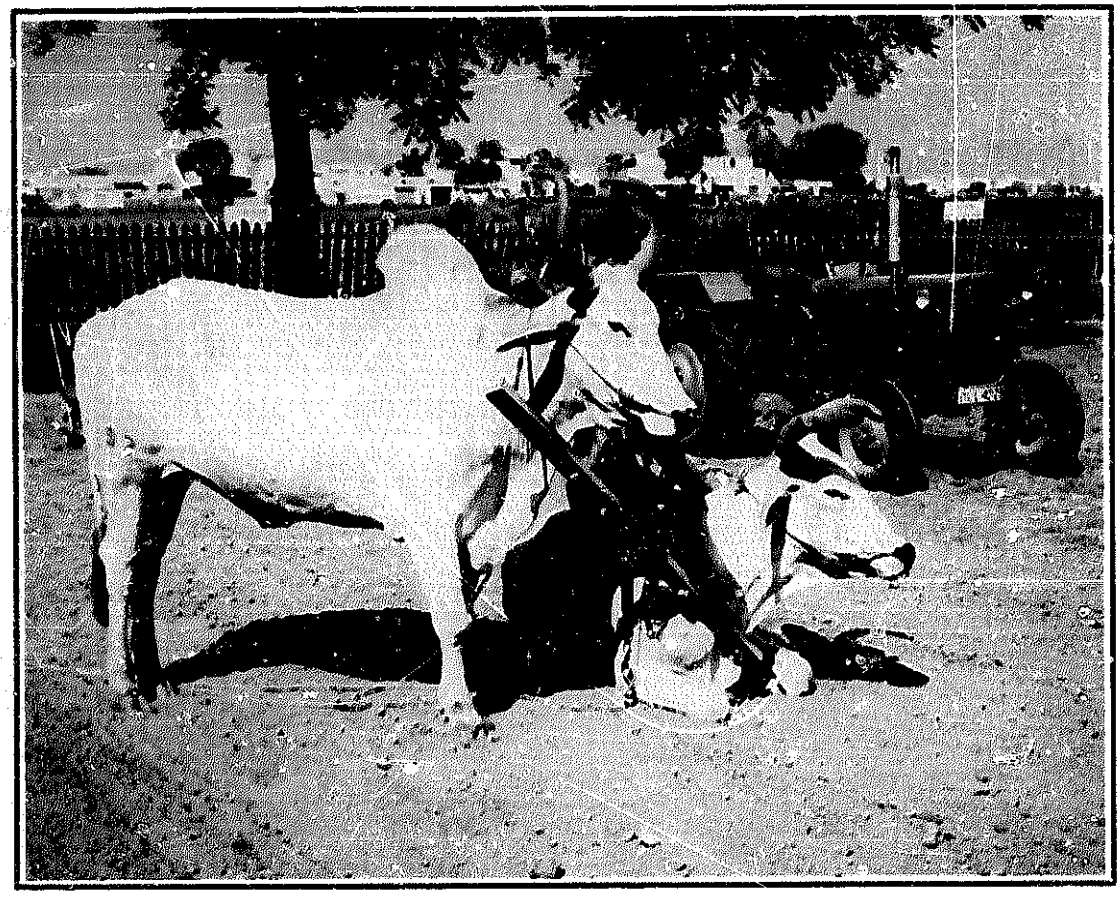
Agricultural Technology for Developing Nations: Farm Mechanization Alternatives for 1-10 Hectare Farms

Published by:
University of Illinois at Urbana-Champaign
Urbana, IL 61801 USA

Available from:
Roy Harrington
Product Planning Department
Deere & Company, John Deere Road
Moline, IL 61265 USA

AGRICULTURAL TECHNOLOGY FOR DEVELOPING NATIONS

Farm Mechanization Alternatives for 1–10 Hectare Farms



AGRICULTURAL TECHNOLOGY FOR DEVELOPING NATIONS

FARM MECHANIZATION ALTERNATIVES FOR 1-10 HECTARE FARMS

PROCEEDINGS
Special International Conference
University of Illinois at Urbana-Champaign
May 23-24, 1978

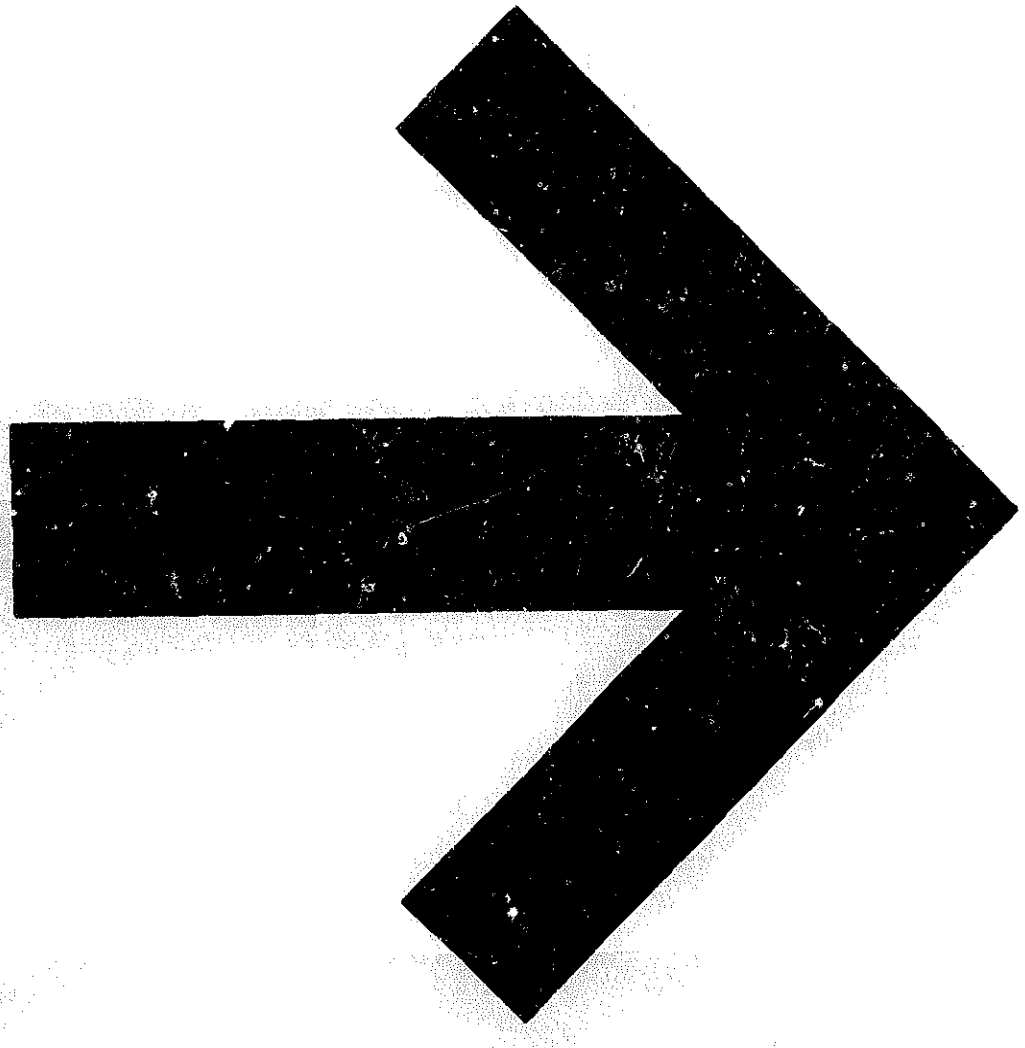
Sponsored by American Society of Agricultural Engineers
Interfaith Center on Corporate Responsibility
University of Illinois at Urbana-Champaign

Funded by a grant from Deere & Company

Library of Congress Catalog Card Number 78-73385

Manufactured in the United States of America

University of Illinois at Urbana-Champaign
Printing Services



Contents

Foreword

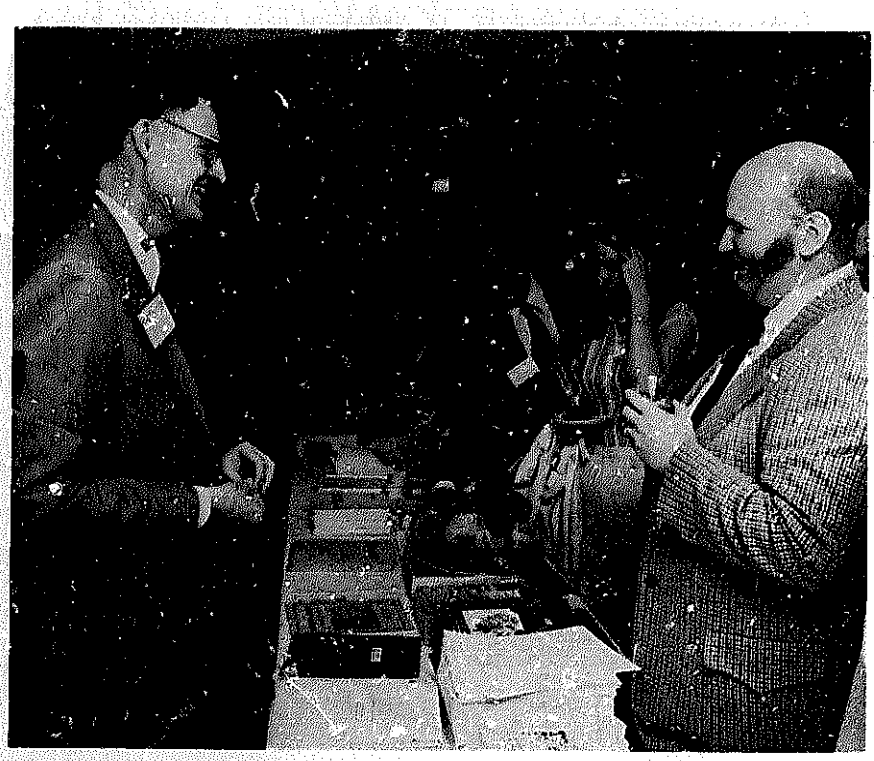
On May 23–24, 1978, a special international conference on "Agricultural Technology for Developing Nations: Farm Mechanization Alternatives for 1–10 Hectare Farms," was held on the campus of the University of Illinois at Urbana-Champaign. The conference was sponsored by the American Society of Agricultural Engineers, the Interfaith Center on Corporate Responsibility, and the University of Illinois at Urbana-Champaign. The program was made possible by a grant from Deere & Company.

The purpose of the conference was to provide concerned people with information about the opportunities and problems associated with farm mechanization as one element for relieving the food shortage in developing nations. Attention was given to the socioeconomic issues involved with agricultural technology transfer, and to the engineering and marketing problems specifically associated with small-farm technology.

This conference on alternatives for farm mechanization for developing nations was the first of its kind to be funded by a multinational corporation. From throughout the world, people of different backgrounds were brought together, to exchange ideas about the global problem of how to increase farm production through mechanization.

The idea for the conference resulted from a stockholders' resolution prepared by a group representing the American Baptist Churches. This group had expressed the belief that Deere & Company could do more to provide farm mechanization for developing nations than it had been doing, and the resolution, in essence, asked for a shift in the Company's priorities. Though the resolution was rejected by stockholders at a 1976 meeting, the officers of the Company felt that the issue of farm mechanization in developing nations deserved further exploration — hence the funding of this conference.

Co-directors of the conference planning committee were Roy E. Harrington (American Society of Agricultural Engineers), Product Planning Department, Deere & Company, Moline, Illinois, and J. Terry Iversen, Head, Continuing Education in International Affairs, University of Illinois at Urbana-Champaign, Urbana, Illinois. Committee members included Robert Bentz, University of Illinois Cooperative Extension Service, Urbana, Illinois; W. D. Buddemeier, Director, International Agricultural Programs, and Associate Dean, College of Agriculture, University of Illinois at Urbana-Champaign, Urbana, Illinois; Lyle G. Reeser (American Society of Agricultural Engineers), Caterpillar Americas Co., Peoria, Illinois; Martha Savio (Interfaith Center on Corporate Responsibility), National Ministries, American Baptist Churches, Valley Forge, Pennsylvania.



Roy E. Harrington of Deere & Company, Moline, Illinois, and co-director of the conference planning committee, greets registrants before the formal opening of the conference. Participants helped themselves from an array of timely publications provided by various corporations, agencies, and educational institutions.

Introduction of Program

ROY E. HARRINGTON

Product Planner, Deere & Company
Moline, Illinois

It is a real thrill to welcome this large audience with such a broad spectrum of backgrounds and interests. Geographically, we have representatives from Korea, Japan, Philippines, Sri Lanka, India, Pakistan, Bangladesh, Iran, and Syria in Asia; Somalia, South Africa, Malawi, Nigeria, Ivory Coast, and Cameroon in Africa; Peru, Argentina, and Mexico in Latin America; plus representatives from Yugoslavia, Austria, West Germany, Canada, and the United States. There is also a broad coverage of various disciplines, including economics, engineering, agronomy, banking, business management, history, political science, psychology, theology, and farming.

In preparing the invitation list, members of the planning committee included four major groups which we felt have had and will continue to have a major influence on farm mechanization in developing nations. We have attendants from eight multinational farm equipment companies and nine firms specializing in low-cost farm equipment. There are seven developmental agencies with a worldwide base and eight that are related to the United States government. Seven universities are represented from the state of Illinois and 18 from other states, ranging from New York to California. In the social action area, we have representatives from 14 church-related groups and 9 groups not church-connected. With such a diverse audience, one of the best opportunities each participant has for benefiting from the conference is to exchange ideas with other attendants.

The subtitle of our conference is "Farm Mechanization Alternatives for 1–10 Hectare Farms." We chose this particular range of farm sizes because it accounts for most of the land and produces most of the food in the developing nations of Asia and Africa. While many farmers of 1–10 hectare farms have changed their agricultural technology with improved seeds and fertilizer, they generally have not changed the mechanization of their field operations. However, in India, where pumpsets are economically feasible and provide a good return on investment for farms of this size, enough farmers have adopted mechanized pumpsets to irrigate an area of land equal to the total irrigated acreage in the United States.

Our program will begin with a broad look at agricultural technology. It will include a look at a package approach to food production, and it will consider some of the problems of transferring agricultural technology to developing nations. Some of the socioeconomic aspects of farm mechanization will be examined, after which five speakers will focus on specific alternatives for farm mechanization. As the program unfolds, it should become evident that the best solutions to these challenging problems will require the best efforts and cooperation of each person and each group represented here.

Before presenting the first conference speaker, Martha Savio of National Ministries of the American Baptist Churches described the dialogue between multinational corporations and social action groups which precipitated the idea for the conference. Never before had a multinational corporation provided the funds for an international meeting on alternatives for farm mechanization in developing nations.

Staff members from the University of Illinois, Office of Continuing Education in International Affairs, assist new arrivals at the registration desk. More than 230 attended the conference, including representatives of eight multinational farm equipment companies, nine firms specializing in low-cost farm equipment, fifteen developmental agencies, twenty-five universities, and twenty-three social action groups.

Introduction of Keynote Speaker

MARTHA SAVIO

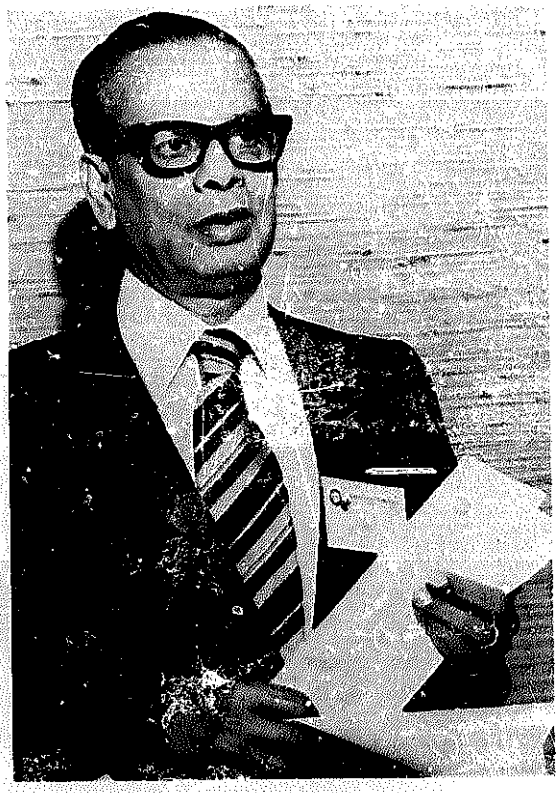
Director, Social and Ethical Responsibility in Investments
National Ministries of the American Baptist Churches
Valley Forge, Pennsylvania

I would like to give you a little background on how this conference came to be. Some of you know that those in charge of making investments for the various church bodies have been actively involved for the last eight years in monitoring some of the policies of the corporations represented in their investment portfolios. Currently the companies that are most likely to be at issue are those doing business in South Africa. You also have read, no doubt, about shareholders who have been questioning company policies at annual meetings.

But there is another realm of church activity that takes place in private, in the headquarters of corporations around this country. Two years ago, the American Baptist Board of National Ministries began conversations with Deere & Company on the question of appropriate technology. We prepared a shareholders' resolution at that time, which was specifically aimed at asking that appropriate technologies be developed for raising crops in countries where small farmers remain productive. By Securities and Exchange Commission standards, the shareholder resolution failed. The conversations with Deere & Company continued, however, and this conference that we are beginning today is a follow-up to that original concern. We do not claim that the concern was ours alone. It was certainly the concern of Deere & Company as well, and certainly it was the concern of many agricultural economists.

Thus Deere & Company decided to fund this seminar and bring together the sponsoring organizations — the American Society of Agricultural Engineers, the Interfaith Center on Corporate Responsibility, and the University of Illinois at Urbana-Champaign — for an exchange of ideas. The actual planning process for the conference began last December and representatives from those groups have met throughout the intervening months. We have met in Moline in the middle of blizzards; we met here in Champaign-Urbana a couple of weeks ago in early May when it was beautiful. We had a good time planning the conference; there was great cooperation among all of the groups, and we are delighted with the turnout here. As Roy Harrington said, four groups were invited — four diverse groups — and we all pooled names for invitations, and we are delighted that there is such diverse representation and from so many parts of the world.

In asking people to come to this conference, therefore, we hoped to present various viewpoints and a range of opinion on what is appropriate technology and what factors need to be considered in employing it. We also needed one person as a keynote speaker who could provide broad background for all of us, including those of us who are not experts in the field. Dr. Samar Sen has 24 years of experience in the field of agricultural economics, beginning with eight years as an agricultural economist. The next eight years were spent in the broad area of economic planning, followed by eight years with the World Bank in financial development and investment banking in India, Sri Lanka, and Bangladesh. Dr. Sen just returned last month to New Delhi where he is now working with the Branch Commission, studying world trade and development policies and evaluating international financial institutions.



The keynote speaker, Samar R. Sen of New Delhi, India, sets the tone of the conference: "The long-term solution of the world food problem must be sought in improving the productive capacity of the farms in the food-deficit regions." While recognizing the many obstacles to success, he was optimistic: "Thanks to modern research, many of the technologies, which formerly seemed suitable for big farms only, can now be adapted to the needs of the small farms."

At the reception preceding the banquet and opening session, participants mingle with old friends and make new acquaintances. Twenty-three countries were represented, including nine from Asia, six from Africa, three from Latin America, three from Europe, and Canada and the United States.

Agricultural Technology for Increased Food Production in Developing Nations: Problems and Opportunities

SAMAR R. SEN

Former Executive Director, International Bank for Reconstruction and Development
New Delhi, India

All available projections of population, per capita income, and demand for food on the one hand, and production and marketable surplus of food on the other, tend to present a large and growing gap insofar as the developing countries are concerned.

There are, no doubt, substantial variations between different projections, particularly in regard to regional estimates, but these variations do not negate the main conclusion that the gap is likely to be very serious and progressively wider in the remaining years of this century, unless well-planned and determined corrective action is taken urgently by all concerned, at the various levels from the local farmer right up to the international community.

According to one of the more conservative estimates, the global gap between food production and demand is likely to be 45 million tons by 1985, and progressively larger thereafter, if present trends are allowed to continue. The gap is likely to be substantially wider if one considers only the food-deficit regions of the world. Further, in most of these regions farms are relatively small, less than 10 hectares in size, employing a large number of people who have very few alternative sources of employment and income. If food is produced elsewhere and is imported into these food-deficit regions, it is likely to accentuate the problems of payment and unemployment.

Inadequacy of Aid or Trade

Matching the global demand and supply situation may not seem unduly difficult in view of the rapid and sustained improvement in food production, processing, and marketing that has occurred — thanks to progressive research and development and continuous improvement in technology — in the developed countries and in some modernized enclaves of the developing countries.

But it is not enough to have global balance. It is important to ensure that imbalances existing at the regional and local levels are effectively erased by extending improved productive capacity, purchasing power, and distribution facilities to all people who need food.

Temporary shortages may no doubt be met by providing food on a donation or easy credit basis. But that will be only a palliative measure and not a long-term solution. The projected need for food is too great and the purchasing power of the people needing it is too inadequate to be met by aid or by trade.

The long-term solution of the world food problem must, therefore, be sought in improving the productive capacity of the farms in the food-deficit regions. But, as mentioned earlier, the bulk of these farms are small, averaging less than 10 hectares, and much of the modern technology that is readily available in the developed countries is prima facie either unsuitable for or beyond the reach of such farms.

One obvious solution, of course, is to combine a number of small farms to form a bigger, and more viable, unit. But that would create not only serious political problems but also an acute economic problem of unemployment, at least for a fairly long transition period, in many of these regions. In addition, many of the developing countries apparently are unprepared for such action. Apart from political and social considerations, the perceived benefits do not appear to them to be worth the perceived costs.

Area Neutral Technology

Fortunately a considerable part of the modern technology is either area neutral or can be made area neutral with certain adaptations, although some of it may originally have evolved in the context of relatively big farms. Some examples are photosynthesis, genetic modification of plant materials, biological nitrogen fixation, fertilizer utilization and nutrient absorption, chemical growth regulators, alleviation of environmental stresses, pest control, improved water use and irrigation, multiple- and inter-cropping, land improvement, no-tillage cultivation or other tillage economy, controlled environment agriculture, nutrient film technology, by-product utilization, waste minimization, and improved animal fertility, breeding, nutrition, and health.

If purposive research and development effort is concentrated on these technologies, many of them can be applied to small farms to a much greater extent than

they are today. Prima facie, biological and chemical technologies appear to be more applicable to small farms than are mechanical technologies. But, thanks to modern research, many of the mechanical technologies, which formerly seemed suitable for big farms only, can now be adapted to the needs of the small farms.

Custom Work or Equipment Rental

Some technology that is not area neutral in itself may be made available to small farms through operational arrangements such as custom work or rental or hire purchase. In fact, renting a relatively large piece of equipment for a limited period may sometimes be significantly more efficient and economical for a small farm than owning a small version of it. Schemes for promoting the use of custom work and rental or hire purchase of costly equipment have not yet been given the attention they deserve in most developing countries. A few countries have experimented with a chain of machine-tractor stations while others have tried cooperative service units. An important shortcoming of these has been the bureaucratic system and the lack of enterprise and flexibility. In other countries, efforts by private enterprise have been rather haphazard and isolated.

There is a need for careful analysis of all these efforts. Perhaps providing a greater degree of autonomy in management of the tractor stations, and a kind of franchise arrangement for the cooperatives backed by large-scale equipment manufacturers, coupled with a closer relationship with credit institutions in both, may help correct many of the shortcomings.

