad communication conditions the islands developed their own culture, reflected also in different types of agriculture. Most of the rice was produced in Java, inhabited by approximately more than 60 % of the total population of 148 million people. Out of a total 190.5 million ha, only about 17 million ha are under cultivation, of which 1.6 million ha are adequately and another 1.5 million ha partially irrigated for rice production. Another 60 million ha are estimated to be potentially suitable for agricultural land development (Soebagy, 1983), most of which lies in the other islands outside Java.

The very uneven population distribution and agriculture activities between Java and the other islands is not desirable, and drastic changes were programmed by the government to distribute more farmers to the other islands and activate agriculture developments. During the third Five-Year Development Programme (Pelita III) in 1979/1980-1983/1984 a total of 500 000 farm families were transmigrated from the densely populated islands of Java and Bali to the other islands. Between 750 000 to 1 000 000 more farm families are programmed to be transmigrated during the fourth Five-Year Development Plan (Pelita IV) in 1984/1985-1989/1990. Each farmer shall be alloted farm sizes between 2 and 5 ha.

The islands outside Java, which were covered by heavy rainforest or alang-alang fields due to shifting cultivation, should be cleared and developed into permanent farms, especially aimed at foodcrop production. The government also developed programmes to increase estate crops production for export purposes to gain foreign currency, also to fulfil increasing domestic needs. It was also intended to reforest rapidly bareland covered only by alang-alang due to shifting cultivation.

All those programmes need heavy inputs in the form of machinery to make it possible to be implemented in the very thin populated areas outside Java.

PROSPECTS OF MECHANIZATION

Reforestation

Much of the tropical rainforest was cut by inhabitants and left bare, only covered by alang-alang grass. Trees were felt and burned further cultivated almost without any additional inputs. Heavy weed and drastic reduction of soil fertility forced the shifting cultivators to cut open new virgin forest. Those large areas, damaged by shifting cultivation, have a very low productivity. Those large areas need to be reforested in a rapid pace. Since man-power was in a minimum, mechanical power was introduced, using crawlers and four-wheeled tractors where possible. Fire barriers were planted to restrict damage by fire especially common in those areas and small water ponds for hydrological aims.

Estate crops

Part of the foreign currency, needed for the development of Indonesia, should come through the export of farm products, especially estate crops such as coffee, tea, rubber, palm oil, sugar, etc. Most of those crops are perennial; they are partly grown by smallholders and partly by agricultural estates. The smallholders were low in capital strength; the agricultural estates, on the other hand, were very strong furnished with capital and technological ability. Due to population pressure and other developments in Java, forced those to look for additional new areas outside Java. Large areas covered by forest or alang-alang were cleaned mechanically and subsequently cultivated mostly also using mechanical means. Efforts lately were made to combine managerial activities between large estates and smallholders, affecting managerial inputs and technological know-how.

To fulfil the increasing demand for sugar, new factories/estates were opened mostly in non-irrigated areas outside Java. The sugar farming system used in Java, known as the Reynoso system, which was heavy irrigated and manually very intensive, had to be changed into a new system, called the 'mechanized system', using the perennial ratoon, rainfed and almost very little manual support during the early periods of implementation. Hundreds of four-wheeled tractors, crawlers and cane harvesters were needed to support those activities.

Transmigration

The need for rapid transmigration to move farmers from Java to the other islands was aimed to release some pressure on the farming population of Java and to open new and isolated areas outside Java. The need for development of those new areas, unknown before, demands high pioneering, skilled and intelectual capabilities, which were rather scarce. It needs also the use of heavy machineries to clean forest and prepare the land before it is suitable for farming purposes. Infrastructure, bridges and roads should be built to support those activities.

Farmers who were used to cultivate half a hectare, need to adjust themselves to cultivate between 2-5 ha of land in a different soil and climatic condition. Special inputs of a different kind of technology, the use of animal power and other inputs of energy are needed to enable the farmer to cultivate his land properly, rather than devastate into a worser condition than the shifting cultivation aftermath.

Established food crops

The situation of the mechanization of established food crops was not bright. It was invested by a high degree of disguised unemployment, which make the farming system very inefficient; and yet those farms need to be taken into consideration, since most farms are of this type. The influence of urban activities in industry and other fields of trade made a strong impact on labour availability near urban areas, especially during peak activities like soil tillage. Experience gained by the IRRI project showed that there was a need of threshers in West-Sumatra, water pumps in South-Kalimantan and tractors in South-Sulawesi. Each locality has its own need. Awareness of those trends specific to a certain area should always be kept.

To accomodate farmers needs, excellent activities were implemented by the Subdirectorate of Farm Machineries through several programmes, such as by the Committee for Agricultural Machinery Testing, mutual exchange of experience between Asian countries through the Regional Network of Agricultural Machinery, and especially the dissipation of new designs to the artisans, workshops and farmers through the IRRI project, which was especially aimed toward farm machinery development supporting rice production. This programme should be extended to oher commodities.

The National Committee on Agricultural Mechanization coordinates activities in mechanization. This committee should be strengthened in its role.

CONSTRAINTS

Technical

Most of the machineries were imported and are not directly suitable to local conditions and needs. Adaptation and modifications are needed. Those new technologies should be absorbed by farmers, dealers, workshops and, last but not least, also by policy makers, so that availability and readiness of machineries are guaranteed during farm activities.

Some experts were reluctant to introduce mechanization into farming systems marked by low capital investments. Many of the machineries imported may exhibit a rather low performance, due to circumstances concerning the availability of spare parts, unskilled operators and unqualified managers. This should not be looked upon as a low suitability of mechanizaton, but rather as a process of the adaptation of new technology, which should be promoted and further developed, especially by domestic experts.

Socio-economical

Farm population increase will add to the increase of disguised unemployment pressure in farming systems, decreasing the efficiency. The population increase should be altered either by:

- introduction of a strong birth-control programme;
- relieve the farm from unemployment pressure by transmigration and open opportunities in industry and other fields of trade.

The need for additional power to cultivate the land in new development areas where labour is scarce, may result in rising more children (especially sons). This could lead to rapid land fragmentation, which may cause inefficiencies and further unemployment.

Government and economic forces tend to hold farm prices down inhibiting the use of farm machinery. Imported machinery need to be purchased using foreign currency. To enhance the use of farm machinery, the industrial countries should open and develop their market for agricultural products of the developing countries and in so doing balance the trade between the respective countries.

Manufacturing of agricultural machineries, especially at village and region level, should be promoted to better suit the local demand for appropriate technology.

Educational

The introduction and adaptation of agricultural mechanization should be looked upon as an introduction and adaptation of new technology. Farmers and related institutions should be equipped through training, education to manage problems related to this transfer of technology. The education should be implemented over the whole line, including farmers, operators, dealers, research institutes, as well as educational institutes. Foreign aid should have a heavy contribution toward this programme since developing countries does not have the ability to provide enough funds. Cooperation between institutes has been initiated and should be stepped-up to keep in pace with the progress and needs of mechanization.

CONCLUSIONS

- The need and prospects of agricultural mechanization are apparent in Indonesia.

- The constraints and problems facing the introduction and adaptation of mechanization are normal as a process of transfer and development of new appropriate technology.
- A comprehensive understanding and overall agriculture development policy is needed to make available the opportunities opened by this technology.

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