The availability of timely and adequate credit combined with insurance, especially for hire purchase, is indeed a key to the development of most small farms. I do not mean cheap credit, but timely and adequate credit. When one contrasts the ease with which the purchaser of an automobile obtains insurance and credit in a developed country, and the difficulty faced by the purchaser of an agricultural implement in obtaining these services in a developing country, one can easily understand why the farms in the latter are as backward as they are today.

Along with rental or hire purchase of equipment, it is important that adequate servicing, spare parts supply, and repair facilities should also be provided, preferably by the same agency. If some of the large-scale agricultural machinery manufacturers had taken the same care to study local needs and provide the supportive services in rural areas of developing countries that some automobile and petrochemical manufacturers have used in the urban areas of developing countries, modernization of small farms might have occurred much faster than it has up to the present time.

Labor and Capital Intensive Technology

It is rather common these days to contrast labor intensive and capital intensive methods when one considers small farms. The important point, however, is that there need be no contradiction between these two methods. In fact, both labor and capital may play a very useful complementary role in overcoming the basic scarcity of the third factor, namely, land, that the small farmer faces. Intensive application of labor on a scarce land unit undoubtedly helps to increase its yield. But it does not by itself improve the productivity or wage of labor; this can occur only when intensive use of capital accompanies intensive use of labor in such a way that yields per unit of both land and labor increase, so that every increase in food production is accompanied by an increase in per capita income of the worker also.

If increased production helps reduce the food deficit, increased income helps modernize agriculture. The two together then ensure that the objective of meeting the food deficit by improving the productivity of the small farm is no longer a one-time operation but becomes a continuous process, as it were.

In other words, the basic deficiency of land that a small farm faces must be overcome by intensive use of both labor and capital — supplemented, of course, by relevant knowledge of improved farming methods. It is the lack of this relatively simple but strangely elusive perception that has often misled the policy makers and planners in many a developing country.

In some countries it was felt that the small size of the farm was an inhibiting factor in itself. An attempt was therefore made either to collectivize these farms or replace them by large-scale capitalistic farms or plantations. In a number of cases this no doubt increased the marketable surplus, but in most cases it did not improve the yield per acre. In some cases it created a problem of surplus labor which could not be quickly absorbed in other sectors of the economy, and this had its social cost.

In certain other countries, it was felt that increased yield per acre of small farms was possible by intensive use of labor alone so that whatever capital was available could be conveniently diverted to industrial and other nonagricultural uses. The result was usually a short spurt in agricultural output but not a sustained process of agricultural development.

It is important that the error of both these approaches is clearly recognized. Agriculture, no less than industry, needs progressively intensive use of capital. Intensive use of manpower can certainly help but it cannot substitute for capital except for a short period. For a progressive modernization of agriculture, which is essential for a sustained, as distinct from temporary, solution of the food gap there has to be an intensive use of both labor and

capital in the millions of small farms in the food-deficit and labor-surplus regions of the world.

Intensive use of labor will be helpful for the adoption of the many biological and chemical innovations which modern science has made or is about to make available to us. But intensive use of capital will be needed to get the best results out of this effort. This will include the provision of the degree of mechanization that is required for optimum efficiency of available labor, and for progressive improvement in its remuneration.

The bulk of this capital may be used by the individual farmer in the form of improved seeds, better and larger applications of plant food, water, and pesticides, items of small equipment, and so on. But a part may also be needed for providing the service of heavy equipment on a cooperative or custom basis, in instances where small equipment is inefficient or inadequate.

The Need for Capital

How much capital is likely to be needed? It has been roughly estimated that, if 45 million tons of additional food grains are to be produced by 1985 in the food-deficit, developing countries, the total capital requirement may be of the order of $20 to $30 billion at 1975 prices. Part of it will be needed for additional and improved inputs, mainly biological and chemical, and part for better land and water use, including mechanical devices. But if this amount of capital is focused on production of 45 million tons of food grains alone, we may miss our other main objective — namely, initiation of a sustained process that would progressively modernize the long-run productive capacity of the millions of small farms.

The latter objective will be realized only if this amount of capital is used in such a manner that the small farmer is both induced and enabled to use progressively improving technology on a continuous basis. This involves adequate research and development to provide the technology and the appropriate extension, credit, supply, and marketing services that will move the farmer to give up his old ways and adopt a course of sustained modernization.

If the requisite biological and chemical technology is to be fully complemented by appropriate mechanical technology, it is possible that the overall capital requirement may increase by another $4 to $5 billion. But that would be a worthwhile investment if it makes for a progressive and lasting modernization of agriculture in the years ahead.

The size of a farm need no longer be the inhibiting factor that it was in the past. In fact, a half-hectare farm using what is called "nutrient film technology" can produce per annum as much as a 4- to 7-hectare farm using conventional technology. But this represents a very high degree of substitution of land by both capital and labor. Whether it will be economical will depend upon several factors, including the nature of the product and relative cost of the various elements of production.

Barriers Against Modernization

Although it is technologically possible today for small farms to produce very high yields per hectare, and in some cases it also may be economically justifiable, there is still the question of why small farms are not being modernized faster than they have been in the recent past. The answer lies in the various technological, economic, institutional, and social barriers that usually must be faced.

If the optimum use of a given technology, which is area neutral, is dependent on the use of another technology, which is not so, it may pose special problems for the small farmers. In such instances the solution lies in providing the latter technology, if possible, on a custom basis by the private sector or on a collective basis by the public sector.

If the profit margin is not large enough or the perceived risk is too great, small farmers may not adopt a desirable innovation. Measures such as efficient marketing services, price or income supports, supervised credit, and crop or livestock insurance may go a long way in reducing this kind of barrier. Measures such as enclosure or consolidation of holdings, abolition of intermediaries, and granting permanent tenancy or ownership rights on land to the farmers are likely to overcome many of the institutional barriers.

Provision of effective and imaginative nonformal education opportunities, extension services closely supported by research and feedback arrangements, and greater geographical and social mobility is likely to reduce many of the cultural and social barriers. These barriers may vary widely from area to area and from one stage of development to another. It will therefore be useful to orient research toward target groups or areas, to identify the specific barriers that inhibit adoption of a new technology or product, and then find ways and means of overcoming them.

Mutually Supportive Innovations

Technological and institutional innovations often are not only complementary but mutually supportive. The rather naive notion that without drastic institutional reforms, no worthwhile technological progress is possible, or vice versa, has sometimes made political authorities take drastic measures that were unnecessary or even counterproductive. Parallel introduction of technological and institutional innovations in a strategic

manner may in fact cause the one to prepare the ground for the other.

The fear that mechanical innovations may create unemployment dates from the time of the so-called Luddites and must be dealt with as a matter of practical politics. It must be conceded that a considerable amount of labor may become surplus if machines are introduced suddenly, on a large scale, and without adequate safeguards for the transitional period. But all labor-saving machines need not create *net* unemployment, and I underline "net." If they make possible more intensive use of biological and chemical innovations there need be no net unemployment. The direct loss of employment may be more than offset by an indirect gain in employment. Further, many modern mechanical devices help make the labor less irksome and more productive instead of making it redundant.

The Japanese Example

Most agricultural implements in the United States have been developed to meet the requirements of big farms, whereas in Japan, and also Taiwan and Korea, they have been designed to serve the needs of small farms. In most of the developing countries, it is the Japanese pattern of agricultural mechanization that is likely to prove more useful. Once the barriers are overcome and the ground is prepared for the Japanese form of mechanization, an unprecedented opportunity is likely to open up for the farm machinery industry in most of the developing countries.

For instance, in my own country of India alone there are over 60 million farms that are below 10 hectares in size. At present most of these depend on animal power. Not only do these animals consume products that otherwise might be useful to human beings, but the animal power is not always the most appropriate for making intensive use of the many highly productive biological and chemical innovations that are now available.

Indian authorities have so far deliberately given lower priority to farm mechanization lest it add to the country's serious unemployment problem. It is not that authorities are unaware of the loss in productivity that this has entailed, but, in the trade-off between employment and productivity, they have deliberately chosen employment.

If it can be demonstrated that a judicious combination of biological, chemical, and mechanical innovations can enhance both productivity and employment and that this can be achieved without undue transitional difficulties, there is no reason why they should not change their policies.

What is true of India is true of a number of other countries in the developing world, especially in South Asia and Africa. It is for the knowledgeable people at all levels — international, national, and local — to indicate the possibilities, identify the difficulties, and initiate programs of study and demonstration that would carry conviction to the governments and farmers alike in these developing countries.

It is important to remember that if response and progress in regard to the modernization of small farms have varied widely from area to area or group to group, it has not been accidental or entirely irrational. It usually has been caused by specific factors, and the identification of these factors on an area or group basis is a very important first step toward change at the grass roots level. The next step is careful consideration, at appropriate higher levels, as to what must be done to overcome the factors that hinder and promote those that will advance the process of modernization. This is by no means an easy task. Considerably more effort and resources must be invested for this purpose than have been spent so far.

This conference will serve a useful purpose if it can clarify the kind of action that is needed at various levels — in government, in academia, and in industry — and mobilize public support for it. The small-farm sector is a very important element of the world economy. Once it is set on the path of progressive modernization, the result is likely to be beneficial for the other sectors also.

SEN: There are various ways of doing this. It is by no means an easy task. There are, as I have mentioned, economic, technological, and cultural problems involved. But this has been done. In a collective way, they have sought to do it, and have done it to some extent, in mainland China. In a private enterprise way, they have done it in Japan and Taiwan and, in a combination of the two, they have done it in Punjab in India. So it is not impossible. The point is that what can be done will depend on the social, political, and economic milieu. And, as I said, there is no complete answer. We have to study a particular idea in relation to a particular area. What are the main barriers to progress? What are the main barriers to the adoption of modern techniques? Once you know what the main obstacles are, you then have to find out ways of overcoming them. Mainland China has done it one way, Japan has done it another way, and in Punjab it has been done still another way. Now, coming to India you have to ask this question. In all of India you have the same central government, the same planning procedure, and the same field of office, whether you like it or not. But still, how is it that in parts of Punjab there has been as much good progress as in any other part of the world, while 500 miles away, in eastern Uttar Pradesh, there has been no progress?

Instead of asking a naive question, whether this or that can or can not be done in a particular political or administrative milieu, you have to go deeper. You will find that there are basic economic, sociological, cultural, and other obstacles. Now, where it has been possible to tackle these obstacles, progress has been made, as I said, in Punjab. It has not been made in eastern Uttar Pradesh, within 500 miles, because the obstacles have not been tackled. And there is the main difference: progress is not impossible, but the effort has not been made in the right manner. It is not so much a question of overall *policy — whether it is socialism, capitalism, laissez-faire,* or government or private enterprise — you will find something has been done in China and in Japan, something has been done in Punjab, something has not been done in Madhya Pradesh. The point is that very often we are taught that we can have a set program, set policy, set prescription, but that is not the case. One characteristic of development is whether a country is or is not homogeneous. The more developed a country becomes, the more homogeneity, for a certain set of policies operates more or less everywhere. But, characteristically, underdevelopment is heterogeneous. To tackle a problem, you have to study specific groups, find out the special difficulties, and take special measures to overcome them. Where this has been done, the policy has worked; where it has not been done, the policy has not worked.

E. O'ROURKE: As you tried to evaluate what technology is appropriate for a Third World country, surely the ability of that country to sustain that technology must be considered. This becomes especially acute when some of the technology or financial assistance is granted to the Third World country by agencies, government or private, in the First World country in initiating the program. And therefore, I fear, many of the technologies I have seen in the Third World look great the first three or four years of their operation; but return 10 years later and it's all gone. Has that problem been a part of your consideration and, if so, do you have any comments?

SEN: This is very true. But it is not necessarily true everywhere, as I mentioned in the example of Punjab, in India, and eastern Uttar Pradesh less than 500 miles away. The problem is, if a particular agricultural or social milieu is there, well then, what you are putting in there is an innovation, so prepare the ground for it. Ground is prepared stage by stage, you see; then you get sustained progress. And if the ground is not prepared and you put in something exotic, then it doesn't work, simply *because there is not time to adapt. Therefore the important* thing is to study the example, and propose it step by step and see what the local people can sustain and observe themselves. There is all this great outside help, but the outside help should not be needed for all time to come. If you give a man a crutch and tell him that the crutch must be used for all time, then he will not walk on his two legs. It should be explained that the crutch is only temporary, so that sooner or later he must be made to walk on his own legs. The crutch should be taken away.

And that is the basic philosophy which is very important to remember, as I said. Forgetting the rest of the world, take India — the same government, efficient or inefficient; the same policies, good or bad; the same plans, good or bad; the same administration system, good or bad. Well, things have worked in some parts, things have not worked in other parts. Why? That is the basic question to ask. And if that kind of study is done, area by area, group by group, and efforts are made to find the reason, then it will work. And *if this* is not done, if we just prescribe the same medicine for everyone, then we will find that the medicine will work in some cases and not work in others.

L. E. SLATER: I'm interested in the possible role of cooperative farming. What's your view on it and its ability to bring high technology to the small farmer in the Third World, wherever he may be located?

SEN: My feelings and my experience of cooperation are mixed. Cooperation has worked in some areas, and has not worked in others. And I think for certain purposes, cooperation works; for certain other purposes, cooperation doesn't work. And where you find that cooperation, particularly in regard to farming, has worked, it has been in areas where there has been compulsion rather than cooperation. In Russia, collective farms are called cooperative farms. Cooperation has worked in farming in Israel but there is a special art, a special ideology, and there are special conditions that may not be possible to repeat everywhere. On the other hand, cooperative servicing and cooperative marketing have worked in many places. Wherever cooperation can work, well, certainly we should give it priority. It should be tried. But I feel that if it is in the field of cooperative marketing, cooperative credit, or cooperative servicing, that gives it a better scope. So far as cooperative farming is concerned, I'm a little dubious. It is not that it has not worked — cooperative farming has worked in Israel, it has worked in parts of the socialistic countries, but there the compulsion may be provided by either government or by the society.

R. C. MILLER: You've indicated that there are many types of development and certainly we have observed some of the great work that the people of the Peace Corps have done and left — poultry projects going on for years, and training and developing people. As you look at mechanization, and that's what we're talking about here at this conference, what is the value of going into some of these countries and showing them how to build their own equipment, creating those jobs to maintain them and to carry on, and to feel that it is theirs? Is there a place for this kind of development?

SEN: There is certainly scope for this kind of work; if I felt that there was no scope, I would not have come here. But the point is, it is not an easy thing to do. This kind of thing can be done more easily under certain situations, and not so easily in certain others. Why is this so? Well, there are certain sociological, cultural, and economic reasons, and therefore, although technology by itself is important, technology by itself is not enough. You have to develop the technology in order to use it, but you also have to look into the sociological, economic, and institutional factors, and try to see what can be accepted, what can be sustained. Then you will succeed. Otherwise, as a do-gooder you go and bring some equipment, tell people that you have donated this equipment, now go ahead, I will show you how to do it. But it doesn't work. But if, as I said, there is a combination of technological research and sociological and economic research, if we try to find out what the obstacles are and try, step by step, to remove them, then there is certainly hope. And I think there is a great hope. I don't believe that we can solve either the food problem or the population problem by merely repeating the old methods and technology, and merely exhorting people to work harder and harder. It may lead to a one-time increase in production, may alleviate the problem for a short time, but you do not establish the process of modernization wherein lies the solution of this basic problem.

M. J. CLARK: Since your talk was introduced as the overview for the conference, I think it's appropriate to ask for your reaction to at least two aspects of the broader social and economic context in which this kind of mechanization or introduction of technology would find itself. In regard to the focus of your remarks, what significance, if any, do you think they have, even in the most successful application of the kinds of principles you've spoken of, in the absence of serious land reform and serious redistribution of wealth?

SEN: Land reform and redistribution of wealth are certainly important, and certainly help. And in certain situations, if you don't have land reform of a certain kind, a minimum land reform perhaps, no modernization is possible. But it is not necessary to go from one extreme to the other. There are all kinds of situations in which some progress is possible. In some situations a drastic land reform may be necessary in the shape of collectivization, as in Russia or China. In some cases, perhaps ownership of land has to be by the tiller. In other cases perhaps even that is not necessary if financing is possible — even for a short time may be sufficient. Now, there can be various kinds of land reform. If there is the old feudalism with absentee landlordism, where one man tills the land and the other merely exploits him, no progress is possible. That kind of feudalistic land system has to be broken if any technological progress is to be made. But to introduce improved technologies, there may be different kinds of land reform, the socialistic or the capitalistic kind, and sometimes reforming the financial system may produce a certain amount of result. Sometimes giving ownership of the land to the tiller may be sufficient. Sometimes a certain amount of cooperation may have to be introduced. And this will differ in application from area to area.

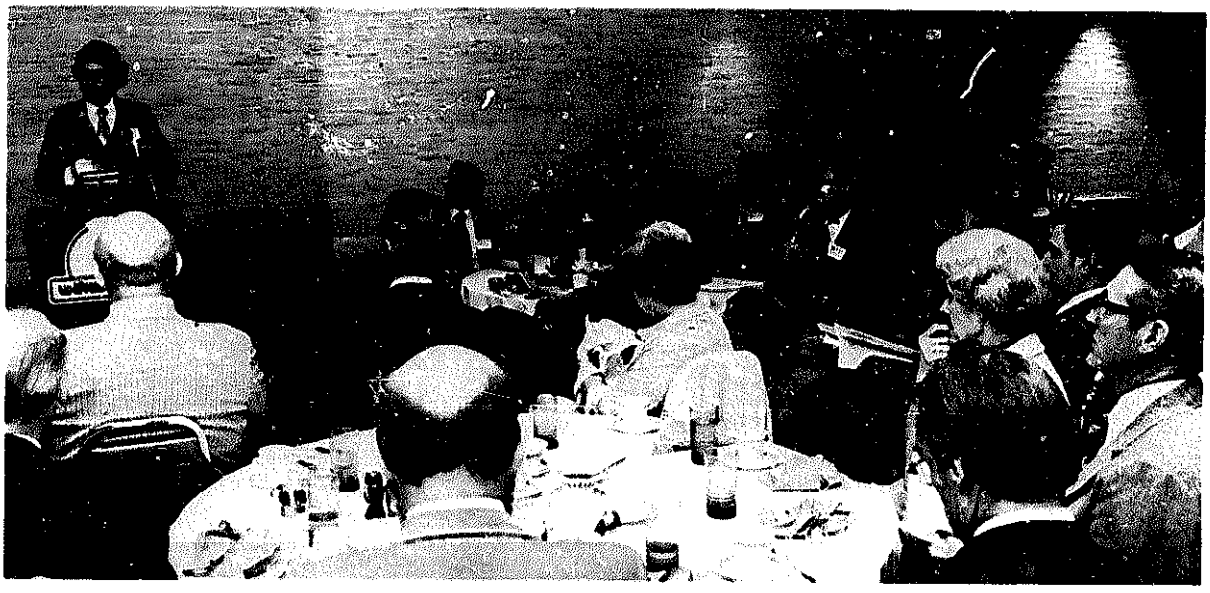
I don't accept the view that either you have wholesale, 100 percent, institutional reform or you will have no progress. My view is this: that as institutional reform helps technological progress, similarly technological progress also triggers institutional reform. And the institution preferred and the technology preferred — well, if this can be brought about step by step, then one sometimes

stimulates the other. And I think that in this way, sometimes you have found in the history of the world that powerful technological forces have brought about institutional reforms. In other cases, institutional reform was necessary before technological reform could take place. I think there may be countries where there is feudalism, and where little progress is possible unless there is some drastic institutional reform. But it is possible that many countries have reached the stage today, that perhaps did not exist 20 years back, where, side by side and step by step, technological and institutional reform may support each other, and may lead to progress.

D. Mshelia: My country, Nigeria, is one of those developing nations that needs the higher technological development, agriculturally. But, in Nigeria about 90 percent of the farmers are not able even to read or write so if we want to present such high technology to them, how will it be possible?

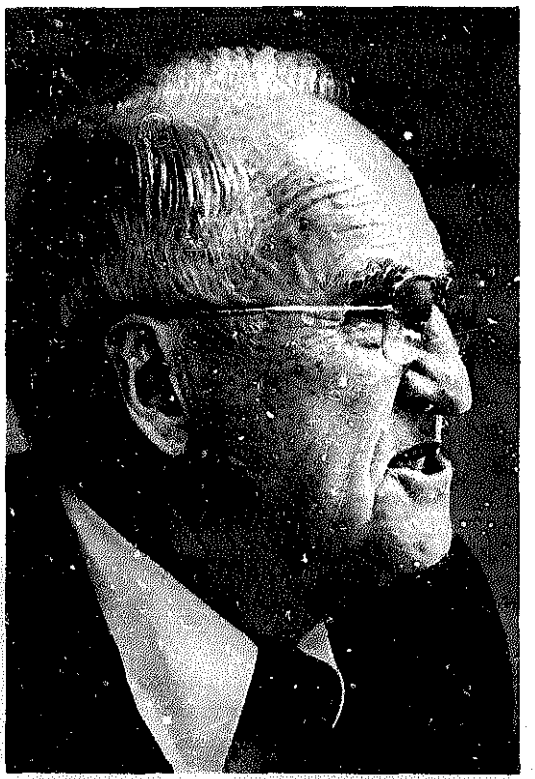
Sen: Education is certainly very important. But I make a distinction between literacy — the ability to read and write — and education. In my part of the world there is Burma, where 90 percent of the people are literate. There are religious schools, small but good, and 90 percent of the people can read and write. And yet there has been minimal technological progress. Agriculture has not progressed at all. They know how to read and write, but this education has been more or less religious, literary, and all that, and it has not helped them to acquire technological skills. On the other hand you have Punjab, where literacy is only 30 percent and most of the farmers, many of them, are illiterate. They have gone to the army and got some skills, but not education. They are not literate, but they have got education through informal means, through extension and other means. And, although to be able to read and write has certainly helped those who have had more education, some of these illiterate farmers have been much more progressive technologically than the farmers in Burma where the majority are literate.

That is why I make a distinction between education and literacy. Certainly there is a need for education. But before we began this emphasis on literacy, there was education: in the classical period, in the Middle Ages, the people did not know how to read and write but they got education through word of mouth. Now, in modern times we can certainly provide them with education, and if we can provide them with literacy it will certainly increase their efficiency. But we need not wait for all that to happen. If we think we must educate or make literate all the people in Nigeria before any progress is made, then it will be 50 years before anything can be done. Today we need not wait 50 years. With radio, television, and extension methods, we can provide formal education. It is possible to communicate with people and to educate people in the sense that we distinguish between literacy and education. And I submit that modern communication methods have given us means so that, even if the spread of literacy takes more time, we can educate people more quickly. And I think we should concentrate on that effort.



J. Terry Iversen of the University of Illinois, co-director of the conference planning committee, makes some announcements and outlines plans for the next day's sessions.

Presiding over the first of two panel discussions is Earl D. Kellogg, University of Illinois at Urbana-Champaign. Four specialists spoke on various aspects of "The Socioeconomic Impact of Farm Mechanization in Developing Nations." The ensuing discussion revealed the consensus of the audience: The answer to providing appropriate technology for developing nations lies in adapting modern technology to the available land, labor, capital, and political and socia conditions of the countries involved.



Speaking from years of experience in agricultural economics and international development programs, Douglas Ensminger of the University of Missouri recommended three distinct, yet interrelated, program packages for enhancing productivity of small farms: land use and tillage practices, technological inputs, and institutional services. But, he cautioned, "Without reliable institutions committed to serving the needs of small farmers, the technological package will have little chance of reaching the farmers."

During a break for refreshments the discussion continues. Sociologists, engineers, economists, church workers, corporation executives, and educators exchanged ideas and opinions — perhaps differing in concept or method, but united in their commitment to meeting the food needs of all people throughout the world.

Panel Discussion
The Socioeconomic Impact of Farm Mechanization in Developing Nations

Introduction

EARL D. KELLOGG

Associate Professor of Agricultural Economics
University of Illinois
Urbana, Illinois

We will begin this panel discussion with a set of mini-papers, as they have been called, that relate to the whole question of the social and economic impact of farm mechanization. We do know, of course, that the effects of farm mechanization are not only felt by the individual farmer and his family, but the ramifications of it occur at the farm firm unit level as well as at more aggregative levels. Today, in talking about the social and economic impact, we are going to be looking at what some have called the package approach to agricultural development, and then we will discuss some of the small-scale equipment that has been developed particularly with Asian agriculture in mind.

But first, however, since we have given this conference the title of "Farm Mechanization Alternatives for the 1–10 Hectare Farm," it might be nice to know what part of the world's farm community is covered by that "1–10 hectare farm" designation. Various data show the great number of units and the large area of crop land accounted for, worldwide, by the 1–10 hectare farm. Admittedly, the accuracy of these data may be open to some question because the figures are taken from census publications of the respective countries. This kind of information is often inaccurate in some sense because it is very difficult to collect in some countries. In addition, we do not have complete coverage of all the continents, only selected countries from each, and if we had included some larger countries, such as Nigeria in Africa and the People's Republic of China in Asia, the numbers would be quite different.

In regard to the percentage distribution of the total number of holdings, by size of holdings, the 1–10 hectare farms account for a large percentage of all holdings in Asia, South America, and Africa, and especially in Asia and Africa. A large percentage of the farms are under one hectare in size, in terms of number of holdings, in certain countries, but the percentage of total crop land represented by farms under one hectare is, of course, much smaller, particularly in Asia.

It is evident that we are talking about a major part of world agriculture when we talk about farms in the 1–10 hectare size. With this background, the papers that follow will deal with four aspects of the socioeconomic effects of mechanization on these small farms.

Macro-Economics of Farm Mechanization

FOLKE DOVRING

Professor of Land Economics
University of Illinois
Urbana, Illinois

The merits of farm mechanization in low-income countries cannot be judged merely on data from "pilot" applications to a minority of farms or to limited areas. Wide application may have effects in the aggregate that are quite different from what appears in the limited environment of a few farms or a small region, when the larger environment is still that of nonmechanized agriculture.

The central macro-economic problem in mechanizing low-income agriculture is that of capital supply — a quantity problem. Capital in agriculture must always be in some reasonable proportion to the size of the industry and its output. In low-income agriculture this is compounded by the general scarcity of capital in low-income countries, and by the terms-of-trade between capital and labor when labor is in excess supply.

A further complication in agriculture arises from the limitations upon demand, known as Engel's law: as per capita incomes rise, the demand for food rises slower than does per capita income (1). This limitation is lessened in countries that have very good prospects for expanding agricultural exports; but such countries, by the inherent logic of the situation, are a minority in the world. Most countries produce the bulk of their own food, and in most of them net exports as well as net imports represent a minor fraction of the food grown in the country. Nonfood products also are generally a minor fraction of all agricultural production.

Because of Engel's law, growth of agricultural production is generally not rapid. This is modified by the rate of growth of the population, but a rapid population growth rate in a low-income country also tends to worsen the general resource scarcity. The stimulus to agriculture from this side is thus counteracted by the sharpened constraints on capital supply, leading to a sluggish rate of growth in per capita income.

The influence of Engel's law upon agricultural growth can be charted with considerable confidence. This is because empirical data show that the income-related demand for food is virtually the same the world over (2). This universal Engel function allows us to estimate some consequences of both population growth and economic growth. With a given rate of increase in population, a given level of per capita income, and a given rate of increase in per capita income, increases in total demand for food can be estimated, and hence the rate of growth in the agricultural sector can also be estimated. These estimates depend, among other things, on certain more or less constant proportions between the size of the whole economy and the size of agriculture's linkages with the rest of the economy — backward linkages to input-supply industries and forward linkages to food processing and marketing activities.

Empirically it has been shown that, in market economies, agriculture's external inputs (the production goods farmers buy from other sectors of the economy) amount to about 3 percent annually of the country's national product — independently of time, place, and level of per capita product; and that the share of food processing and marketing comes to about 8 to 9 percent of the national product, again rather independently of time, place, and level of per capita national product (3). These constant relations have been named the Simantov constants, after the scholar who discovered them. These constants apply in market economies but not always in planned economies such as that of the Soviet Union.

Markets and Use of Resources

Now it can be shown that the Simantov constants are consequences of the shape which the universal Engel function happens to have (4). It is logical to conclude that these constants reflect some of the discipline which the markets exercise over the use of resources. When the constants are violated to some large extent, as in the central planning of communist countries, this leads to more expensive production (5). The same is true in market economies in which the promotion of a high rate of capital use in agriculture leads to proportions other than what is consistent with the demand function for food.

Simply expressed, the first Simantov constant (3 percent of national product as external inputs to agriculture) reflects a level of external costs which agriculture (a) will need in order to deliver the goods to fill the demand for food, and (b) can recoup out of the food

prices without unduly raising the prices for farm products. The same level is also what the whole economy can spare for use in agriculture and is able to pay for through the prices for food. Increasing the use of external inputs much above the 3 percent of the national product tends to push agriculture toward excess production which is followed by falling prices of agricultural products. Such falling prices soon force farmers to reduce their purchases of external inputs until excess production is curbed and the prices of their products again rise to a level that can pay for the external inputs as well as agriculture's own, internal factors of production (land, labor, and farm-owned capital). In the meantime, and for as long as the oversupply of external inputs to agriculture continues (maybe subsidized by exchange rates or special credit arrangements), the nonagricultural sectors experience a worsened scarcity of capital goods needed for their expansion. The hardware that goes into farming cannot at the same time go into factories. The sum of hardware is limited, and especially so in low-income countries whether they import it or make it themselves. Such capital starvation of the nonagricultural sectors slows the rate of economic growth, in the nonagricultural sectors and in the economy as a whole. Consequently the total demand for food grows more slowly, which is particularly unfortunate when agricultural products are in excess supply because of too many external inputs going to agriculture.

Overcapitalizing agriculture is therefore a self-defeating strategy — it hurts the agricultural sectors and the economy as a whole. Undercapitalizing agriculture produces all the opposite consequences — undersupply of food, rising domestic food prices and pressure to use foreign exchange to import food when foreign exchange is needed to import inputs to both industry and agriculture. This hurts the whole economy, both its agricultural and nonagricultural sectors. The consequences could be similar when scarce funds are allocated the wrong way — for example, labor-saving machines are acquired when fertilizers are needed for larger output.

The first Simantov constant thus reflects a twofold constraint on the economy and its agricultural sector. Agriculture should have about 3 percent of the national product as external inputs — not much more, and not much less either. This leads to the question of how this limited "cake" should be divided for best results, among the inputs that are (or may be) competing for limited funds. We must discuss the effects which each group of inputs has on production, on productivity, or on both, and we must discuss the rationale of increasing either production or productivity, as well as the meaning of the latter concept.

The Use of External Inputs

Increased use of external inputs in agriculture may serve four basic purposes, singly or in combination: (a) larger output, (b) better quality of output, (c) reduced risk, and (d) substitute for labor or land, or both.

Using external inputs to obtain a larger output is rational on two conditions: that there is a ready market for the added output, and that the same, or an equivalent, result cannot be obtained by more intensive use of labor and land. More intensive use of labor is sometimes but not always, possible — for land clearance and land improvements, for increased intensity in the use of land as in double-cropping, more intensive hand tillage, increased "recycling velocity," and so on.[1] The scope for such labor intensive development depends, among other things, on the degree of underemployment in the country's agriculture and on a variety of geographical factors.

It is evident that if the objective is more output, emphasis in the use of external inputs must be on fertilizers and agricultural chemicals (6). Mechanization seldom contributes much to the level of crop yields, except in the form of pumps for irrigation. To some extent mechanization can contribute to larger output by providing speedier tillage needed for double-cropping, but this has two limitations. It does not hold where the labor surplus is very large (high level of underemployment), and where the crop sequences are truly polycultural, with several different crops having different time schedules. The argument for mechanization as a help to larger output holds mainly where there are certain fixed two-crop sequences (such as the wheat-cotton sequence in Pakistan) or where mechanization can be made so comprehensive that draft animals can be dispensed with altogether, freeing the land that fed the draft stock and thereby saving 10 to 20 percent of the crop land. This should be least important in South America, because the region has vast areas of potential crop land not presently in use and because this is where low-income agriculture is the most highly mechanized. Land saving should be of greatest importance in Asia, but here its importance ought to be reduced through the Green Revolution which, by higher crop yields, relaxes the land shortage, making draft animals more acceptable yet for some time to come.

Higher quality of output is sometimes desirable also in low-income countries, and generally the more so as agriculture becomes more commercialized. It is charac-

[1] "Recycling velocity" refers to the rate at which the same plant food enters the food chain again and again through recovery of crop, animal, and human wastes. The techniques of recovery, and the rates of double- or multiple-cropping of the same land in the course of a year, will affect recycling velocity. This path toward agricultural expansion has been important in mainland China in recent decades.

teristic that the agricultural machines that were first adopted widely in late nineteenth century Europe — threshing machines and milk centrifuges — were in this category. Threshing machines can be driven by human or animal labor, so the mechanization argument comes down to substitution of fuel for muscle.

Safeguarding the output against risks of loss or deterioration can also be fairly important even in low-income countries, but with a clearly distinguishable trade-off against cost. Many of the crop risks that can be reduced by mechanization hinge upon harvest weather, which often is less critical in the tropics than in temperate countries.

Substitution for labor has been the most important gain from mechanization in the high-income countries. Clearly the trade-off depends very much on the relative prices of labor versus capital (including fuel). Since the price of labor is largely a function of per capita income,[2] the trade-off is generally unfavorable (based on realistic pricing) in low-income countries and tends to improve gradually with rising income levels. Rising fuel prices since 1973 may cause some reassessment of the fuel/labor trade-off even in high-income countries, and should do even more so on lower levels of per capita income.

Private and Social Effects

These conclusions sometimes appear to be contradicted by the economic experience of farmers who have found mechanization profitable — in many countries, from Argentina to the Punjab in India and Pakistan. It is necessary, therefore, to remember the differences between productivity and rate of return in private account and in social account.

Private rates of return are sometimes affected by special pricing arrangements — for example, by manipulation of exchange rates or foreign credit.[3] Productivity in private account often differs a good deal from productivity in social account because of the way unemployed or underemployed people are treated. Private firms generally do not support the unemployed — only the underemployed, if they are members of the farmer's family or extended family group. To the labor-hire farmer, a saving on the labor bill becomes a real saving in private account. In social account the same is true only to the extent that the workers displaced by mechanization find other work. Such is sometimes the case locally but it does not happen across the board, for whole countries.

[2] Actually the price of farm labor tends to rise somewhat faster than the average per capita income in the country, because the degree of farm-nonfarm income disparity tends to lessen as the general income level rises. Cf. Folke Dovring, *Problems of Manpower in Agriculture*, OECD Documentation in Food and Agriculture 67, Paris (Dec. 1974).

[3] See (6), especially the chapter on Pakistan by Carl Gotsch.

Innovative farmers and progressive farming regions sometimes use mechanization to expand their production vigorously, which will then also create employment in agriculture. But if this were to happen in the country as a whole, or in some large part of it, the result would be oversupply of farm products and falling terms-of-trade for these products, as mentioned above.

In net social account, premature farm mechanization on a large scale would lead to higher costs of production and falling real productivity. The cost of mechanization is added but the cost of displaced (now unemployed) labor cannot be subtracted — these people must live somehow. They will either be charges of organized welfare, as in high-income countries, or be charges of relatives, neighbors, or employers of retainers, as is more common in low-income countries. America has experienced the south-to-north migration of workers displaced by the mechanization of cotton farming on large estates, with unmistakable consequences for welfare and other matters touching the aggregate economy. Retainer employment in many low-income countries often serves mainly to protect the employers against the dangers of the unemployed; such practices become a built-in drag on productivity development in the country, and a disguise for part of the unemployment.

Productivity in private account becomes a criterion for economic planning mainly when factor supplies are in balance, and specifically when there is no large unemployment or underemployment. As long as unemployment is important, productivity in social account requires full employment of factors rather than using production inputs of high productivity in private account.

These observations make it possible to chart a rational forecast of when various types of capital ought to become important in one country or another. In general, heavy mechanization of recurrent farm operations should wait until substitution of machines for labor (and draft animals) becomes rational on grounds of costs and returns in social account, and on grounds of capital supply in that country. It is noteworthy that "tractorization" of agriculture in Europe (excepting England and Sweden) did not begin in earnest until the 1950s.

In the meantime, mechanical power in agriculture can still fulfill some important functions even in low-income countries. One is for nonrecurrent operations requiring greater power than peasant farms can muster: land clearance and leveling, digging the main canals for irrigation and drainage, and "subsoiling" by deep plowing. Another, already mentioned, is motorized pumps for irrigation — here the difference in efficiency against hand or animal labor is often so large that substitution makes sense even on fairly low levels of income. A third category is in small tractors for peasant agriculture, specifi-

cally in land-scarce areas but also where idle seasons are very long so that draft animals become a heavy overhead cost.

Other than that, the low-income countries will need to concentrate what heavy hardware they can afford on developing industry and infrastructure, with large-scale water control works as a category serving both agriculture and other sectors. Bulldozers, excavators, dump trucks, and so on, are needed in building roads, dams, factories, and housing construction, and for equipping factories and transportation outfits for their vital tasks in economic growth and development.

To maintain such a rational growth of capital use in a low-income economy, small farms are better suited than large ones, for the small farmers do not experience the same pressure to substitute capital for labor; no one wants to mechanize himself out of his job. Large farms are in fact the least economical, in social account, in the use of scarce capital and underemployed labor. Land reform countries generally exhibit a better record of a resource use that is rational in social account. This makes it all the more essential that the true needs of small farms, in terms of what capital they should have, be clearly recognized and efficiently served.

REFERENCES

1. Marguerite Burk and Mordecai Ezekiel, "Food and Nutrition in Developing Economies," *in, Agricultural Development and Economic Growth*, eds. H. M. Southworth and B. F. Johnston, Ithaca, N.Y. (1967), pp. 327–358.
2. "Factors Influencing the Trend of Food Consumption," chapter 3, *The State of Food and Agriculture 1957*, FAO, United Nations, Rome (1957), pp. 70–110, 166–169.
3. A. Simantov, "The Dynamics of Growth and Agriculture," *Zeitschrift für Nationalökonomie*, 27(3):328–351 (1967).
4. Folke Dovring, "Macro-Constraints on Agricultural Development in India," *Indian Journal of Agricultural Economics*, 27(1):46–66 (1972). Cf. idem, "Income Growth Rate and Sector Proportions: The Share of Agriculture at Successive Levels of Income," AERR 97, University of Illinois Department of Agricultural Economics (Dec. 1968).
5. Folke Dovring, "Soviet Farm Mechanization in Perspective," *Slavic Review* 25(2):287–302 (1966); idem, "Progress on Mechanization in Soviet Agriculture," *in, The Soviet Rural Community*, James R. Millar, ed., Urbana, Ill. (1971), pp. 259–275. Cf. idem, *Land Reform in Hungary*, AID, SA/LR/C-10, Washington, D.C. (June 1970), pp. 36–41.
6. *Mechanization and Employment in Agriculture: Case Studies from Four Continents*, International Labor Office, Geneva (1973). *Cf.* review by Folke Dovring, *Economic Development and Cultural Change*, 25(4): 764–769 (1977).

The Social Consequences of Mechanization

WILLIAM C. THIESENHUSEN

Professor of Agricultural Economics
University of Wisconsin
Madison, Wisconsin

Several experiences that I have had over the past few years have added to my concern about the problems that even the simplest kind of substitution of machinery for labor might have in some less developed countries, but one experience sticks in my mind particularly.

It was on a hot day last January, the middle of the dry season, and corn picking had been finished a month previously in the shadow of the Usulutan volcano in El Salvador, the most densely settled country in Latin America. This is the country's cotton belt in lower altitudes but corn is raised at these higher reaches. At Santa Catalina, a fledgling production cooperative with 46 members, the Gulf of Jiquilisco to the Pacific could be seen at the southern horizon. The cooperative, I was told, would tally modest profits this year after all income was added up and expenses were subtracted.

I asked members what they would do with these funds. Buy a machine-powered corn sheller, they said. A tour around the harvest area showed why. They were paying each of four outsiders — nonmembers of the cooperative — six U.S. cents per sack to hand-power a rented manual sheller. Rent was only $2.50 a day, but to shell out their 6,000 quintal harvest would take about $300 in machine rent alone, and a self-powered simple sheller would cost — they calculated — about $250. The co-op could find no bank to advance them the money against the coming harvest, so their first priority was to make a purchase when they had their own earnings in hand.

The decision was a rational one on the part of the co-op members, but unanswered questions still bother me. Most relevant to our present concerns was, what would happen to the four men who spent from dawn to dusk taking turns at turning the crank? Would they get a better job or become unemployed? Given the order of unemployment in El Salvador, a pessimistic answer is the more realistic.

Half a world away from this scene, Collier et al. (1) document another case of a seemingly innocuous change in technology and its social impacts. In parts of Indonesia, by tradition, large numbers participate in harvesting rice; as many as 500 persons per hectare have been recorded. Harvesters are mainly women and they traditionally use a small hand knife, the ani-ani, to do the work. Landlords traditionally have paid the harvesters a predetermined fraction of the bundles harvested, depending on the worker's socioeconomic status, relationship to landowner, and amount harvested. By long-standing custom the system leads to a wide distribution of the harvest.

The ani-ani, with which the rice stalks are cut individually, is now being replaced by the sickle, which cuts several rice stalks in one stroke. With the ani-ani, 200 or more man-days are needed to harvest one hectare; with sickles, the same amount is harvested using only about 75 man-days. Since fewer harvesters are needed, fewer people reap any benefits of the harvest.

Technical change in these situations is thus a powerful force for social change. And in the absence of job alternatives, its adoption decides which people work or don't work, eat or go hungry. The choices were never as tough for us in the United States during our early history. We worked. We ate. And we need to keep in mind that, while the corn sheller and the sickle are examples of some very minor changes in technology, major changes — such as the introduction of large tractors and heavy implements — are just as characteristic in some areas of the developing countries today.

This is important for discussion here because there is probably only one practical way to fight the stark battle against poverty in the developing countries — that is, with employment. And there is no surer way to plunge people into poverty than by denying them jobs.

Questions of Land Tenure

Both El Salvador and Java suffer from overpopulation, but there is another characteristic that unifies them. Both of these agricultural societies are organized in a hierarchical manner. Landlords make most of the decisions (such as whether or not to adopt technology) and workers simply accept the consequences. Call them highly stratified societies if you will. I suggest that in highly stratified countries, understanding land tenure patterns is essential to assessing the differential impact that technology may have. In unimodal or more uniform societies there is less to understand.

Said somewhat differently, land tenure is a manifestation of society and class in some countries. This, I hypothesize, is not the case currently in the developed countries, but it is certainly true in many contemporary countries of the Third and Fourth Worlds.

After a certain threshold point in development, tenure systems appear to become rather unimportant: land simply responds to market forces as another economic factor of production and tells us little about social class or stratification. In the United States, for example, we long ago departed from the Jeffersonian egalitarianism that was reflected in the tenure system originally established when the West was being settled and the United States was underdeveloped. The combined effect of generally plentiful jobs in the industrial sector, expensive labor, cheap capital, and relatively inexpensive food was to enlarge family farms. In the last decade, farms that could be operated by one family have become very large, are highly capitalized, and often involve owner-rental tenure patterns. But we cannot say that as farms grew larger, a new elite appeared. Instead, the farmer became more surely another element in an ever more homogeneous middle class.

The elites in the United States were nearly always a manifestation or outgrowth of the industrial or service sectors. In contrast, most very large farmers operate with continuing low-profit margins. The Mill-Marshallian treadmill with cost-saving innovation leading to lower farm prices and ever larger farms came to prevail. That is, early adopters got high profits before the vast majority came to use the technology, whereupon price and profit dropped for all, and small farmers went to work in town as machinery on bigger farms replaced them.

Our land tenure system now has little to do with the egalitarian ideas upon which it was based. It worked itself out the way neoclassical equilibrium models say it will, and, with a caveat here and there, U.S. farming is probably as good an example of pure competition as a capitalistic system can provide anywhere. A new wrinkle today is the rate at which farm families have been giving up entirely and, in some sections of the country, corporatism at the producer level is becoming a more important tenure form. Whatever their ownership structure, most remaining U.S. farms are large and highly capital intensive.

This is a far cry from the situations prevailing in most developing countries where land is a factor of production, but not a very manipulable one because it is much more than that. It is a reflection of society and its classes (2).

As a general and oversimplified rule, countries in Latin America and Asia represent tenure and societal systems that are quite highly stratified. Although any one society may have multiple systems, one system is usually dominant (3). In Latin America the highly stratified latifundio-minifundio (large estate-small farm) system is usually dominant, but in most countries — mainly in pockets of isolation — there is the egalitarianism of the tribal Indian. In Asia there seems to be a stratified class structure in which tenure patterns are reflected as surely as in Latin America. Look at the plantations of Malaysia, Sri Lanka, Assam, the Philippines, and so on. Look at the landlord-moneylender-tenant relationship spread widely in most of South and Southeast Asia — even in Java — where we see in microcosm the kind of patron-client relationship so common in Latin America.

It is widely recognized that land tenure systems have important political repercussions and the least egalitarian ones seem to require ever more repressive forces to keep nation-states from pulling apart at the seams. The reasons are not hard to find. If resources such as land are distributed inequitably, incomes are also. And even where the average per capita incomes are rising, the incomes of the lower half of recipients may be dropping relative to the upper 50 percent. Some groups at the bottom may have declining absolute incomes even as the mean income of the economy as a whole rises. While we cannot say that this inequality in overall income distribution is due only to marked class differentiation stemming from tenure inequality in agriculture, the evidence points in this direction because resources there are so inequitably distributed and agriculture bulks so large in national income accounts.

Technology and Income Distribution

It is disturbing to note that, even in those countries of the Third World where technical change is taking place most rapidly and gross national product is rising most appreciably, all indications are that the distribution of income is becoming more skewed with time. Perhaps we should not be surprised, however. These are also the countries that are most hierarchical, most stratified. The 2.6 percent rate of economic growth of Latin America between 1950 and 1975 — resulting in a doubling of mean income — is most impressive, but there are fairly good indications that a substantial number of people within that population have not benefited at all. One study estimates that the lower 60 percent of the population is relatively worse off than two decades ago and the bottom 10 or 20 percent may even have lower absolute incomes (4).

The story covers more than Latin America, however. When the International Labor Organization constructed a market-basket poverty line based on a nutritional standard in four states of India, Bangladesh, Malaysia, and the Philippines, it found that in most cases the percent-

age of the rural population below this indicator increased in the 1960s. In the Philippines, from 1956–1957 to 1970–1971 the bottom two deciles of income receivers suffered a decline in real income. In rural Egypt, real wages have been falling and the proportion of households dependent on wages for a livelihood has been rising (5).

This is not an argument against economic growth—far from it. In those few countries in which average income fell in the past quarter-century, the absolute situation was worse for nearly everyone. But it is a reminder that growth by itself, given the social structure prevailing in many developing countries, has left a great many people behind as economic dropouts, a phenomenon that is unique in history. One suspects that there may be some irony in all of this: it may be that the technology required for economic growth, or that is *perceived* as being necessary for economic growth, is displacing job holders to an unacceptable degree. One thing is certain: policy-makers must scrutinize the use of the machine process much more carefully in the future than they ever did in the past, if they have any concern at all for the poor who must depend on a wage or self-employment with minimal resources to survive.

The idea that technology has power for both good and ill is hardly new or fresh. It was analyzed by social scientists even before Dickens popularized it for the Western world. But what the Industrial Revolution in England (and in the United States, for that matter) did not have was highly labor-displacing, borrowed technology superimposed on a large and rapidly growing labor force. The monotony, drudgery, and exploitation of the factory worker became well known, but we did not then have, to any appreciable extent, the phenomenon of a less developed world of millions upon millions of voiceless workers who today seem to find a niche in the interstices of the middle- and upper-class population and who, for the time being at least, suffer quietly. Even our Great Depression was not comparable, because it not only affected the lower classes but also the highly vocal middle and upper classes.

Clayton (6) maintains that "the recent effects of this [technology] in many countries have been to increase income inequality and unemployment and thus, in the absence of specifically designed policies, to deprive small farmers (partly or wholly) of the economic benefits of mechanization."

Is this an exaggeration or does a chain of neo-Luddite reasoning lead to it? I think not, and would like to pose several fairly simple reasons why agricultural mechanization might lead to unemployment that is especially serious in stratified societies. (Were there time, we could go through similar reasoning to show why urban employment does not easily absorb migrants from rural areas.)

1. At the farm level, most kinds of technical change, such as the adoption of tractors, represent a large, "lumpy" investment. This is another way of saying that tractors, as capital, reach the lowest point on their long-run average cost curve at fairly high levels of output (and acreage). Further, since collateral is needed to obtain loans to buy them, tractors are beyond the reach of most unaided, unorganized peasant operators.

If larger commercial farmers in the country choose to adopt tractors, which they are doing, they may well displace wage labor. This unemployment of resident farm labor and migrant labor in the first round may affect small acreage farmers in the second round. This accentuates the dualism of the economy, for as one group grows richer, another falls farther behind. Over time, the increased food supplies may lower commodity market prices, with the result that small farmers are likely to be absolutely worse off in income terms as a result of this big-farm bias. Of course, there may be a net welfare benefit to society from lower food prices for urban consumers, depending on the extent of monopoly in the market (which is likely to be great).

2. If cash-rent and share-crop farmers previously worked land with their families' labor and a bullock, tractors may well arrive when high-yielding varieties and the accompanying input packages make some crops far more profitable than others. In this event, landlords may evict tenants in order to capture the newly found gains of a more profitable agriculture.

To elaborate these points briefly, the most direct way that income distribution can be affected by new technology is if rural workers—who already crowd the low end of the spectrum of income-receivers in most developing countries—lose their jobs or have even less employment than presently because of it.

Whether the mechanization displaces workers seems to depend somewhat on which constellation of the following (nonexhaustive and interrelated) list of factors is found and how it is changing over time: (a) which crop is grown (some are more amenable to the machine process than others); (b) diversity of farming program followed; (c) kind and amount of machinery and in which practices it is used or comes to be used; (d) whether double-cropping is practiced; (e) pattern of land tenure and presence of tenants, occasional labor, resident farm labor, and so on.

The reason mechanization seems to accompany the introduction of high-yielding varieties is that government policy may, for one reason or another, encourage it. Regardless of the countrywide situation, regional or seasonal

labor scarcities are common — or landlords may perceive a scarcity even when one does not prevail. Labor, after all, must be dealt with in a personal manner lest it go on strike or in other ways disrupt the harvest. Whatever the reason, many governments have adopted a credit program or differential exchange rates which encourage mechanization of agriculture. Frequently a higher minimum wage also is introduced which, even if badly administered, tends to provide further impetus to mechanization and to have a negative effect on employment.

The chain of events is likely to be cumulative and when one operation — seeding, for instance — is mechanized and the power source becomes available at the farm in the form of a tractor, it will be relatively inexpensive to mechanize other farm operations. The cost of adding implements is probably marginal when the investment in a tractor has already been made. In this instance, even if the first round produces increased labor use, second-round effects will probably be adverse.

Social Effects of Mechanization

All the evidence is not in on the social disruption which mechanization causes, but that which is does not reassure us. One authoritative study by Abercrombie (7) concludes that mechanization has created substantial rural unemployment and increased rural inequality in Latin America. He admits, however, that:

> The principal effect of mechanization on the level of agricultural production is achieved through the expansion of the cultivated area that it makes possible. . . . But the most important aspect is the much greater speediness of mechanized land preparation. This is crucial in overcoming the seasonal labor shortages that occur even in labor-surplus economies, for example in arid areas where only a limited time is available for land preparation and in tropical areas where multiple-cropping is possible, provided the land can be prepared quickly for the next crop. . . . The direct effect of mechanization in yields per hectare is much smaller.

On social matters, Abercrombie continues:

> . . . although mechanization raises the productivity of labor, in the conditions prevailing in most Latin American countries its benefits have gone mainly to swell the profits and rents of the large landlords and the wages of the few tractor drivers and other machinery operators, so that it has tended to have a regressive effect on income distribution which has been felt not only in the agricultural sector as a whole but also within the laboring class itself. . . . it may be roughly estimated that about three workers are displaced by each tractor in Chile, and about four in Colombia and Guatemala.

Abercrombie concludes that, although data are insufficient, they do "show definitely that labor has been displaced by mechanization, and that the displacement may possibly have been very large. . . . a total of approximately 2.5 million jobs have been displaced by the tractors at present in use in Latin American agriculture." All indications are that this is a conservative estimate (7).

Since Abercrombie's data were collected, mechanization in Latin American agriculture has continued apace. In the late 1960s the countries with the most tractors were Argentina (180,000), Brazil (100,000), and Mexico (70,000). Using 1975 data we find that tractor use from that point increased about 4 percent in Argentina, 150 percent in Brazil, and 100 percent in Mexico. Because Brazil and Mexico have far greater problems with agricultural underemployment than Argentina, the implication is that if we accept Abercrombie's conclusion based on late 1960 data, the situation he describes is aggravated today. Taking the 17 countries of Latin America for which we have the 1965–1969 data reported by Abercrombie and the 1975 data reported by the Food and Agriculture Organization (FAO), tractor use rose 52 percent in the 6-to-10-year period. If we use the 26 countries of Latin America for which we have 1961–1965 data and compare them to the 1975 data, tractor use rose about 84 percent (8) in the 10-to-14-year period. Tractor use is outpacing growth of the available labor force in farming.

Another study, by Binswanger (9), which painstakingly examines a large number of heretofore largely unavailable empirical works over the recent past in the Indian subcontinent, concludes:

> That tractor farms generally do not have much less labor use per hectare than bullock farms does not imply that they are not labor displacing. What counts is, first, that the frequently higher levels of output on tractor farms on account of their better capitalization are generally produced by equal amounts or even less labor. Second, even if the tractor investment left employment unaffected we must count the foregone employment of not investing the capital into employment-creating irrigation or even nonagricultural investments as an employment cost of tractors.

Simply to argue that the weight of existing evidence seems to be on the side of those who maintain that the net effect of mechanization to date in developing countries is to create more unemployment and underemployment, is not to say that technological change cannot be utilized in a more imaginative, socially beneficial manner in the future. It does argue that the chance of social dislocation in countries with a great amount of social stratification is probably great and each step toward mechanization may bring about unwanted social costs in the form of unemployment. In some cases, governments can make appropriate adjustments to exchange rates. And machinery manufacturers themselves may be able to do something to make the technology which they market truly appropriate to the situation at hand.

Under what conditions might mechanization have a salutary effect on employment? (10)

1. *If mechanization leads to greater land use it may increase employment.* In some instances a frontier may exist on which a productive agriculture could be established, but a major effort with land-clearing equipment must be undertaken. In others, speed of harvesting one crop and putting another into the ground requires such short turnaround time that mechanization decides between single- and double-cropping.

2. *If mechanization leads to manpower release which can be deployed to undertake other needed tasks within the farm gate that will raise family farm income, it may raise labor productivity.* If no outsiders are normally employed and only family labor is utilized, substituting a small hand tractor or mechanical cultivator — or even a two-wheel rotary cultivator — for labor may release the time of family members for caring for additional livestock, market gardening, or more careful irrigation than was possible previously.

3. *If the backward linkages to manufacturing are to be found in the country rather than abroad, it may be that for every job displaced in agriculture another is created in industry and in service and maintenance activities for equipment.* Argentina, Brazil, Mexico, and India have built up full-fledged tractor manufacturing industries. In smaller countries, animal draft equipment factories or small tractor factories may perform a similar function. The more the linkages that are retained within the country, the greater the relevant employment impact of the utilization of equipment.

One caution: It is highly unlikely that all or even most of the labor that is released from agriculture will be employed by other agriculture-serving sectors. The agricultural labor force in the United States fell from more than 10 million in the 1920s to 4 million in 1960. Dovring (11) shows that "the industries and services supplying farm requisites have increased to such a degree that they have been able to supply a vastly increased physical volume of goods and services without using up any correspondingly increased portion of the nation's work force."

4. *If greater food and fiber production is made possible by mechanization, forward employment linkage effects become more probable:* in harvesting, rural processing, milling, weaving, and so on.

REFERENCES

1. W. L. Collier, et al., "Recent Changes in Rice Harvesting Methods," *Bulletin of Indonesian Economic Studies* 9:36–45 (1973); *and* Rudolf Sinaga and W. L. Collier, "Social and Regional Implications of Agricultural Development Policy," paper presented at South East Asian Agricultural Economics Association meeting, Balikpapan, Indonesia (Nov. 1975). *See also*, W. L. Collier, "Agricultural Evolution in Java: The Decline of Shared Poverty and Involution," background paper (mimeographed), International Seminar on Agrarian Reform, Institutional Innovation, and Rural Development (July 1977), Madison, Wis.
2. Don Kanel *in, Land Tenure in Latin America: Issues and Cases*, ed. Peter Dorner, pp. 21–35, University of Wisconsin Press, Madison (1971); *and* Don Kanel *in, Problems of Rural Development: Case Studies and Multi-Disciplinary Perspectives*, eds. R. E. Dumett and L. J. Brainard, pp. 47–57, E. J. Brill, Leiden (1975).
3. J. E. Spencer, "Rudiments Toward the Development of a System of Tenure in Land," paper (mimeographed) given at the Fiftieth Anniversary of the Department of Geography, University of Wisconsin–Madison (May 1978).
4. Richard Weisskoff and Adolfo Figueroa, "Traversing the Social Pyramid: A Comparative Review of Income Distribution in Latin America," *Latin American Research Review* 11(2):71–112 (1976).
5. Keith Griffin, "Increasing Poverty and Changing Ideas about Development Strategies," *Development and Change* 8:491–508 (1977).
6. E. S. Clayton, "A Note on Farm Mechanization and Employment in Developing Countries," *International Labour Review* 110:57–62 (1974).
7. K. C. Abercrombie, "Agricultural Mechanization and Employment in Latin America," *International Labour Review* (July 1972); reprinted in International Labour Organization, *Mechanization and Employment in Agriculture: Case Studies from Four Continents*, Geneva (1973).
8. *1976 Production Yearbook*, FAO, United Nations, Rome (1977) (for calculation of 1975 data).
9. H. P. Binswanger, *The Economics of Tractors in South Asia: An Analytical Survey*, Agricultural Development Council (in press). *See also* International Labour Organization, *World Employment Programmes: Research in Retrospect and Prospect*, Geneva (Feb. 1976).
10. *See* C. Voss, "Agricultural Mechanization, Production, and Employment," *Monthly Bulletin of Agricultural Economics and Statistics* 23(1):1–7 (1974).
11. Folke Dovring, "Productivity of Labor in Agricultural Production," Illinois Agricultural Experiment Station Bulletin 726, p. 13, University of Illinois, Urbana (1967).

The Package Approach to Agricultural Improvement

DOUGLAS ENSMINGER

Professor of Agricultural Economics
University of Missouri
Columbia, Missouri

In my presentation I have selected as my target group the small food-crop farmers throughout the developing countries whose farm lands are outside the irrigated areas and where the rains are uncertain and moisture is uneven. These are the high-risk farmers and are generally referred to as subsistence farmers, for the main goal of this group is subsistence or survival. It is this sector of agriculture that was ignored by the colonial powers and until recently has been given little attention by the governments in the developing countries of the world.

It is the small, subsistence, food-crop farmers who offer the potential of meeting basic food needs of most of the developing countries. This is the group of farmers whose level of living must rise if there is to be a meaningful improvement in the quality of life of all the people.

Around the world there are only a few research institutions that have focused attention on the needs of the small farmers engaged in food-crop production in the rain-fed areas where the moisture supply is limited and uncertain. What is interesting about this group is that they have survived and functioned largely outside government policies and institutions down through the ages. Their sense of security has been and still is in following the traditional practices handed down from generation to generation, and in looking to themselves, not to governments and institutions, for the know-how and inputs.

Since accepting responsibility for preparing this paper, I have visited Egypt, Niger, Upper Volta, Senegal, and Tunisia, and in all of these countries I was concerned as to how to develop needed and appropriate technology to meet the needs of the small subsistence farmers who are outside the irrigated areas. One possibility is a package approach to the development of small-farm food-crop agriculture. I see the need to develop three interrelated packages which, when put together, will become a food-crop agricultural development program, or a package program for small farms. These three distinct, yet interdependent, program packages are: land use and tillage practices, technological inputs, and institutional services — which I will briefly describe.

Land Use and Tillage Practices

If you have seen as much barren soil throughout the Third World countries as I have, and if you accept the critical role of moisture in plant growth, you are already persuaded that the starting point in putting together a package program for food-crop production is to answer two questions. First, given the soil texture, the moisture available for a given crop season, and the climate fluctuations, what crops will make the best use of the moisture and provide the greatest security for the farmers? Second, what tillage practices will promote maximum absorption and retention of rainfall for plant growth, and minimize water and wind erosion? (Tillage, as used here, covers the entire process of plowing, seedbed preparation, seeding, and cultivation to keep down weeds.)

Only painstaking research can answer these two questions and provide the technology for tillage practices. Thus, research is the first step in providing the tillage technology that is appropriate for arid and semi-arid agriculture, and it must assume a position of prominence in the research institutions of the developing countries. Without first knowing what tillage practices will conserve water and soil, the technological inputs lack their full potential, and soil and water and wind erosion will continue.

Present tillage practices keep the soil bare and exposed to wind and rain erosion in the semi-arid areas of the world. As a result, desertification is now in advanced stages in vast areas of the world. The research to provide the technology to halt this process should focus on maintaining a surface residue to permit the water to enter the soil and be retained for plant growth, thereby minimizing soil erosion from wind and water. Research is also needed for developing alternatives to the present practices of deep plowing for seedbed preparation and cultivating to control weeds.

Mechanization must play a part in improving other tillage practices. Seed and fertilizer drills, both animal- and tractor-drawn, must be developed for seeding wheat, barley, oats, and the like. Research should provide a better alternative to the practice of broadcasting the

seed and fertilizer simultaneously, which also feeds the weeds and is wasteful of precious seed and fertilizer.

The objective of tillage research, then, should be to develop the technology which, when applied, will provide for a tillage conservation system. And, it seems to me, it is the responsibility of those in the field of mechanization to provide the equipment that will make it possible to carry out this kind of program.

Technological Inputs

Today the world is caught up in a high-yielding-variety/fertilizer/water technology package which has had wide application on the large and medium-sized farms in irrigated areas. Since this package of inputs relies on an assured water source for irrigation, it does not fit into small-farm agriculture in the arid and semi-arid areas where it is high-risk technology. The farmers in the semi-arid areas of the world know from experience that within a five-year cycle they can count on two years of above-average rainfall, one year of average rainfall, one year of near crop failure, and one year of drought and crop failure.

The technology inputs must be concerned with developing the plant varieties best suited to the arid and semi-arid farming areas. Plant breeders, soil scientists, plant pathologists, entomologists, and agricultural engineers will have to work as a team. Varieties will be needed that are disease- and insect-resistant, with root systems that penetrate the soil, providing for greater adaptability to fluctuating and limited moisture.

Because of the importance of maintaining the moisture in the soil for plant growth, increased attention should be given to adding herbicides for weed control to avoid the exposure of the soil to the sun and wind that occurs in cultivation.

If the plants are to make maximum use of moisture for growth, pesticides to control insects and disease must find a place in the package of technology inputs.

Institutional Services

Without reliable institutions committed to serving the needs of small farmers, the technological package will have little chance of reaching the farmers. One very important role in the package is that of the institutions and services whose work it is to minimize the farmer's risk in accepting the new technology. With few exceptions, the existing institutions in the developing countries that were created to serve export needs and large-farm agriculture are capable of being transformed to serve the needs of the small farms.

Until a package of institutions and services can be created to which the small farmers can relate with trust and confidence, they will be slow to adopt the new technology. Altogether, the effectiveness of the package program is dependent on political commitment, the people's participation, land and institutional reforms, and agricultural and rural development policies, especially in relation to agricultural prices and allocation of manpower and finance.

When I was invited to present this paper, it was specifically requested that I (1) state why the package approach is particularly suitable for improving agriculture in the developing countries; and (2) give my views on how mechanization can be included in the package approach to fit specific situations.

There are three reasons why I am an advocate of the package approach for improving agricultural development.

First, the evidence is overwhelming that the piecemeal approach followed for the past 30 years has contributed little toward the development of small-farm agriculture.

Second, until the critical elements that contribute to the development of a modernized agriculture are provided for in an agricultural development program, small-farm agriculture will falter, and the food-deficit nations will experience social and political tensions as governments fail to meet the people's minimum food needs.

Third, with the experience of the past 30 years and the changes that have occurred in institutions in the developing countries, and the presence today of more compliant and experienced manpower, it is now possible to put together an integrated approach to agricultural development. If effectively implemented over the next two decades, the package program approach can stimulate continuous and achievable progress in transforming traditional, small-farm, subsistence agriculture and move it toward a modernized agriculture.

Action Is Needed Now

My travels through Africa during the past two months, and my haunting memories of the plight of the small farmers throughout the Indian subcontinent who wait for the monsoon rains, have convinced me that the tillage practices being followed in the dry-land areas of the Third World countries have completely disrupted nature's balance.

Soil depletion leading to desertification will leave millions of rural people throughout the developing countries with no basis of survival if the process is not checked within a decade. Two practices have contributed to the destruction of the soil and, if continued, will transform millions of acres into barren, unproductive land that will succumb to desertification. These practices are (1) the tillage practices that keep the soil bare and exposed to wind and rain erosion; and (2) overgrazing by cattle, sheep, and goats.

Correcting the present soil-deteriorating tillage and grazing practices will not wait for decades. The very existence of millions of people is involved. Without a soil base and moisture to maintain plant growth, neither man nor animal can survive. I do not want to be an alarmist, but I feel that the present tillage and grazing practices which have disrupted the balance of nature in the arid and semi-arid regions of the world today represent a greater threat to the survival of man than overpopulation. It is estimated that each year 14 million acres of land goes into desertification and is taken out of agriculture.

Now, my final comment as to how mechanization can be included in the package approach to fit specific situations: Since mechanization has become synonymous with motorized equipment, we need to define the term. As used here, mechanization encompasses the use of hand- and animal-operated tools and implements as well as motorized equipment.

Remember that, in setting the stage for my presentation, I identified my target group as the small, subsistence, food-crop farmers in the dry-land farming areas of the Third World countries. For this group of farmers, I think we have to accept that the primary source of energy for agriculture in the future will continue to be animal power and human labor.

In my usage of mechanization, I include all improved hand tools and animal-drawn implements that contribute to improved preparation of the seedbed, tillage, weed control, seeding, harvesting, and threshing. While I do not rule out a place for engine power in small-farm subsistence agriculture in the arid and semi-arid regions of the world, I think the record shows that the use of tractor power for deep plowing has contributed greatly to keeping the soil bare of residue and exposing it to erosion from both wind and rain. As I mentioned earlier, this excessive turning up of the soil has resulted in less, not more, rain penetration of the soil and more rapid moisture evaporation than would occur if there were surface residue.

There is a place for small tractors where animal power is unavailable. Diesel engines for small threshers are an important contribution in saving grain losses. Hand-sprayers, animal-drawn seed and fertilizer drills, and animal-drawn mowers for cutting forage are examples of mechanization that fits into a package program for small-farm agriculture in the dry-land areas throughout the developing countries. Small mechanical threshers have proven to have a place in small-farm agriculture and need to be promoted where they have not yet been introduced. Diesel engines for irrigation must have a place of prominence.

In closing, I would suggest that in the future when we have an opportunity to assist in the development of small-farm food-crop production in the developing countries, we should think in terms of helping to develop a modernized agriculture. I use the term "modernized agriculture" to mean an agriculture that has been transformed from a traditional agriculture relying on traditional methods to a modernized agriculture relying on science and technology. Within a modernized agriculture, mechanization must play a prominent role. But it should be made clear that mechanization can take place through either human, animal, or tractor power. We should understand and accept that, for the great majority of the small food-crop farmers, animal power will continue to be the chief source of power.

The development of improved animal-drawn implements, hand-sprayers, and diesel and powered threshers will be positive contributions to the development of a modernized agriculture. This kind of mechanization must meet small farmers' needs and fit into their limited resources if it is to be most effective.

Locally Manufactured Small Farm Equipment for Asian Farmers

AMIR U. KHAN

Director, Agricultural Machinery Program
International Rice Research Institute–Pakistan
Rawalpindi, Pakistan

I have not prepared a sequential kind of speech or a documentation. I will speak on various issues, some of them disconnected or disjointed, but, within the time limitation, I think it is best to touch on some of these different subjects. I will begin with the subject of labor surplus and unemployment, which you have heard so much about at this meeting. I believe that while there is a problem of labor surplus, the real problem is inappropriate technology. What we are trying to do is push the kind of technology that will certainly create labor surpluses. But we are judging it from the U.S. style of mechanization, and then we are going out to a developing country and saying that the same result will happen.

I very strongly believe that the situation is going to be different. I will say that in regard to the Philippines, especially, where the International Rice Research Institute and the Economics Department have been studying the labor situation in the two major rice-growing areas for nine years. In the nine years, tractors have moved in, power tillers have moved in, and, in the nine years, labor input in agriculture has steadily gone up. Another example that I would like to talk about is Japan. You look at Japan, with a very highly mechanized agriculture, 3 hp per hectare. Yet it has one of the highest labor inputs in Asia. It doesn't make sense, if you listen to the other speakers we have heard here.

Although the demographic figures tell you that there is a lot of labor surplus, I think this is not so, and I will give you an example. Two weeks ago a man came into my office — a retired colonel, who owns 15 acres of land near Rawalpindi. He had several acres of wheat on this farm and he couldn't get anybody to thresh it and he heard that we were developing some threshers and he wanted to borrow one. Because we were still busy trying to improve our machines, we said no, and then he said, all right, if you take it out you can have the whole crop: I don't want anything. In fact it's that bad a situation and he said last year he had done that. Now I also know that in Pakistan last year there were a number of farmers who couldn't transplant their paddy because they couldn't get the labor.

People say that there is such a labor surplus, and yet you have these cases. And these are not only being repeated in Pakistan; in the Philippines and Thailand you may come across this incident daily. So I feel that there is another side of it. Granted, there are idle people around the villages, maybe, but they are not interested in working. And actually, who wants to work behind the tail end of a buffalo all day? You walk behind one and you will see what it is like. There are problems of this nature that we have to contend with. We are there in the field and we have to satisfy some of the needs of the farmers. We have to talk to them and then come up with some solutions, not just look at the figures and draw conclusions.

Now I will touch on a few other topics that are unrelated. There is the issue of many people saying, well, we shouldn't mechanize; then they say, well, let's go back to the animal-drawn implements. I think India had a love affair for 30 years with this attitude and this philosophy. I have not been able to do much in that field, but I think they have a large number of funds, put in trust, for developing improved animal-drawn implements: and yet if you look around hard, except for one or two cases you do not find much success.

The Transfer of Technology

I contend that the real approach to animal-drawn implements is to transfer technology, not to reinvent the wheel, nor to redesign the products. The ideal strategy would be to transfer successful implements from one region to another to try them out, test them, and see what they look like. And if they succeed, then you find a couple of manufacturers to build them. Incidentally, the National Institute of Agricultural Engineers in England and the French have been at this for about 25 years and have had a very similar effect.

Then I hear lately in the United States, let's do selective mechanization. This is a phrase that I expect to hear more often. And I have a feeling this is the engineers' conspiracy, to argue with the economists, because the economists keep talking about the labor problem, and the engineers say, well, we will take the peak off the labor problem with selective mechanization. My argument is that, if you look down the road, how will you apply selective mechanization? You know very well that

the big pools, tractor pools and hiring services, have not been able to function at all. I have yet to see one operating successfully and if you try to think of a way to apply selective mechanization in a developing society, I just do not see any hope of making it happen. You give a farmer a tractor and tell him to use it only for land preparation. Don't touch it the rest of the year because socially it will create problems. Well, I don't think he would listen to you.

Then we get another revival of this hiring pool question. I have heard many speakers at many meetings, speaking on this issue. As I said, in the public sector, I do not believe you can successfully run a tractor and machinery hiring setup. It requires very close management on a local level which is unheard of in the public sector. I doubt that they could function that way. Now, the other side is that many of these contract hiring organizations really cater to only one of a farmer's operations. But the farmer has entrusted them with his whole requirement, not just one operation, and if he starts going through this hiring business for his whole operation, he will be ruined even worse than he is now. My feeling is that, yes, there is hope for hiring, but that it should be done by the neighborhood farmer, hiring himself out to the neighborhood. This is where we have had success. We have succeeded in Malaysia, in Thailand, in the Philippines. And I am talking about small equipment also, not necessarily just big equipment — power tiller hiring to a neighboring farm, things of this sort.

Next I will touch a little on the current mechanization strategy. You see, for the last 30 years we have been trying to mechanize agriculture and basically we are talking of utilizing machines that are designed for the industrially advanced countries. The manufacturers — and I can understand, I don't blame them — are trying to expand their market so they say, well, let's go sell a few more. This is something we developed for our own base of operations, but let's go in and try to market it in the developing countries. And the poor farmers in the developing countries, of course, the small ones, cannot afford it; but the big ones, those who can, buy it.

This is merely looking at one end of the mechanization system, and I feel very strongly that you have to look at the whole system. That means market research, the development of equipment, the manufacture of it, and then finally the use of it. If you touch only this one end of it, I do not believe you can solve the problem. Well now, when I talk to the manufacturers in the industrially advanced countries, they ask, why are you talking about manufacture? There is not sufficient demand to make production economical. Well, I believe that is not so. It is not a question of sufficient demand; it is whether the technology that you are offering is adequate to create that sufficient demand. Let us look at the technology and see how things can be made that can create a demand. Then we will have the markets.

Product Design and Development

Now, when we come to the question of product design, that is really a problem of machinery design and development, and the manipulation of the design, not just the production process. These two elements of technology have to be considered if you want to satisfy the needs of the small and the medium-sized farmers that we are concerned with today.

Look, for example, at the available technology for dry-land farming, which is very popular in the United States and in Europe, and the one that we have been trying to transfer. You have all the yardsticks, the data on labor displacement, and all that we talk about, and India of course has been trying for 30 years to use this technology. They have 14 tractor plants right now, making somewhat similar equipment. The total production is 38,000 tractors, which is really not much to brag about. In 30 years, approximately 2 percent of the land has been tractorized or mechanized. Now, I think that is not very remarkable progress for this length of time.

But let me say that the picture is not as bad as I am trying to paint it. I was in India about two weeks ago to look at the threshing machine development, and I drove from New Delhi to Ludhiana and I saw a transformation occurring in the Indian mechanization technology. I predict that, 10 years from now, you will see a tremendous change in their mechanization. They started with the classical approach, importing tractors and trying to copy them, and 30 years of experience have shown them that things are not happening. They are now questioning this approach. I talked to the Swaroj Tractor Company, which is making large tractors — and, incidentally, they are introducing a 19 hp tractor — and they said they also would like to introduce a very simple tractor, something like one the Thais have, which will be locally made and called the Genta tractor.

Now, coming on down the list, we look at the power tiller market. Five companies are producing power tillers, exact copies of the Japanese machines, and all have failed miserably. So only last year they started to look at a cheaper version, something like the Thai tractors and the International Rice Research Institute machines. I am pleased to report that there is considerable production starting now on the simpler power tiller.

Then you drive in Punjab and you see this 5 hp diesel engine which has really become the main power for small-scale mechanization. You see wells with pumps, you see chaff cutters, and you see threshers working, and I think this is the direction in which they are going.

But, mind you, it is not the people in New Delhi who helped it. This situation occurred because the farmers, as well as the small entrepreneurs, realized that nothing was happening and they had to do something, because the pressures of mechanization were coming. Many economists and others were telling them not to do it, but it did not matter: they had to do something. Now they have started to do it, and I predict that in 10 years you will find an appreciably different kind of mechanization coming in India and the subcontinent there.

We have not been talking of the wet land, of course. That involves small-scale Japanese mechanization, which has been mentioned by others at this conference — and I very much agree on the point of size. I also agree entirely that the style or technique of mechanization will somewhat resemble the Japanese style but it will not be the same implement. Now, the Japanese technology, of course, is not very economical and it is rather complex. Besides, it has changed rapidly in recent years and the result is no longer highly applicable.

Our implements will be different but we will slowly advance in the same direction. Some of the countries that started from the top will have to come down. I can already see it happening in India and I think it will come, more and more.

Steps Toward Mechanization

Now, we are trying to find some answers to the question of mechanization for small farms in developing countries. I would have preferred the discussion to be in terms of three specific sizes — two hectares, under two hectares, and between two and ten. But for argument's sake we will take the one category — the 1–10 hectare farm and how to mechanize it.

First, I feel that we should take the operator of the smallest farm and give him the divisible inputs — fertilizer, insecticides, and what have you — the new technology of that kind. I think you cannot do much mechanization because he does not have the resources for buying a machine on his own. Then the question becomes, can't he organize a rental? For the answer, I go back to my earlier comments. I have seen quite a few things tried in developing countries, and I believe the use of centralized tractor pools does not work. Certainly there should be an effort to encourage the medium-sized farmers to rent small machines from the neighborhood. I think this is where our major emphasis should be, as far as mechanization goes, and I think I agree entirely with my economist colleagues that, in this particular group, there is a danger if we go into too much mechanization.

On the other hand, I think there is a scope for more labor production by bringing in new technology. As far as the medium-sized farmers go, I think they have moderate resources with which to purchase some kinds of machinery. And here the main bottleneck is the lack of appropriate technology, the lack of machines for him to buy. His farm is too large for a pair of animals and too small for the 35 hp tractor, so he faces a dilemma. I think here our engineering community, which has a very poor record in the developing countries, will have to deliver something. Development in the 5 to 10 hp range of mechanization is one of the important problems of today, and I think that if we can solve this, we will eventually see progress.

In terms of production of these machines, of course, the first category will always be on the village level, very decentralized. But for the second category, I think we will look into more manufacturing on small-town levels, in addition to the high technology, complex elements of the machines at a still higher level. As for the larger machines, I would only like to mention that there is considerable need for restricting the makes of machines that are coming in, and of course I feel that some countries are hoping to produce without licensing. I think it is important that, in the larger technology, mechanization licensing plays a very important role in terms of quality control with which there has been a problem in many developing countries.

I wanted to touch a bit on the role of the manufacturers, especially of those from the United States, because I find that some of the big manufacturers have not taken as much interest as they might. It is very healthy to have this conference that we are participating in here, to have discussions and things of this sort. I know that a number of the small companies in America have been making an effort to sell equipment abroad — but, take the case of Pakistan where I happen to be located right now. The country is importing 15,000 tractors, an eighty-million-dollar business with poor mix, right now. It would be better if we were to take only 1 percent of that and put it into a concentrated program with some of your highly talented engineers. And please locate them in the developing country, not in a design center, working in the United States and catering to Guatemala. Otherwise I think it will not work. It has to be done at the site so that all of the economic, engineering, and social problems are known. Then we can try to cater the technology to fit them and we will see greater progress.

Audience Discussion

T. HARRIS: It seems to me that the real problem, the whole problem — what this conference needs to sort of zero in on — is, what is it really all about? What are we really talking about here? I believe the technology exists, the machines exist; this isn't the question that should be addressed at this meeting. What we should be addressing is, how do we in fact transfer that technology to the small farmer? I'm accepting the fact that the small farmer does need to be mechanized, and I think we're wasting a lot of time going around and around in this circle. We keep on talking, for example, about unemployment. We don't talk about the consequences of the malnutrition and starvation that occur if you don't increase your crop production. This is the spectrum that nobody seems to be addressing. So the point I really want to make — and I'm not asking any questions — is that a few of us have actually worked on the problem of developing small tractors, and worked on the problem of transferring small tractors, and then have seen those small farmers, in fact, increase their production as a result of that. Dr. Khan is one such person and there are one or two others of us. It is quite refreshing to see that, in the midst of this rather academic sort of "let's-not-get-anywhere" conversation that seems to be going on here.

A. U. KHAN: I would just like to say that maybe the technology exists, and I do feel that the technology does exist, but there is this whole process of adaptation which is sometimes a bottleneck. You take a tractor developed here and go and put it somewhere else in its existing form, and then you suddenly find that it just doesn't sell. I think that, while it does exist, technology sometimes, or many times, has to be tailored to fit another situation. This has been our experience.

F. DOVRING: I just want to add that the quantity problems of economic development don't go away just because they are pooh-poohed. They need discussion.

D. E. NESTRICK: First, as both a farmer and a representative of American Baptist Men, I want to assure you that the average American Baptist does not agree with the corporate responsibility statement that is put forth by the people here from the Interfaith Center. But it is merely a statement by a vocal minority. Next I would like to ask a question of Dr. Khan. If the multinational firm such as Deere were to build in these developing countries, how would you keep the corporate responsibility people from taking it away from them? Then I would ask anyone this question: I farmed with horses until I was 24 years old (I guess we were poor farmers) and we had pretty good ground, but it took 20 to 25 percent minimum to take care of the horsepower. When I hear them talking 10 to 20 percent here, perhaps they're making it up with manpower, I don't know. I hear them talking about double-cropping, and I would remind you that the land is just the same as my bank account.

A. U. KHAN: I'm not sure that I can respond to some of those questions. Yes, there is a danger that the corporation could take over whatever is developed and whatever came out of it; but on the other hand, I think one must recognize the limitations of the operations too, and especially the environment they are operating in. If it were that easy, they would have done it; that's the way I feel. I think that the danger is not that severe that they will take over. For instance, there has been some interest from the corporations and some support for various national and international programs of this nature. For example, Briggs & Stratton today gives us 100 engines every year, free. And, of course, Briggs & Stratton has had tremendous sales because of our development efforts. Now, that was a direct relationship, but there have been indirect benefits to industry right here in the United States from our exercise. We were perhaps the first to develop an axial-flow thresher device and commercialize it, and I know of some of the benefits that have come here. Similarly, we have done some work on heated sand application which is now being used here experimentally in various universities. So, my thinking is that if the corporation sees that it is mutually beneficial — if it assists some of the organizations, whether they are church or national organizations — then there is no danger because the technology coming out will be locally used, given to the local manufacturers. That's what I was trying to discuss. I missed the second question, but if the gentleman wants to repeat it, I will try to answer it.

NESTRICK: I just said that I keep hearing that animal power, as we've discussed it here, is using 10 to 20 percent of the land. That may be true, but I didn't find that to be true in my 23 or 24 years of it as a youth. The other question was just directed to the panel, and I want to apologize — I don't want you to think I'm taking any potshots at you. Thank you very much for your presentation. The double-cropping is the thing that concerns me. All of the economics that I see in printed material are based on double-cropping and I don't know whether

you've taken into consideration the economic aspects of double-cropping.

A. U. KHAN: Since none of the other panel members seems to want to respond, I think I'll say this about animal power in relation to the land situation. I think it is true in certain countries that animals do take quite a bit of land out of agriculture. On the other hand, in other countries, such as the Philippines, I think animals graze on public grounds quite a bit. But I know that in Pakistan and India, sometimes the farmers reserve some area for growing feed, so that crop is taken out; unfortunately I don't know what percentage. I think the subject should be studied. In fact, the International Rice Research Institute has been concerned with this impact of mechanization and we have just started a multinational study on the effects of mechanization — what has happened, what is going to happen, and the different levels of mechanization, and small, medium, and large tractors, and so on.

DOVRING: Since I was the one who put out the range of 10 to 20 percent, I guess I should explain why. The 10 percent as a lower bound is based on a key figure we had in Western Europe at the time when horses were as prevalent as mechanical power. It was estimated that you needed a horse for every 10 hectares and that the horse ate what grew on 1 hectare, which makes 10 percent. The 20 percent as an upper bound is a figure I found when analyzing information from Eastern India many years ago. And this does not mean, of course, that all of what the draft animals eat could be readily converted into grain; but most of it could be converted into other food production such as milk, and in this sense I think the estimate of 10 to 20 percent of the land is justified.

W. C. THIESENHUSEN: I just have to say something on the double-cropping issue. In claiming that all land that can be double-cropped, should be double-cropped, one has to do an economic calculation to find out whether it's feasible, and certainly I'm not talking about mining the soil. But I am talking about several experiences I've had where a rain-fed crop is planted one season and then a very quick turn-around has to be made if the crop is to be grown in the second six-month period when it's dry. So I was just barking back to the experience I had in Venezuela where, if you really hurried, you could get in a crop of sesame during the second growing season. But you had to do it in a hurry, otherwise you would miss that last rain and would not be able to get the crop in at all. But I'm not suggesting that the soil be mined.

M. B. RUSSELL: This is not so much a question as a comment. I have been working in India for the last 10 years, particularly on trying to manage water more efficiently, which means we're talking about the rain-fed area. I'm working with the International Crop Research Institute (ICRISAT), which is focusing on trying to increase and stabilize food production in the semi-arid tropics, including the Sahel, Northeast Brazil, Thailand, and of course, large areas in Western India. My own experience has been largely in India and particularly in the Deccan Plateau, which Dr. Ensminger knows very well, on the black cotton soils. I'm on record as saying that there is more opportunity for increasing production in India by getting rid of water than by adding water. And one of the best opportunities for increasing and stabilizing food production in India is by developing a system of management, a system of farming, that will allow them to crop in the rainy season.

This is an anomaly — in an area that is short of rainfall, 30 inches of rainfall coming in 100 days — thousands and thousands of hectares of those deep black soils are fallow during the rainy season. They are cropped on the basis of residual water in the profile. Why? It just defies all logic that you would not utilize them when your natural resource basis is optimum. The reason is, the small Indian cultivator doesn't have a way to manage that black soil when it gets wet. Now methods are being developed that are very, very promising, and they are based on animal-drawn power, or adaptations of the method which the French have developed in the West. Our system is working on land and water management, multiple-cropping, inter-cropping, animal power, and we can increase production substantially without any great investment in capital or technical ability. It isn't enough to provide the farmer with a tractor. You've got to provide him with the support service so that he can keep that tractor operating. One of the great mistakes in managing a scarce resource in many areas is to overcapitalize and then get very inefficient use of that scarce resource. So our target is the small farmer, and trying to utilize the scarce natural resource, water. I think that the program has demonstrated that with animal-drawn power on those difficult black soils, we can grow both a kharif (summer) season and a rabi (winter) season crop. So I'm optimistic, and I think it is indicative that soils with this potential in this climate can be made to produce two or three times their former yields.

R. HEISNER: There is a point that I think should be emphasized and I'd like to do it by directing a question to Dr. Ensminger. There are several facets to the question but the basic question is, how will these packages of technology be delivered? The question follows, how

can research provide answers if it's not matched, perhaps even over-matched, with a program of continuous, locally controlled education? Can a centrally controlled system of extension education accomplish the acceptable adaptation of this new-found knowledge on a peasant farm level? Are there alternatives to the U.S. Cooperative Extension Service, controlled by the state government? I'm basing this on the experience I had in working in Peru with the extension service there, and also on the work we have done with our Nigerian students. Many of them have indicated that there are many enclaves of knowledge but when you start moving into the northern areas of Nigeria and some of the less-developed areas, it's a hit-and-miss kind of proposition. It's a three-week emphasis and then the expert is gone. And the people don't know the expert; they don't know his roots or who his family is. So the Nigerian asks, "Why should I follow a complete stranger? I'm taking all the risk, he's gone." Are there alternatives to this kind of extension?

D. ENSMINGER: Referring to the first question, in regard to the institutions and services, I think I said in my paper, and I would like to say again very strongly, that one of the reasons why much of the technology has not been applied, ever though many times it has been appropriate, is because the institutions did not exist, or the institutions that were there were not oriented to the small farmer. So the institutions and institutional services are absolutely essential if you are going to get the technology applied. Now, on the question of extension services. I think the one great mistake, as it has worked out, is that the developing countries have taken the U.S. Extension Service in total and it hasn't worked. Now, let me just give an illustration in terms of Tanzania, where you're dealing in a tribal culture. There is no place in the tribal culture for the innovator. Our approach is to find the innovator, work with him, demonstrate, and he in turn will influence others. Now I think the extension service, as it is operated abroad today, becomes too much of a conveyor belt — of putting the knowledge out and not helping to apply it. And I couldn't agree more, that this is one area where we need more research in terms of understanding how the farmer makes a decision; and one of the things that we haven't really thought through is that this new technology must be fit into the farmer's pattern of work and his cultural approach, in terms of when he and his family will spend time at fairs and festivals and weddings and deaths, and all of these. So I think we need a lot more research in terms of each individual culture, and the process by which change takes place, because we don't know enough about these things at the present time.

E. CRAIG: In what we've heard so far, it seems to me that there are two elements that might be addressed by a group that I don't think we have discussed yet. First, many people have said that an important element of the whole problem is that the technologies be carefully and sensitively adapted to local and/or nearly local situations, and that they not be across-the-board kinds of situations. And, second, that some sort of distribution system is needed that is very effective and efficient, so that we know that if the technology has been found, it can get to the people who can use it. I think the unspoken question is, when and in what way can we entice the most efficient distributors into all of this, and can we do that without their being insensitive to local situations? The translation of that is, can big business, which is the most efficient system we know for getting things done, be enticed to participation in the problem of technology for the small farms, but in a way that is really responsive to local situations instead of producing solutions across the board? I'd like to hear that addressed by a number of different people if it's possible.

ENSMINGER: I think that the one thing you are asking for is, where and how do the people who have to make the decision to accept or reject the technology fit into this whole process? Now, in too many cases, the government decides what the people are to do and how they are to do it. If there is any one thing that I think we should have learned out of the last 30 years, it is that the people who are to make the decisions work must be involved in the process from the very beginning. And they and they alone can determine whether the technology can be fitted into their situations and whether or not they have the resources to apply and use that technology effectively. Somehow or other along the way, officials of government have always felt that they knew best what the people should do, and I say again, that if we have learned any one thing, it is that the people who are to act upon the decisions must be involved in the process from the very beginning.

HARRIS: I want to comment because I think this sort of question is addressed to the big manufacturers. I work for one and I think it's worthwhile to repeat a little of the history of the famous "developing nations tractor" which Ford started working on in 1965 and completed in 1972. In the process we spent $2 million and we developed a machine and went through an extensive testing period, not only in technology and in terms of the product, but in terms of its productivity as it would apply to a farmer. In fact, we carried out extensive productivity tests in the Dominican Republic, which are documented and which showed that by using a small

tractor you can increase a farmer's income by four. And that's a minimum; in fact, four is a conservative number. Having spent all of this money and all of this time, we then decided to test-market the tractor in two small markets, Jamaica and Ecuador. When we went into these countries we knew straight away that the number one problem is, as I said earlier, when the technology exists, the problem is the transfer. We were trying to sell this tractor, in effect, *a los des camisados* — to the shirtless ones, the great unwashed — and there were other people who did not have the purchasing power.

If in fact you are ever going to put this machinery into the hands of these small farmers, you have got to provide some form of unsubstantiated or uncollateraled retail credit. Unless you do this, unless some person of importance picks up this problem, you are never really going to solve the problem. We found that the need was there; the farmers clamored for the machines — and the machines, incidentally, are still working in these countries, quite happily, so from that standpoint it was a first-class piece of machinery. But what we found was that we couldn't get the money to the farmer so that he could purchase the machine. Naturally any large manufacturing concern, whether it invests $2 million or whatever, at least wants to break even, however sensitive the corporation may be. I personally worked on this for five years. Six months of these five years I spent in Jamaica, working with extension officers, trying to get this money transferred from the government, which had the money, via loans from the Inter-American Development Bank. The money was in the country, so this was not the initial problem — and, incidentally, that was in the days when the World Bank loaned practically no money for small-farm rural development. (Since then it has changed its policy completely.) That was also in the days when the Agency for International Development (AID) concept of the whole problem was to tear down the fences and put North American agriculture into the country. But even in those days the money was there in Jamaica, from the Inter-American Development Bank; but the problem was getting the money to flow within the country and out to the small farmers, because purchasers couldn't buy.

So I keep banging this drum, and you may have noticed that the World Food Conference which was held in Rome a few years ago likewise decided that providing retail credit and placing the purchasing power in the hands of the small farmer is the critical need, and the crux of the problem. So the technology exists, or if it doesn't exist, it's just down the road. Give any major machinery company, or small machinery company, the opportunity to transfer the technology in a normal, logical way by providing some form of credit and you will go a long way towards turning subsistence production into surplus production. And that's the key to the whole problem. That's why you want to mechanize these small farmers, to get another 5 to 10 percent out of that subsistence sector, and to start to really solve the world food problem, because you won't solve anything the other way.

O. Lucero: I would like to contend that any technology that is not accessible to the farmers, poor farmers — or, in other words, if you have technology that farmers cannot buy — then that technology is inappropriate for Third World countries. Also, I would like to see if anyone will address a question of alternative forms of energy that are available in their countries, outside of petroleum-based commodities. For example, the possibility of technology that deals with things such as electrical energy, based on energy from the sun, or methane, or wind power, or water power. I think that as long as we deal with any kind of farm technology that can't reach the farmer we are talking about technology that is inappropriate for developing communities.

A. J. Chavez: I wanted to provide a point of information, if you wish, and perhaps a focus for your discussions of a very practical nature. The United Nations Development Program (UNDP) is presently assisting a project, a regional network for agricultural machinery in Asia, which includes India, Iran, Republic of Korea, Pakistan, Philippines, Sri Lanka, and Thailand. The objectives being pursued through this project are: to identify the bottlenecks of mechanization and manufacturing of agricultural machinery; to strengthen the capabilities of national institutions in testing, evaluation, design, development, and fabrication of prototypes; to select, evaluate, and supply suitable design; to promote local manufacture of appropriate agricultural machinery, tools, and equipment; and to set up a clearing house to generate an exchange of information. It is a very broad objective. I would like to add that the subject-matter has been produced by all of the participating countries and is focused at the present time on the question of testing and comparing prototypes of rice transplanters, cereal harvesters, power tillers, power weeders, threshers, and seed and fertilizer drills.

This whole program has been carried out with an institution in each participating country, and each country is creating a national farm mechanization committee. This committee includes representation across the board, from all the sectors involved, including agriculture, industry, credit, and so on. All of this is oriented toward the possibility of local manufacture of these implements. I think a question arises in a program such as this, which is being planned and designed by the developing coun-

tries, where the role of the UNDP is merely to assist them, and where the funding is large. The question is, how can industry from developed countries help, or what measures can they take in order to contribute to this very worthwhile initiative of these countries? In addition, as long as I'm here, and since the topic this morning is social changes, could I just drop a thought? To us, women seem to play a very significant role in farming in developing countries. And I would hope that this would be a topic that somehow or other is introduced in discussions vis-à-vis the farm mechanization question.

J. A. McMennamy: I would like to direct a question to Professor Dovring about the influence of commodity prices. In most Asian countries the prices of commodities are maintained at a low level as a matter of government policy, so that food prices are kept low. But we often wonder what would happen if commodity prices were allowed to increase, which would allow the economy to expand and, in turn, create jobs in other sectors besides agriculture. Also, there are those who feel, and I tend to agree, that the supply somehow seems to meet the demand. If the prices of commodities were higher, production would increase correspondingly. Then, of course, higher commodity prices would make mechanization prices more economical as well. I wonder if you could comment on this for us?

Dovring: Yes, this is basically quite true. As a matter of fact, we have recently completed an inquiry from the Philippines regarding the adoption by the Philippine farmers of the whole package of recommended inputs to go with the new crop varieties. The question raised by the technologists was, why don't these peasant farmers apply the whole package? The answer from the economists' analysis was, quite briefly, they don't do it because it doesn't pay. Their relation of commodity prices to input was certainly that, by applying the whole package the farmer would incur a financial loss, and the analysis showed that the level on which they do apply the inputs is in fact the rational one. And one thing we should remember as regards the low-income farmers of the low-income countries is that they are far from being irrational beasts. They are, in fact, some of the most rational economic men in the world and they had better be, because otherwise they wouldn't survive. They are, in effect, a population that has stood the test of time as operating farmers, and the traditional wisdom by which they do this has its own validity. So, with all due respect for the transfer of technology and extension services, and so on, the basic precondition is of course that it be made economically attractive to the farmer population in question, in relation to a given locality.

V. K. Mittal: Several times the name of Punjab has been mentioned and, since I am from Punjab Agricultural University, I thought it proper that I should give a sort of account of the main job there. In my view, the problem naturally is that we should have some appropriate mechanization with more opportunity for labor employment in order to have more production. This is the problem, in a nutshell, for all the developing countries. If we remove any of the constraints we are faced with problems. Now, in the previous summary I think I heard that there is the need for a package of practices. In India we have had the experience, and if we analyze that experience we find that those pockets in India where this package of practices was applied have more production per acre or per hectare. The program in those selected areas was one of the AID programs and since then these are the areas that are much more advanced in the country. Now, therefore, this question of package practices is very important. The second thing that has been pointed out is that economical help from the government is very much needed. In India, for the last 10 to 15 years we have had support prices and in making the decision to have support prices, all economies, agricultural price commissions, and farmers' representatives, had their views taken into account. However, the cultural sector is very important.

Now, for example, the experience in Punjab. We have found that the so-called power tiller has once again dropped from favor, though we have tried to introduce it many times and it had success in Kerela and the southern part of India. Now, one of the reasons given when I ask the farmer is, "Well, when we invest about ten thousand rupees we don't want to walk behind a tractor." Though he oversimplified, I think the main reason is that for four to six months we have very hot weather with hard winds blowing, and that is not the time for walking behind the tractor. Then, much later it is the rainy season and it becomes successful. A second example is that of the thresher. In Punjab we have 250,000 threshers. In the rest of the country there are not so many; they are catching up, although not as fast as in Punjab. Again, the weather factor is there. In the case of combines, they became popular immediately. We have 400 combines in Punjab alone, which I think is the largest number of all the provinces in India. But immediately after the introduction of combines there was a lot of objection from labor and there was some sort of petition in Delhi. So these are the dictates from the society which we face by introducing these different machines, and therefore the question of prepared technology should consider all these aspects, cultural and social, as well as economic and agricultural.

M. J. Clark: As a member of the staff of the Interfaith Center for Corporate Responsibility, I was a little concerned when there wasn't a stampede on the part of the panelists to take over the microphones in response to Eleanor Craig's question about enticing business to meet some of these needs. And the one response, really, was in terms of the need for people using the technology to be involved in the process from the beginning. Yet I think perhaps that was not the full answer, because I think what Ms. Craig was asking was that those producing the technology need to be involved in the process from the beginning, and I guess that leads to a couple of questions. One is, to anyone who wishes to respond, do you see a greater sensitivity on the part of the multinational corporation to meet the kinds of needs all of you have touched on in one way or another? If in fact that sensitivity is seen, are there specific instances that you can point to in which the kind of cooperation that is needed between host governments, corporations, and development programs has taken place and is taking place? And, finally, what kinds of mechanisms, if any, need to be structured into corporate decision-making so that the priorities being set are being determined by the needs of the people and host governments, rather than the reverse of that process?

E. D. Kellogg: This question has already been asked several times, in several different ways. Do the panelists have further responses to it?

Dovring: Well, I will comment that I think maybe you are asking too much from the machine-building corporations to have all the wisdom in the world as to what the host country may need. I think the host country governments should figure out for themselves what they think is the desirable level of mechanization in their agriculture for the next five years and for the next ten years, and make this known to the machine-exporting corporations to give them a little more insight into what they have to expect.

Kellogg: I think if you look at the program you will see that there are some people here who represent some of the larger firms that we've talked about, and you might want to repeat that question to them.

W. F. Buchele: The system of farming which the Europeans and their descendants used was developed under the marine climate and this system, which is very successful there, has been brought to other areas of the world with devastating results, as we have already heard. I have sometimes suggested that, before a farmer can plow, he has to file an environmental impact statement. My question is, are USAID and other people who propose mechanization projects around the world going to submit a mechanization impact statement before they start to carry out a project that will be based on a European system of farming, and not in line with the particular climate and environment existing in that particular developing country?

Thiesenhusen: Well, I would like to see the governments, as Professor Dovring has suggested, analyze carefully the social consequences of potential adoption of technology. Now, in order to do this, it seems to me that we have to think of peasants, not as individual, separate operators, as the midwestern farmer family is an individual separate operator, but simply on a smaller scale. We should think of the peasant operator as a part of a very interconnected structure, so that we have the major portion of the under-10-hectare farmers who are somehow connected in very many ways to other parts of the structure. And we must analyze the structure in order to discover the social impact that mechanization is going to have, and AID should be aware of these effects before it begins to make it possible for countries to have technology. What I mean by this is that there are resident farmers and laborers living on large farms, there are renters, there are share-croppers, there are money lenders; all of these are interconnected in the system and the effect on each one of them should be clear, it seems to me, before AID makes it possible for mechanization to occur.

Kellogg: There may be someone from AID who would like to answer that in a very practical way, as to how projects are submitted, and certain statements that have to be made.

J. S. Balis: I work with the Latin American Bureau of AID. I think that many of you already are aware that most of our projects are the product of considerable inputs by a number of university consultants. After Dr. John Hannah became the administrator of USAID there was a move toward developing a cooperative style. He was probably one of the most articulate gentlemen who emphasized the imperative necessity for AID to work in collaboration with the host government in defining what they wanted to do. One has to recognize that it is their country and one has to use a considerable degree of diplomacy, and sometimes we don't come out quite where we think we ought to be, and probably many times it's just as well we don't. So that, as we proceeded, I think that most of the people tried to use their good judgment and the good information at their disposal to get to the right place. But the interesting thing about it

is that, in looking back, we always find something wrong with what we did. It's the very nature of the business we are in, going down a road that we haven't been down before. We welcome collaboration, we welcome inputs and suggestions. We become very riled, as persons, about the criticisms because we probably know about some that you haven't discovered yet. But, for those of you who really do feel that you have a constructive suggestion, I think that at least I would be very happy to have it.

KELLOGG: Do you, as a matter of course, have to indicate in your project preparation papers the kinds of impacts that a project may have, in a secondary way as well as a primary way?

BALIS: AID is required, right now, to file an environmental impact statement and also a statement regarding the impacts on women. And it is required in some cases — for example, in the use of pesticides or chemicals that are considered to be dangerous to human health — to make reference to this in the project paper, and refer it to the Environmental Protection Agency in the United States government. In fact, it takes us two years to get a project approved because of all of these things, and often we are unable to find enough consultants to provide those inputs — so be careful about putting more requirements on us or we may never get anything done.

S. RAO: Just one short comment. We are glad that this meeting is being held, but I hope that this will not be the end, and that the next meeting will be held in a developing country with more participants and decision-makers from developing countries, so that we can learn from the horse's mouth exactly what the problem is. I just wanted to say that the agricultural mission, world trade share of the developing countries in 1967 was $1.6 billion, and in 1975 it was $19.2 billion. That was what was imported by developing countries. The agricultural mission itself constituted 90 persons in developing countries of all sectors importing. If this is the area, it is very clear that the mechanization policies will have to be done by governments of developing countries themselves. Nobody can tell them what they should do. If that is the case, then what is the role of industrialized countries and their institutions and what is the role of the large-scale manufacturer? In this respect I would like to ask Dr. Khan, question number one, how can the industrialized country or the big corporation assist developing countries in the local development of technological capabilities, and, number two, what is the result? Also, how can they assist, or how can they work in their own corporate research from the industrialized countries to meet the requirements of developing countries? And, how can they assist in appropriate technology transfer that is also economical?

A. U. KHAN: First, I feel that the big and small corporations must be generally committed to this situation of helping and not regard it as an eventual source of competition that will kill or hurt their own markets. I think that kind of commitment is the crux of the problem, and unless it comes through public pressure and other sources, I don't see any other way because they are independent organizations. You can't just force them into your way of thinking unless they see some motives or some self-interest. And I think you can't blame them for that; I feel that somehow the climate has to be created, that you can't just export the $19 billion of products like Mr. Rao mentioned. Well, if you have collected that much you ought to be able to put some back into the need. So I think that is the one side, but in terms of helping the development process, I find that, for engineers, experience in the developing country, in the whole process of product development, is most effective. Unfortunately, many of us go to colleges and universities where we never learn about product development. This is an area not taught in the colleges and we learn only by doing it, and in the industries themselves. I think this is a training area where corporations can play a major part; they can get people and take up the problems and work them out. On the other hand, they can also assign their best and most creative engineers, not the ones they want to get rid of for a while, but send the good ones to a developing country and let them work with some of the organizations that are involved there. In many ways I think if one wants to address the problem, it can be done. I think that sending people from here can also help orient the people of other countries to the ways here. But when it comes to product development and market research, as I mentioned earlier, 99 percent of the engineers and economists in the developing countries don't know what you're talking about, and product planning is not understood at all.

I think this is my main gripe with the U.S. educational system. None of these subjects is taught to engineers in the universities, and only those who go to a company and work up through the process of apprenticeship seem to learn the technique. I think they're opening their doors a little bit, going out, reaching out to them, and perhaps providing a little funding too, but I think that's not as important as the commitment and getting involved in the thing.

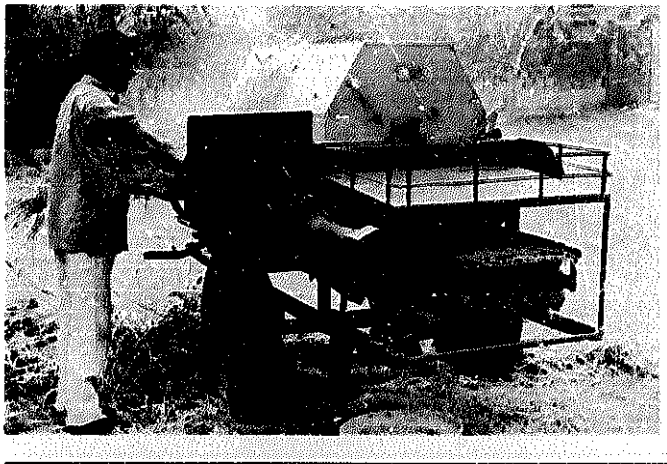
E. O. FINCH: I believe expansion was given as one of the acceptable motivations for mechanization. I assume that you mean expansion in area, and I would like to

speak from my Brazilian experience that this is one of their big motivations in the 150 percent expansion of mechanization that has been mentioned. The other would be in double-cropping, which is also essential for Brazil in its wheat and soybeans. The third type would be into new areas, and Brazil is now involved in one, an alcohol program supported from agriculture. This brings me to my question, which concerns the technical dependence on either animal power or imported petroleum in developing countries. I believe nobody has addressed this question this morning and I would like to ask the representative from IRRI or others, what is being done, for example, on the farm or in the community in developing fuel for increasing mechanization?

A. U. KHAN: I think the Institute is actually looking at this problem today to a limited extent. We have projects on wind and solar energy as well as projects on bio-gas, not bio-gas, but producer gas. But in this energy problem our assessment, and my personal opinion, is that the resources available to the Institute are so limited that I think this requires a higher level of funding and expertise for real breakthroughs. In fact, I believe that the developing countries are often wasting too much money in trying to develop some of these simple energy devices. Some projects have been going on for 10 to 15 years without any real productivity. I contend that the major developments will come through research in the developed countries, and then the findings will be adapted for others. In terms of some of the other things mentioned, India has done quite a bit with methane and I think it is worth looking at. I do feel that the petroleum problem is a serious one and is something that is difficult to tackle unless we have a breakthrough, and especially in regard to mobile equipment. You can possibly come along with these low-cost energy solutions in a stationary applicator, but when you get down to mobile equipment you tend to have difficulty.

Amir U. Khan of Rawalpindi, Pakistan, recommended that successful implements from one region be tried in another, to test their performance under a specific set of conditions, and if they are successful, then find manufacturers to build them locally. "I contend that the real approach to improving animal-drawn implements is to transfer technology, not to reinvent the wheel, nor to redesign the products."

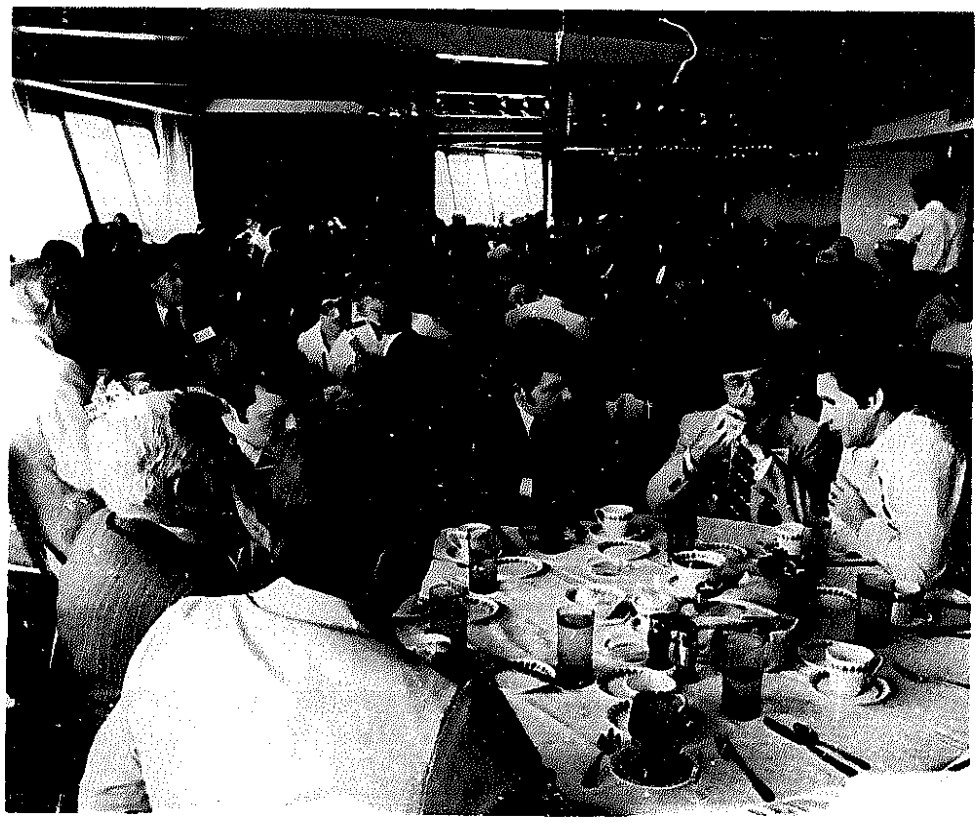
One of the implements designed and manufactured in the Philippines is this axial flow thresher for multi-crop operation.



During the afternoon panel discussion, E. William Hakes of Massey-Ferguson, Ltd., Toronto, Canada, describes his company's experiences in manufacturing and marketing farm equipment for Africa. From first-hand observation of conditions in Third World countries, he concluded that "... if hunger is to be eliminated in this world, the future growth in food production must come from the developing world. Somehow, the developing countries must feed themselves."

Yoshisuke Kishida, businessman and editor of agricultural journals, Tokyo, Japan, asserted that "The development of a farm machinery industry within the developing nations is quite necessary for the promotion of agricultural mechanization, and the best system is one that produces machines that are profitable for manufacturers, dealers, and farmers alike." He documented his talk with facts gleaned from a study of his country's success in agricultural technology development during the thirty years since World War II.

Mixing business with pleasure, the conferees share ideas at mealtime. A recurring theme was the recognition that technical change in many instances is a powerful force for social change. Some advocated gradual change and other safeguards against upheaval; otherwise, when machines replace manpower, unemployment and therefore poverty may be the result. Others maintained that mechanization can improve production to such an extent that new jobs are created in allied industries, thus providing work for people who are released from farming.



Panel Discussion
Developing and Marketing Equipment for Small Farms in Developing Nations

Agricultural Technology Transfer and Value Conflicts in Developing Nations

MARTIN M. McLAUGHLIN

Senior Fellow, Overseas Development Council
Washington, D.C.

No one at this conference needs to be reminded that there is a world food problem, or a world food crisis, as it is more often called. Every day, tens of thousands of people (nearly half of them children) die of starvation or of diseases facilitated and accelerated by malnutrition — diseases that we have long since learned to control in the industrialized world, except perhaps in its poorer sections. The deaths are tragic, but even more tragic (or perhaps ironic) is the fact that many, if not most, of these persons die unnecessarily.

Famine, hunger, and starvation are not new problems. They have been with us throughout recorded history. Two U.S. studies in the last 12 years have focused on this issue — one by the Science Advisory Committee under President Lyndon Johnson, and another which completed its work last year for the National Academy of Sciences under the direction of Dr. Joel Bernstein, who is a participant at this conference. In the 10 years between these reports, more than half a billion people were added to the world's population, most of them in food-deficit, developing countries.

Also during that period the United Nations convened its World Food Conference in Rome in November 1974. The conference solved no problems but it caused a great deal of homework to be done by ministers of agriculture from the 134 countries that participated, and it focused a great deal of public attention on the world food problem.

Despite abundant harvests in the last three years, a relatively steady level of food trade, and the building of grain and financial reserves in several countries, there has been no significant moderation of the disturbing projections of food requirements for the 1980s and for the rest of the century. At the Overseas Development Council it is estimated that, by the year 2000, the total import demand for grain in the developing countries will be about 350 million metric tons. Under present world production patterns, 100 million metric tons of this amount must be provided by North America — about twice the present level of American grain export. This would, of course, be in addition to meeting our increased domestic and commercial demand, and therefore it is rather unlikely that it can be done — and if it is done, prices will rise rapidly. The World Food Conference concluded that the only long-term solution is to increase production on the small farms in the countries where the food deficits prevail.

There are several reasons for this conclusion: (a) production increases can be achieved more cheaply in relatively underdeveloped areas; (b) high shipping costs and the attendant energy costs can be avoided; (c) most of the world's underutilized crop land (in both acreage and yield) is located in such areas; (d) the incremental gain from increased use of agricultural inputs (seeds, fertilizer, energy, tools, pesticides, training) is much greater in the developing than in the industrialized countries; (e) the dependency relationship often fostered by food transfer programs can be mitigated; (f) undue food-price rises in the industrialized countries and in the poorer parts of the world can be prevented.

Although not every country can be or needs to be self-sufficient in food, all could become self-reliant — that is, able to purchase their food, if not grow it. This point, of course, relates not so much to food policy as to development policy — especially to rural development policy, which, since it deals with the quality of life of the rural poor and with their health, education, employment, and income, has a much broader scope than merely in-

creasing agricultural production. If people cannot buy food, it makes little sense to stress all-out production. The world food problem is at least as much one of distribution as of production; and small farmers and rural families in the poor countries — as the World Food Conference repeatedly emphasized — are the principal victims.

Help for the Small Farmer

These small farmers — who constitute 80 percent of the population in many Third World countries — desperately need agricultural inputs such as appropriate machinery, tools, fuel for their equipment, fertilizer, seeds, and pesticides. In order to acquire these items they need a great many other things, such as credit on reasonable terms, more equitable patterns of land holding, storage facilities, roads, transport, and a marketing system that assures them a fair return on their investment and their labor. They also need extension services that are adapted to their situation, education, and training (including management skills), low-cost effective health care, nutrition programs, and access to family-planning services, and environmental sanitation and water purification programs.

The World Food Conference established several institutions, the most important of which is the World Food Council. It consists of representatives of 36 countries, including the United States, whose purpose is to monitor and coordinate programs aimed at carrying out the conference resolutions. The Council will hold its fourth session in Mexico City later this year. Advance reports indicate, however, that it will paint a sobering picture of nonperformance and lack of political will on the part of the countries who unanimously pledged their support in 1974.

The Food and Agriculture Organization of the United Nations has been working closely with the Council and has increasingly stressed the needs of the small farmer in the poor countries. This emphasis has been in the forefront of thought in the development community for many years, particularly among those who hold that not only societies and economies, but people, develop. In fact, if development is not for people — if it does not benefit them equitably — it may be growth, but it is not real development.

If one looks at the world food problem and wonders why the food import requirements of Third World countries persist in the context of the international food system, one can only conclude that this system, which is part of the international economic order, is seriously malfunctioning when more than 500 million people are going hungry in the world. Approaching the problem from the angle of the supply-demand equation, as my former colleague Lester Brown does, one concludes that it is the small farmer who is hurt most by constraints on land, water, and energy; by the skewing of research toward the commercial market and temperate-zone agriculture; by the vagaries of weather; by the population growth rate; and by the rising food consumption of increasingly affluent elites. Finally, if one accepts the thesis that people are hungry because they are poor, and poor because they are powerless, it is clear that the hungry, poor, and powerless are the small farmers (and the landless laborers) who toil away in subsistence agriculture.

The great temptation of the industrialized world, when faced with the problem of world hunger, is to look for technological, scientific, or perhaps managerial breakthroughs — some sort of modern miracle. How do you increase agricultural production in poor countries? Well, you turn poor, illiterate, small farmers into rich, educated, big farmers. You introduce high-yielding seeds, which require heavy inputs of fertilizer and irrigation water, as well as more sophisticated agricultural processes and land management. You innovate, mechanize, modernize, and you transfer technology.

American agriculture is often pointed to as the world's model in both production and productivity (in terms of unit of labor). And American agriculture is highly capital- and energy-intensive — or we might say technology-intensive — and terribly wasteful. But the very success of American agriculture, based as it is on constantly improved technology and an unparalleled network of research, extension, and financial institutions, seems to have obscured the real meaning of technology's impact on society. We have tended to take it for granted that "more is better," and because technology produces more, it must be good per se. But technology, for all its effectiveness, is a means — a resource that produces resources, as U Thant has said. Only in an intermediate sense is it an end.

My colleague at the Overseas Development Council, Denis Goulet, has recently published a provocative book (which some of you, I am sure, have seen) called *The Uncertain Promise*. As often happens, its subtitle — *Value Conflicts in Technology Transfer* — reveals more of its content than does the title itself. In this work Goulet argues that since technology (which includes not only products but formulas, designs, and personal know-how) is related primarily to production and supply, it tends to omit from the economic cost calculation precisely those demand-side values that are central to development: the abolition of mass poverty, the preservation of the ecosystem, and the enhancement of human dignity.

While it is true that there is much hunger and malnutrition in the world, those phenomena do not arise out of production short-falls. There is no shortage of food against effective demand — that is, ability to pay

— but there is no surplus against nutritional need. The problem, in short, is how to convert that nutritional need into effective demand — that is, into income. In a way, one may call that the economic purpose of development. One important — perhaps the most important — way is through increasing the productivity of the small farms in the poor countries. Technological inputs are part of that process, but they have to be adapted (to use old-fashioned foreign-aid terminology) for use in different cultural and economic settings. The probability of a collision course is high, because technology is inherently dynamic, but cultures tend to evolve slowly over time.

Problems of Transfer

When modern agricultural methods or sophisticated machinery are introduced under the conditions of traditional agriculture, they can be extremely disruptive unless they are balanced by the creativity they often bring to societies already on the way to modernization — societies out of which the technologies spring, more or less, by a swifter evolutionary process. Technology, moreover, generally exhibits its efficiency in economies of scale, which may be altogether inappropriate for the small farmer and other rural poor.

Projects that help the poor often encounter many obstacles. Rural people are often geographically remote and therefore hard to reach. Projects from which they benefit are generally small and unsuited to conventional cost-benefit analysis. Their developmental effects may be visible only over time and thus are not susceptible to the appraisal and evaluation requirements of those who want to give assistance. They are empowering the people who don't have power and are therefore threatening because, if properly designed, they will involve the poor in their creation, administration, and benefits and thus begin the redistribution of power that is essential if development is to become successful. Modernization, despite new benefits it may bring, is inherently destabilizing. It is crucial, I think, that the villagers, the poor, understand what is likely to happen, and plan for it and participate in it. If they don't choose the new technology and adapt it, there will not be genuine development.

Now, Goulet goes a little farther. He argues that the value conflicts, which give his book its subtitle, arise not only out of the ambiguous character of the values of technology (which he describes at some length), but also out of the channels and mechanisms that deliver technology from the rich countries to the poor. This consideration brings me to the central purpose of this conference, which is to discuss the problems and opportunities associated with farm mechanization alternatives in developing nations. Mechanization is not all there is to technology, but it is the most conspicuous and the most generally understood form of technological advance. There is no question that agricultural production can be dramatically increased in developing nations through mechanization (though more so through intermediate-scale machinery). Through consolidation of holdings, satellite farms, or collectivization (in a different ideological model), vast economies of scale can also be achieved. Bangladesh could produce four times as much rice if it followed the Japanese model; India could produce three times as much wheat if it were farmed like the United States. But none of these changes necessarily improves the lot of the poor and hungry, because the problem is not so much production per se as it is the method of production and the distribution of the benefits — just as the problem with large technology transfer is in part the mode of transfer, which is mainly through transnational corporations.

The Role of the Corporation

Much has been written in recent years about the transnational corporations: they are damned, defended, and praised. Their critics say they are essentially anti-developmental; their supporters say they are the engine of the development, the forerunners of a leisurely technological future. Even the authors of *Global Reach* begin by conceding that "The men who run the global corporations are the first in history who have the organization, technology, money, and ideology to make a credible try at managing the world as an integrated unit."[1] The United Nations has issued two large volumes on the operations of transnational corporations, and a Select Committee of the United States Senate has delved deeply into the same subject. Some analysts point to the stimulation of world trade and the revenues that result from their activities; others claim that as much as fifty percent of that so-called trade may actually be intrafirm transactions that do little more than maximize profits. The Conference Board describes the transnationals as one of the four "Partners in Agronomic Development" (the others being governments, research organizations, and "intersect organizations," such as the United Nations agencies, the Agribusiness Council, private regional investment groups, consultants, and so on). Other critics question whether the production know-how which agribusiness firms bring to food-deficit countries helps to feed the hungry people in those countries or whether it mainly supplies Americans and well-fed foreigners with luxury products grown on land that could feed hungry people. The jury, it seems to me, is still out.

Now I would like to present a list of questions that I have compiled — because I took the liberty of seeing this conference as a kind of questioning, rather than an

[1] Richard J. Barnet and Ronald E. Müller, *Global Reach: The Power of the Multinational Corporation*, Simon and Schuster (1975).

answering, session. These are questions that I think might well be asked whenever we are considering the introduction of a particular piece of equipment or a methodology aimed at modernizing agriculture, and improving the food supply, in the developing countries of the world.

1. Has introduction of the item or the system been decided upon to meet a need perceived by the potential user or beneficiary, and to what extent have the poor participated in the decision? Such participation is a human right that is to be fostered as much as are individual political rights.

2. Is the item within the financial means of the poor or of a group they have organized to purchase and use it? It is senseless to try to sell a $5,000-tractor — or even a $1,000-tractor — to a person whose annual income is about $100.

3. Is the equipment or system simple to operate, maintain, and repair, and if it is to be used by more than one family, individual, or group, is it easy to supervise its use? Developing countries are littered with inoperative tractors, trucks, generators, pieces of road equipment, and pumps that are rusty from lack of maintenance and spare parts.

4. Can the equipment be manufactured locally, using local materials and workmanship? If it can be, the business is more likely to fit into the local culture and then evolve naturally in unpredictable, but probably beneficial ways.

5. If its use will generate more employment, more profit, or better service, has an equitable way of allocating those benefits been devised by or with the participation of the users? In the Takase rice project, for instance — which seeks to double production in Asia by 2000, mainly through $54 billion in irrigation projects — the question of how farmers decide on allocation of the water becomes crucial.

6. If use of the equipment or system will save time, what provisions have been made for the use of that time — education, training, part-time employment, leisure? For example, if the use of photovoltaic plates or methane converters as an energy source in the village releases a large block of time for the women and children who used to gather firewood for such purposes, some thought should be given to productive use of that time.

7. What efforts have been made to accommodate any significant changes in the status of people stemming from the introduction of the equipment or system? Women, in particular, may lose major functions.

8. To what extent does the particular equipment, system, or method meld with other policies and programs bearing on the development of the country or sector? In Mexico, there is the question of whether to increase irrigation or expand the area of rainfall agriculture; the latter would involve breaking up large ranches, which agrarian reform laws have long called for.

9. Is the equipment or system a relevant improvement on an item or method traditionally in use, rather than a totally new item extraneous to the indigenous culture, values, or incentive system? Current patterns of technology transfer often exact a very high price, not only in terms of development objectives, social justice, and employment, but also in terms of cultural autonomy given up to standardization of products, work styles, and so on.

10. How much foreign (Western) cultural baggage does introducing the product or establishing the system entail? Technology, in particular, being dynamic and insatiable, poses a particular challenge to culture, which tends to be relatively static.

The sponsors of this conference are clearly in the mainstream of effort in regard to development and the search for mutually beneficial solutions to the problems of low agricultural productivity of small farmers, and of hunger and malnutrition among the poor. Thus, increasing food production in the developing countries, in a manner that ensures that those most in need have access to a better food supply (which in turn requires increased income and jobs), is in the interest of all people, everywhere.

The problem of world hunger, like the problem of population growth, is not easily solved, but the people who need and want to be developed, to improve their own lives and those of their children, are, for the most part, small farmers — 200 million of them. The development process should focus on them; if technology is to be transferred and machinery is to be introduced, these must be appropriate and adaptable to local conditions. Development — that is, meeting needs — must be the criterion, not marketing. The focus must not be limited to agriculture alone — that is, to production — but must be broad and encompass all that is meant by rural development, which includes energy, infrastructure, credit, land tenure, prevention of postharvest loss, and so on. Structural improvement is essential, and for that, political will is the crucial ingredient.

Something can be done to help those millions of small farmers in the food-deficit countries to increase their production in a fashion that accords with the fundamental purpose of development — which is, to meet the basic needs of the poor majority by providing the appropriate technology, while respecting the dignity of the people and the integrity of their culture. Then the pressure on our own food supply will be relieved, unnecessary food price rises and inflation will be alleviated, and the kind of enlightened self-interest that brings us together here can serve the cause of social justice — which is also the purpose of development and of life.

Introducing Power Farm Equipment to Small Asian Farms: The Experience of the Japanese Farm Equipment Industry

YOSHISUKE KISHIDA

President, Shin-Norinsha Co., Ltd.
Editor, *Agricultural Mechanization in Asia*
Tokyo, Japan

I am pleased to be asked to discuss my experiences in mechanization as it applies to the traditional systems of small-scale farmers in Asian countries, and especially in Japan, which is recognized as one of the successful examples of full-scale mechanization.

First, however, I would like to set out the basic ideas that we need to discuss regarding farm mechanization. One point is that we should think about the purpose of mechanization, and then to what extent we should promote it. In the case of the United States, the farm population is under 5 percent; and I understand that in Japan the farm population is already under 20 percent. Recently I visited West Germany. One professor told me we should not increase tractor size because already, in Germany, the number of farmers has seriously decreased; if we decrease more, that would be too dangerous.

The question is, how do we make use of the labor supply that results from mechanization? I employ many people who formerly were from the farm and, in my experience, the result has been very good. I don't know why, but I can say they know how to develop things properly. But now, in the highly developed countries, where most of the people have had no experience in agriculture, we find social problems in these modern societies that we didn't have in the old days. This is one of the problems we could face unless we determine to what extent we should promote mechanization.

There are some other points I would like to make. Mechanization has to be done in a way that preserves the ecological balance. This is a very important point. Also, we need to decide what our targets are — that is, what kinds of technology and equipment we need and what kinds of systems will fit the various conditions that exist in the countries we are trying to help. We also need to decide how to promote mechanization successfully with the farmers, and how to develop a good agricultural machinery industry in each country as quickly as possible. That means developing designs that are suited to the particular country, and standardizing them so they can be efficiently and profitably produced. Another point I would like to mention is that there should be cooperation between the industries of the more advanced nations and those of the developing countries. We need to help them absorb the new technology, one step at a time if necessary, so that it will be more effective.

And last I would like to comment on the need for effective communication, because to promote mechanization it is essential that there be cooperation among the various factory owners, dealers, manufacturers, government policy-makers, financiers, extension personnel, business representatives, and so on. I have found that every sector has its own way of communicating and thinking and we need a system that will allow us to share our ideas and communicate with one another. Forty-five years ago my father started *Agricultural Machinery*, a weekly newspaper, and I succeeded him as editor 10 years ago. It has helped to develop our industry effectively, and I mention it as one example of what communication can do. And now I will let the paper which I have prepared speak for the other points I should like to make for this conference.

In thinking about the mechanization of the small farms in Asia, first I would like to talk about the ideas most necessary for promoting such mechanization, and second, the general problems of agricultural mechanization in developing nations. Then I would like to describe how we have developed the mechanization of small farms in Japan since the war, and the present state of agricultural mechanization and its aim. Also, I visited China in August-September of 1977 with several members of the agricultural machinery industry of Japan, so I would like to comment on the present condition of agricultural mechanization in China and their coming problems, based on my experiences there.

The most important role of the agricultural machinery industry is to advance the mechanization of small farms in Asia. In discussing this, I should like to talk about the present state and problems of the agricultural machinery industry in Asia, and how to promote the industry in the developing nations. I also would like to discuss

the problems of designing and developing the agricultural machinery most suitable for developing nations, and the transfer of technology from advanced nations to developing nations.

Basic Ideas of Agricultural Mechanization

People have various opinions about agriculture. Many people consider agriculture as food production, but I think there is another aspect — the human element. By this I mean the farmer, who is able to produce organic material that is useful for mankind from the inorganic material that exists in seemingly limitless quantities in the universe. This has been going on since the beginning of history and it is all a part of a system of universal laws. I agree with another view that recently appeared — that the earth is life itself in which a mixture of organic and inorganic components are harmoniously interchanged.

But what is our situation now in the eternal history of the universe? I believe mankind now stands at the crossroads. A chicken will die in its shell if it cannot break it. Much effort is necessary for us to break out of our shell; if we cannot do it, mankind may be ruined in the future. How can we break out of our shell? We must change the situation that exists in parts of the world today, where more than 70 percent of the people work only to get food. Most of mankind lives in the areas of Asia and more than 70 percent of them are engaged in farming. The progress of our civilization is defined by how much labor we can release from food production. If we can average out the agricultural productivity in the world, we will be able to release 30 percent of the labor now spent in food production and turn it into other useful purposes.

Agricultural technology must be done in a way that shows how everyone, everywhere, can profit from it. The technique suitable for various farmers — small, large, and part-time — must be developed and provided for them. Machinery for the large farm is not suitable for the small farm, and a mechanical system for the professional farm is not suitable for the part-time farmer. A variety of technical systems is needed today, for the same machine functions differently according to place, crop, and season.

The Cost of Mechanization

To promote agricultural mechanization we must talk about the cost of mechanization, the price of machinery and products, and the value of the surplus time released by mechanization. Agricultural mechanization brings much surplus labor, and it is used to satisfy various human desires that are common in the advanced nations today. This is impossible in the nation in which all the people must work only to obtain food.

Productive value per hour in the nonagricultural sector is greater than in the agricultural sector. This has been basic to the advancement of our civilization up to now; we moved from the agricultural sector because the productive value per hour of the nonagricultural sector was high. So, today, a man working in the agricultural sector is at a comparative disadvantage in spite of the fact that he produces food — the most important commodity for mankind. Thus, a suitable agricultural policy is required to adjust the imbalance. Too much feedback to the agricultural sector delays the development of a nation, so it is a difficult problem to find the ideal structure and quality of such a policy. Looking at the history of Japanese agricultural mechanization after World War II, the movement of population from the agricultural sector to the nonagricultural, by mechanization, brought the largest expansion of the gross national product. We can also see this in Punjab in India and in other Asian countries where mechanization resulted in increased employment.

The price of farm products varies greatly from nation to nation but it is always lower than that of industrial products. A laborer in industry is paid more and has more leisure than the farmer and, in many instances, his work seems unequal to the hard labor of farming; but the economic value of this system to the nation is well recognized.

However, there are many systems on this small earth and some may move at a different pace. If we go to New Guinea we can find ourselves back in the time of the Stone Age. In other countries they work in the fields with hand tools that were invented 7,000 years before Christ. Even in Japan, a small nation, some farmers use a plow invented several hundred years ago while others have the newest machines with automatically controlled equipment. When we promote agricultural mechanization, therefore, we must take into consideration the historical background and system of values of the nation. On an international level there are various relationships between the price of farm products and the prices of other components of the economy. In regard to farm machinery, for example, so much depends on the rate of inflation in a country and the value of its currency in terms of foreign exchange. We must have factors such as these in mind whenever we consider making changes.

Is the Food Problem a Global One?

The problem of providing food for mankind is immense if we look at it globally, but the same may be said when we view it as a local problem. In Asia, some provinces always import food but others always export it; some areas are troubled with perpetual starvation but others have abundant food every year. Advanced indus-

trial nations with sound currencies are not troubled with food shortages because they can buy whatever food is not produced in the nation — although it can become a problem if, for example, the transportation of food is stopped by war. Regardless of what may happen in the rest of the world, the food problem is always present for the people in countries that do not produce enough food and haven't the money to buy it elsewhere.

Such matters must not continue. Each nation must utilize all of its resources to increase food production enough to meet its needs. The words "development" and "import" are often heard in Japan these days. Agricultural mechanization must occur in developing nations before they can produce their own food supply. But agricultural mechanization is a local problem and mechanization suitable for every nation does not exist. To mechanize agriculture, every nation must first develop the farm machinery that suits its own region, its own crops — that is why I make a considerable point of seeking a solution to the problems of food production and mechanization on a local or micro-level rather than on a global basis.

How to utilize the surplus time that results from agricultural mechanization varies according to the nation's stage of development. Agricultural mechanization, as already mentioned, can cause an unemployment problem unless the surplus time is used productively. Agricultural mechanization in Japan has rapidly increased, along with industrial progress which has much higher productivity than agriculture. It is not too much to say that every bit of surplus time produced by agricultural mechanization in Japan has gone into industry or non-agricultural productivity.

In developing nations, industry may not be advanced enough for farmers to find ways of using their surplus time when they obtain it, but Prof. W. J. Chancellor of the University of California has done some research that gives a good example of what can happen. According to his research in Malaysia, more than 95 percent of the surplus time produced as a result of agricultural mechanization was used in profitable ways, without waste. I rely on human creativity to utilize the new time that may be gained by the use of technology and I believe that farmers can promote agricultural mechanization fearlessly.

Mechanization for Multiple-Cropping with Rice

It is difficult to speak generally about Asia, because matters vary between the western part, India, and the eastern part. As progress in rice production has a great impact, I would like to talk about small-farm mechanization in the highly populated eastern part of Asia where rice cropping is performed in the monsoon. There are many rice-growing nations — India, Bangladesh, Burma, Thailand, Indonesia, Vietnam, Philippines, Malaysia, China, Taiwan, Korea, Japan, and others — each with various stages of development. Agricultural mechanization is most highly developed in Japan, followed by Taiwan, Korea, the Philippines, and Thailand.

Agricultural mechanization in most developing countries was started with introduction of the machinery from advanced nations. Then the assembly and production of the machinery started with technical and business cooperation. Next, some makers appeared who produced lower-priced farm machinery that could be manufactured in the nation itself by changing the design. There is a different story in the case of Japan, where, in the early stages of mechanization, they invented some original and important agricultural machinery, such as the impact-type rice huller, roll-type rice huller, head-feeding thresher, reversible suki (a kind of plow), Mangoku (a kind of separating sieve for unhusked and husked rice), and Beisenki (a kind of rice grader). Among the main agricultural machinery, Japan imported and improved sprayers, pumps, engines, and tractors.

When machinery was exported to small farmers in Asia from advanced nations it was basically designed for use in the advanced nations. I have rarely heard that the machinery design had been greatly changed for Asian farmers. The machinery originally designed for farmers in advanced nations was exported without any model change because it could also be used in developing nations, but such export is often accompanied by high cost. Farm machinery, like a plant seed, is suited to the circumstances surrounding it. If we want to grow a rice seed in another country, it will cost a great deal and will be almost impossible to grow because the seed can't change to suit the climate and natural features without being adapted through plant breeding. Similarly, to mechanize appropriately at low cost, the machinery must be redesigned, as in plant breeding. Few people realize this about farm machinery. Improvement of farm machinery varies according to crops, climate, the farmer's level of ability, the number of dealers, and developmental stage of the industry. Further, we must consider the differences in culture and social system. Even in a small country such as Japan, farm machinery varies in every area. An attachment on a tractor can make a great difference.

In a word, to change machinery can be done at lower cost than to change the circumstances. In developing nations they tried to change the circumstances and did not change the design of the machines. But recently they have started to design machines especially for developing nations in many institutions and factories. In considering the mechanization for developing nations, there were

many arguments about large- or small-sized machines. As long ago as 1971, when many specialists paid no attention to small-sized machinery, I published articles on this idea as the one that would have the greatest impact on Asian agriculture in solving the problems of average, small Asian farms. It can be said that Japan is the nation that promoted the mechanization of small farms to a great extent and has contributed much to the advancement of the developing nations in Asia.

Advanced nations assist the developing nations in various ways. Although such assistance is necessary, it is impossible to import all of the necessary farm machinery and to promote agricultural mechanization with the assistance of advanced nations alone. We must consider a system that applies surplus capital of those small farms for increased mechanization. The mechanization of China is an example. China has about 30 million hectares of rice-transplanting area. To supply one tiller with 5 hp per ha, it needs 150 million hp in tillers. If it costs $200 per hp, $30 billion is needed for the total cost. No developing nation has enough foreign currency to import all the required machines.

I think multiple-cropping is the best way for the farmers in Asia to apply their small capital and promote one step in their production. Fortunately almost all nations in the tropical areas have full solar energy and water. Research by Dr. Richard Bradfield at the International Rice Research Institute (IRRI) has demonstrated the effect of multiple-cropping projects. Dr. Bradfield showed that rice-cropping farmers gained an average of more than $3,000 gross income per ha per year, with irrigation and using family labor and a tiller of 6 to 7 hp, and producing five crops per year.

The fields in Asia are subject to strong sunshine and high temperatures in dry seasons, and the organic content of the soil is very low so the fields are sterile. However, if we introduce multiple-cropping there, the field would be naked for less than 10 days a year, and we can increase the fertility of the field year by year. Dr. Bradfield got a yield of 34 tons per ha with five croppings a year, a figure which can supply 73 persons with 2,600 cal and 55 gm of protein a day. Good feed for livestock, corn, and beans can be produced on these fields.

Mechanization is necessary to promote multiple-cropping, but we can see how effective the practice is. In Taiwan, for example, farmers have purchased power tillers in the area where multiple-cropping is practiced. New businesses appeared, to deal with manure and to supply agricultural chemicals, pumps, and other machinery for multiple-cropping. Experience in some dry climates shows the possibility of 50 to 150 percent increases in food production. I believe that the multiple-cropping project (rice and another crop, or double rice cropping) being promoted by IRRI and other organizations will become the greatest motivation for changing the small farms in Asia. Multiple-cropping has some problems — in regard to pest control and irrigation, for example. Still, multiple-cropping is the best way to feed the population of Asia which cannot expand its farm land, for it increases food production with relatively small amounts of capital. Thus, to promote mechanization for multiple-cropping is very important, especially in the production of rice.

There are many opinions as to whether a machine should be used in cooperation by several farmers, but it is very difficult without a good leader, even in Japan. Cooperative use of machines may seem to be a good plan on paper but it has problems under real farming conditions. Rice planting and harvesting seasons are very short. In the cooperative use of a big machine, the order of planting or harvesting is a great problem for each farmer, and what seed and technique should be used to fill the time lag between the first planting and the last. I think that the cooperative use of machinery has little future in Asia. In Japan many institutes and the government have failed in their efforts to promote it.

Irrigation is most necessary to promote multiple-cropping. Simple irrigation equipment is needed first, then other mechanization such as an engine, power tillers, threshers, and rice transplanters should be supplied. The order of introduction of machinery is very important. In Japan the thresher was in use earlier than power tillers, and research has shown that introducing the thresher was more beneficial to farmers than the power tiller. So the thresher may be introduced following the pump — but the pump must be considered first. As for power tillers or four-wheel tractors, whether large or small and so on — these selections should be considered carefully for different farming conditions. Research on implements has been slow in coming but is very important.

Agricultural Industry and Machine Design

As mentioned earlier, the development of a farm machinery industry within the developing nations is quite necessary for the promotion of agricultural mechanization, and the best system is one that produces machines that are profitable for manufacturers, dealers, and farmers alike.

Such machinery must be produced with simple facilities, using materials obtained in the developing nations as much as possible, to limit the cost of importation. Its price should be feasible for the small farms and must be determined by competition and free enterprise. The design should be simple enough for local manufacturers, dealers, and farmers to produce, sell, repair, and use it.

The basic motive is profit, and when these three can realize enough profit, development and demand will come. The rate of feed-back is sometimes very rapid. In the Philippines, IRRI designed a simple tiller without a side clutch, and some makers manufactured it. A few years later a tiller with side clutches was requested by farmers. So, the engineers of IRRI got busy and designed a simple tiller with side clutches. The machinery which IRRI is now designing is nearly the same as that of the advanced nations. This process is very important, with makers, dealers, and users forming a cycle to really promote agricultural mechanization.

The role of the dealer is apt to be overlooked. Farm machinery dealership is a very small business, even in advanced nations, and is hardly conspicuous in society; but its role in agricultural mechanization is very great in the United States, Japan, and other advanced nations. And good new machinery is not successful in a country unless farm machinery dealers are involved, because farm machinery dealers function as the pipeline between manufacturers and farmers and play an active part in the profit picture. By contrast, farm machinery is distributed by agricultural cooperatives in many developing nations and the system is not so effective. They are generally very slow to promote agricultural mechanization because the profit motive is missing. Sometimes cooperatives are needed, but they will be replaced by independent dealers in the future.

Raising the price of agricultural products is generally the most effective means to promote agricultural mechanization. In Korea and Taiwan, for example, agricultural mechanization showed a rapid increase after the rice price was raised. Another important element is communication. Papers and other publications are essential because they are the most effective way to inform the public and obtain the cooperation of farmers, dealers, manufacturers, policy-makers, bankers, researchers, extension people, school teachers, and so on, in promoting mechanization for the good of all.

Developing a Farm Machinery Industry

As we have seen, the farm machinery industry should provide profit and other incentives for the manufacturer, the dealer, and the farmer alike. The machinery itself should vary according to the stage of development of industry and agriculture in each nation. Without such a system, farmers cannot develop their potentiality in the developing nations.

The development of the farm machinery industry in the Philippines is a good example. When Dr. A. U. Khan started his work at IRRI in 1967, he found only imported machinery — large and small tractors, a large McCormick-type thresher, and other implements such as pumps and weeders. However, after IRRI designed some simple machinery and made it available to the industry, there soon appeared about twenty makers of power tillers, and still more thresher manufacturers. Today there are about fifty makers of farm machinery in the Philippines. Other countries also show progress. In Korea, many machines are made from Japanese models. In Taiwan, many makers are producing copies of machinery under a technical arrangement with Japan, and are also improving their own original models.

To design machinery for developing nations, care must be taken in regard to production engineering. Farm machinery can be manufactured without expensive machine tools by redesign. Another important point is production volume and suiting the design to the demands. For example, an expensive mold is needed for press work and many machines must be sold to redeem the investment; therefore we must design machinery with a low requirement for press work. When we design a machine, we must make certain that the precision and the price of parts can be supplied in the nation. Precision parts do not always mean good machinery for developing nations because they must be used precisely by the farmer. It may be that rough parts are adequate in some machinery at the beginning stages of development at least.

Precision parts, press work, and mass production can be introduced when demand becomes great enough. This has been the process of development of farm machinery makers in advanced nations. It is difficult for the people in developing nations to produce these machines immediately. We have proposed for a long time that we should establish public institutes to do it, and some efforts of this kind have been made. It is important that excellent engineers, especially production engineers, be integrated into the developing nations. Research activity in advance by official institutes will provide a great incentive.

Technological transfer from advanced nations is necessary to promote agricultural mechanization in developing nations. The problem is how to promote the transfer smoothly and quickly. Much information about farm machinery is given along with the farm machinery when it is introduced to farmers in developing nations. As in advanced nations, almost all information about farm machinery is spread through industry, often with great effect. So the public institutes are needed to advance the technical cooperation of industry between advanced nations and developing nations — for example, in providing financial support for engineers of developing nations to study and receive training in farm machinery factories in advanced nations.

Much technical information is included in catalogues and product manuals by manufacturers and it is necessary that such information is easily obtained by the

developing nations. To promote technical transfer, it is better done by industry through their businesses than by university professors who serve as consultants or by holding many international conferences.

We must also find some way to promote the free import of farm machinery. When farm machinery is exported to developing nations from advanced nations, the greatest bottleneck is the official export limit caused by a foreign exchange shortage. In Japan there was no restriction on imports, which was most necessary for the development of agricultural mechanization. I think that machinery factories must be established in each developing nation, but we must promote free imports of machinery from advanced nations until the factories in developing nations become a paying business.

Agricultural Mechanization in Japan

I would like to talk briefly about the rapid progress of agricultural mechanization in Japan. It can be separated into two periods, one before World War II and another after the war. Before the war, it may be said that mechanization started with the processing of rice by a rice pearling machine and huller. The first machine owned by farmers personally was a man-powered thresher, which was followed by a power thresher and an electric motor. As for engines, a large, water-cooled, low-speed kerosene engine appeared first, and high-speed engines appeared after the war, to promote mass production. Development of a power tiller was delayed, mainly because there was difficulty in developing a light-weight high-speed engine.

Agricultural mechanization in Japan made rapid progress when kerosene and air-cooled gasoline engines and a high-speed, light-weight, small diesel engine were produced along with other technological advancements after the war. In Japan, tractor horsepower for tillage was nearly zero per hectare in 1950. It jumped to 0.9 hp per ha in 1960, an increase unequaled by any other nation in just 10 years. The farmer in Japan had only about one hectare on the average, and one or two cows. Almost all farmers were engaged in rice cropping, and they all used the same farming methods.

So, mechanization, which can solve the problems of typical farmers, has made great progress and has been widely accepted. The government of Japan had advanced the use of animal power, but mechanization of tillage increased rapidly when a simple 2.5 hp tiller with drawn implements was introduced from Europe and the United States. This tiller had a great impact by replacing a cow in the 1 ha field. They used it not only for tillage but also for transport. The price of a cow was higher than that of a tiller, so the farmer paid no money for the tiller but gave the cow to the dealer, who took it to the market to sell. Thus animal power decreased constantly and machine power increased. It cost less to manage and operate the machine than to keep a cow. Many people rushed into the tiller business.

A few years later, a maker of small air-cooled engines appeared in Japan, and farmers could obtain a lower-priced engine. Several kinds of small air-cooled engines were being imported from Europe and the United States but they could not compete in price and capacity with the Japanese engine. More than 200 makers were producing such engines for a time, but after severe competition, only about ten makers survive today.

In the 1960s there were signs of moving away from the tiller to a four-wheel tractor. Japanese manufacturers thought that a small four-wheel tractor with 15 hp would follow the tiller, but a government policy-maker, after observations in Europe and America, decided that it would be economical to produce large-sized tractors and use them cooperatively. A 50 percent subsidy was given to the farmers who bought big tractors in common, and a subsidy for research was given to the makers to develop large-sized farm machinery. Naturally many makers stopped developing small tractors and changed to the larger size. However, Kubota Tekko Company continued its research on the small four-wheel tractor and it rose to the top. Toto-sha Company was the small-tractor manufacturer. The company concentrated its efforts on four-wheel tractors under 15 hp, and it still follows this practice today, while other manufacturers gave their attention to the larger tractor.

In the early 1960s research on a rice transplanter, binder, and a combine harvester prospered actively. A side-delivery and bundling reaper appeared and spread rapidly; then a binding reaper appeared in 1965 and replaced it. In 1963 a pinset-type power rice transplanter for long seedlings from traditional seedbeds from Mametora was ready for sale but was replaced by a soilless seedling transplanter. The idea of the pinset planter was to transplant the usual, nursery-bred seedling automatically, but it was not easily systematized because the seedlings were unequal in size. Then a standardized seedling was developed through artificial growing and the soilless seedling transplanter worked successfully.

In 1965 a multiple-row head-feeder combine was introduced, and a two-row combine was developed and sold by Iseki in 1966. In the 1970s, transplanters, four-wheel tractors, and combines have made rapid sales increases. Production of four-wheel tractors amounted to 286,000 units in 1976, but this proved to be overproduction so there was a decrease to 266,000 units in 1977. Four-wheel tractors and combines account for most of the farm machinery production in Japan today, amounting to 65 percent of total production. Eighty percent of

total production is in rice-cropping machinery. Mechanization for other crops has progressed slowly and requires more research. While the average four-wheel tractor shipped is 23 hp, we now make one with 83 hp and in 1979 there are plans to produce tractors with 100 and 120 hp.

As mentioned earlier, agricultural mechanization in Japan owes much of its progress to the productive use of labor in industry that formerly was engaged directly in farming. Agricultural labor used 28 percent of its time for Japan's industrial production in 1970 and 48 percent in 1976.

With respect to the national economy of Japan, agricultural mechanization has been successful in increasing food production besides supplying industry with much labor. It may seem that Japan is excessive in its use of energy, but the power necessary for producing 1 kcal of farm products in Japan is less than that of Europe and America. Tractor power used on the farm was 73,000 hp in 1950 and has increased to 31,098,000 hp in 1976. The labor needed for rice production was 2,045 man-hours per ha in 1950, compared with 797 man-hours per ha in 1976.

The farm population of Japan has decreased from 16 million in 1950 to 7,830,000 in 1975. The investment in farm machinery in this 25-year period amounted to about 6,147,600 million yen ($30 billion), which means that 752,000 yen ($4,000) was invested to replace one farmer.

The units of production of the principal farm machinery in Japan in 1977 were as follows: four-wheel tractors, 266,344 units; rice transplanters, 279,615; reapers, 116,466; power threshers, 72,106; combines, 172,908; dryers, 161,845 units. The total output of farm machinery in 1977 was 658,800 million yen.

There are several problems in regard to future agricultural mechanization in Japan. One is, how can we increase productivity by using the fields that are dispersed in small plots, and how can we make the best use of the slopes, which occupy 76 percent of the land in Japan. Also, we have a lot of localized torrential rains to contend with. It is important, too, that we maintain our forestry. The forestry population has decreased markedly, so we need mechanization to reduce the labor of forestry on the mountain slopes. In Japan, greenhouse agriculture is very popular today, so the farm machinery industry needs to grapple with the problem of developing an automatic system that will serve this most intensive form of agriculture.

Agricultural mechanization in Japan is thus entering a phase where it needs more brain power than muscle power. However, thanks to the declining costs of computer technology, it is expected that the brain power will be forthcoming.

Agricultural Mechanization in China

I visited China for two weeks in 1977, at the invitation of the Chinese Association of Agricultural Engineers. The purpose of the visit was to exchange information about agricultural mechanization, and I organized a group of 14 persons from our farm machinery industry to share in this exchange.

To understand China we must consider the fact that overpopulation is a basic fact of life in that country. Recently a scholar, who has researched the problems of population and who has visited China, has estimated China's population to be 900 million. It is a large nation with an area of 960 million ha and various kinds of people, culture, and agriculture.

The question we asked was, how can Japanese industry cooperate with agricultural mechanization in China? China could make progress in agricultural mechanization independently, but I think they could use our technology. China has ten times more farm land than Japan, so there is a real opportunity to promote trade on a long-term basis.

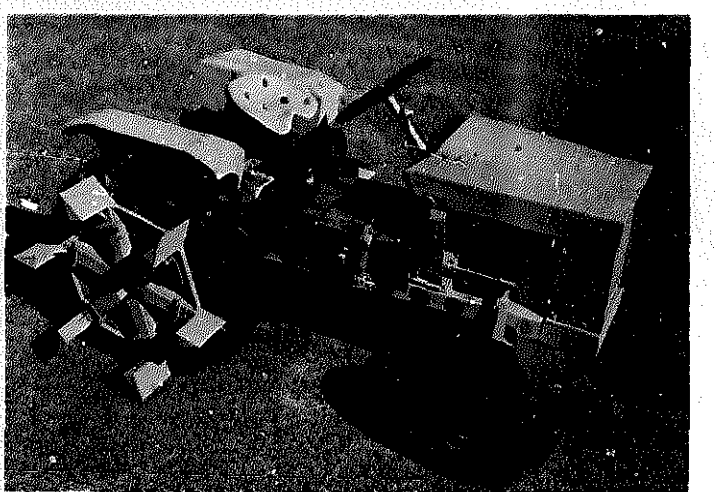
It seemed to me that the level of China's culture was higher than that of Japan in some ways. Their culture and history have developed over a period of 5,000 years, and this is an important fact in understanding this country. Their national policy is clearly defined. Some people consider it totalitarianism, but I felt, in reading the history of China, that there has always been a current of spirit and ideology when a new dynasty and a new leader appeared.

Regarding the agriculture in China, intensive agriculture is practiced to utilize all of the available space. This can be seen in the well-ordered paddy fields, fish-breeding under surface, and multiple-cropping. Cultivation of the land is thorough and the weeds that are removed are used as green manure, to promote soil fertility, because chemical fertilizer is scarce. Factories are widely dispersed, which will play an important part in agricultural mechanization. China is a large land with various kinds of agriculture from north to south, and regional development will allow more progress. I was impressed with their tillage machinery and their axial-flow-type combine. They are full of ideas for developing new machinery suitable for their present needs. This is different from other developing nations.

In China, labor is a national virtue and people work very hard from childhood to old age. Personal wages in China are much lower than in Japan; thus some kinds of labor-intensive industry will find advantages in China, and I think their low labor cost will create strong com-

petition for other nations in the future. My impression of Chinese factories is that they are lacking in certain elements. Strenuous efforts for increasing production were being made in every factory, but there was a lack of management of the goods in stock, such as cost accounting, raising funds, half-finished work, and so on. Cost accounting, especially, requires timing. And, seeing their products, value analysis will become increasingly necessary, especially since their natural resources are limited. This means raising the level of factory management, process control, and labor management. I think these will be the greatest factors in increasing the productivity of China. My impression was that there are many important farm machinery factories in China and their production is much greater than I thought before my visit, which provided first-hand observation.

John S. Balis, U.S. Agency for International Development, described his experiences in working with farmers in the villages of India. "The tractor evaluation project demonstrated the functional utility of small tractors on small farms," he said. He recommended that the data should be analyzed in terms of specific localities and suggested that "the benefits of small tractor use in some areas of the world may exceed the benefits observed in India."



Small tractors such as this Philippine model are being built to replace animal power on the small farms in a number of developing nations. Others include the Monowheel, designed in the United Kingdom and tested in Africa, the Kabanyolo in Uganda, and the Tinkabi in Swaziland.

Introducing Tractors under Twenty-five Horsepower to Small Farms

JOHN S. BALIS

Chief, Rural Development Division, Office of Development Resources
Bureau for Latin America and the Caribbean, Agency for International Development
Washington, D.C.

As a preface to the more formal remarks that I have prepared for this conference, I would like to show some slides that illustrate our experiences in introducing tractor power to the small farms in India. I realize that the slides cannot be reproduced in the published proceedings, but pictures seem to convey our experience in India better than words.

When I went to India in 1962 I did not go with any particular romantic attachment toward bullocks. I went because I thought it was possible to apply modern engineering skills to improve upon the functional capabilities of the traditional wooden plow. When we arrived in India, Allahabad and a number of other places were producing quite a variety of improved animal-drawn implements. Small workshops and slightly larger workshops were involved in this. One of the first things we decided to do was to add to the line of implements and, specifically, to produce and design an improved disk harrow, the thought being that this was a tool that could improve the work productivity of a pair of animals during preparation of the winter crops. We produced this machine and put it on the market for $40. It used wooden bearings and doubled the work production of a pair of animals.

The first time we took this disk harrow to the field for farmer demonstration was during a three-day swing through western Uttar Pradesh, and 16 out of 17 farmers who saw that machine work on their land wanted us to leave it in the field. They said they could get the money from the village if we agreed to leave the machine there. It was the only one we had and our purpose was not going to be served by leaving it at one farm, but it demonstrated something to us quite convincingly: that the Indian farmer was very responsive to better tools. His judgment agreed with the judgment we had used in selecting our design requirements.

We produced some 1,500 disk harrows that year and then we ran out of imported disk steel. It took another three years to convince the Hindustan Steel Company that there was a sufficient market in India to roll the kind of sheet steel that was needed for producing disk harrows. In other words, it is not always the farmer who holds up progress; it sometimes is another part of the supply or service system.

We continued to develop other machines such as an animal-drawn reaper, seed drill, and others. At the same time we increased the production of improved animal-drawn plows, which were the bread-and-butter item at the time, to more than 1,000 plows per month in one factory. That factory then expanded its operations and moved into modern headquarters. Unfortunately, at that point we began to realize something about our selling program. Up to that time, sales had been largely subsidized through the block development officer, community development officer, and other people, and we could sell to them 1,000 plows in one order. But when the subsidy program ended and we tried to sell to individual farmers, the company went bankrupt. The problem of selling and distributing to individual farmers is horrendous.

While we were having some success and many problems with improved animal-drawn implements, we began to look more closely at what was going on in Indian agriculture. First we noted that 200,000 diesel engines were being made each year and were sold for pumping irrigation water. At the same time, the Punjab area was just being introduced to power-driven threshers. Also, the Russians were selling some 15,000 14 hp tractors to India. It is true that those tractors were not serviced very well, and the roadside mechanics and other people were doing what they call in India a rather kutcha (poor) job. But it kept the tractors running, and probably running as long as tractors are kept running in U.S. agriculture. In fact, at that particular time the oldest Caterpillar tractor and the oldest Caterpillar road grader in service were both in India. So when you are talking about the capabilities of mechanics in the developing countries, it is best to be a bit careful about stereotyping their ability.

In this survey of agriculture, we found one manufacturer in India who was beginning to experiment with a Japanese power tiller chassis and an Indian pumpset engine. And in Allahabad a Peace Corps volunteer and an Indian engineer had taken a couple of Beaver trac-

tors that were leftovers from an industrial fair, and began to hang some of the improved animal-drawn implements on the back of the tractor.

The Possibility of Multiple-Cropping

All of this led us to look a bit more seriously at some of the facts that we thought we knew. One of them has been alluded to repeatedly, and that is that the land can really be used intensively when there is no need to worry about frost and where there is water within 30 feet of the ground surface. If we could quickly harvest and replant the land, we could get three crops on one acre of land in one year's time. And if, at the same time, we went to the higher-yielding varieties, we would increase the yield, but we also would increase the amount of straw and the total work load of harvesting.

When we began to look at agriculture in other parts of the world, we began to realize that the classic notion that labor is displaced when you increase the number of tractors does not show up in the statistics in a number of countries. Thus, we discovered the association between intensive use of machines and labor, and the higher levels of yield. That meant we had to think more seriously about which kind of power we wanted to have on the Indian farm.

We began by looking again at where the animals were and asking what size of farm was best served by one pair of animals. We soon discovered that most of the farmers — those of average size and smaller according to the statistical average, which was five acres at the time — had no expectation of providing their power with their own pairs of animals. They all used hired power. In fact, a quarter of the land was farmed by this group. Then we looked at some of the other groups and began to ask, "Are they best served by a multiple set of animals or would they be better served by a small tractor?" We began to discover that the farmers themselves were not satisfied with the power they had, so we looked at other economic principles such as economies of scale, independent management, and so forth, and we concluded that probably the small tractor ought to be considered quite seriously.

It was in 1963 that I suggested to Wallace Giles, the agricultural engineer with the Ford Foundation, that we ought to try some small tractors on Indian farms. Eventually we persuaded the Ford Foundation to grant about $300,000 to Allahabad Agricultural Institute to import some tractors into India. We brought with each tractor all of the implements that we thought we could use in India and enough spare parts for four years. We chose tractors from Japan, Germany, Switzerland, and the United States. The Japanese tractor in the four-wheel riding class was the Hinomoto, which at that time had about 10 hp. The Holder tractor from Germany was about the same as a Farmall Cub, and there was also the U.S. made Economy tractor in that same general size and configuration. In the 10 hp, two-wheel class conventionally called walking-type tractors, we brought a Rapid tractor from Switzerland and two Holder tractors, one of which had a riding sulky. We represented the smaller-type Japanese tractor with the Iseki and its implements.

With some of the tractors we brought some unconventional implements to give us a little experience with their potential. For example, the Rapid tractor had a reaper-binder which we were thinking about for the utility in harvesting the high-yielding wheat varieties. That didn't work out well, but the double-drum thresher proved to be very popular for threshing sorghum heads. The seeder that was attached to the Hinomoto tractor did not do well the first year, but once the farmers gained confidence with the tractors, seeders became one of the key interests.

Selecting farmers gave us some concern at first, but we concluded from the beginning that we probably should work with the more progressive farmers. Consequently, we asked the village-level worker and the block development officer to nominate three to five farmers who they thought would cooperate. They had to be progressive farmers and linked to the marketplace in some way. We also wanted men who could keep simple records so we asked for those with at least a third-grade education. We found that there was no trouble in finding men who wanted to cooperate; two or three in every village came forward to participate in the projects.

Tractor Drivers in the Making

The first few days were pretty hard for the men while they were learning how to operate a tractor. Our training program evolved over time into an initial three-day routine at Allahabad, where the farmers learned the simplest care of the tractor and how to operate it with a trailer and one or two implements, whatever was in season at that time. By the end of the third day the farmer was able to drive the tractor from the Institute to his home farm and put it to work in the field. We visited the farmer about once a day for the first week and after that we visited him somewhat less regularly, usually about once a week, at which time we picked up his record of tractor use and also occasionally assessed for ourselves just what he was doing with the machine at that time.

Some farmers did abuse the tractors. For example, one man was walking backwards in the furrow in front of the tractor because he had not adjusted it properly. If the adjustments are done properly it is only necessary

to clutch at either end of the field, but this man had not quite mastered the adjustments. We had other problems like these, but in the three years of operation in India, our experiences did not differ greatly from the tractor servicing reported by the University of Illinois, for example, in its maintenance inspection of 60 farm tractors in the state of Illinois.

We tried some unconventional uses of equipment. I remember, for example, the reaction of some Japanese engineers when they saw pictures of how we were using a machine that was made for working in wetland paddy. In India there is a practice of dragging a log across the field to smooth the field and break the clods, to create a mulch of fine dust and serve as a moisture conservation practice. We could accomplish the same function with the riding sulky and leveling blade, although the machine was not sturdy enough for dryland use and once in a while we had some wheel failures. We tried as best we could to simulate the kinds of operations that Indian farmers were doing, one way or another, using conventional or unconventional power sources.

We conducted other, more detailed, experiments with some of the machines at Allahabad to find out a little more about their optimum adjustment under Indian conditions. For example, we spent quite a bit of time in determining the optimum weight on tires, evaluating the performance at different plowing depths, and experimenting with alternatives to moldboard plowing, such as field cultivating. By the end of the project we had made Indian versions of all the imported implements, starting with bullock-drawn implements and a welder. We even substituted some engines, such as the Indian-made Krishi 5 hp kerosene engine on the Beaver tractor chassis. We tried to say to Indian manufacturers, "Look, don't think of this as an imported tractor, think of it as a functional tool." We were much impressed with the reaction, as we felt that our most important message was to convey to entrepreneurs the potential of this industry. One such entrepreneur, the maker of the Krishi engine, began to develop not only a similar chassis but also a diesel engine with a bit more horsepower for the same kind of tractor. And the Government of India tractor-testing station began to work with a small, simple 5 hp version similar to what Sears and Roebuck offers gardeners.

The Benefits of Tractor Power

The farmers who cooperated with us in the project — and there were 29 farmers in the whole program — were all very enthusiastic, almost from the very beginning. In fact, practically all of them sold their bullocks after the first month. A little later we discovered that almost all of them had trained their hired labor to be the tractor operators and were enjoying a bit more leisure on their own, which was a surprising thing to us. We had expected them to dismiss their labor. However, by gaining some spare time in this way, they found that they could be in the marketplace in the planting season to get their share of seeds and fertilizers that were in scarce supply at that time.

So we were not surprised when we demonstrated the tractors at farmers' fairs and had large crowds around the tractors all of the time. This was not a circus exercise, however, for they were asking legitimate questions about how those tractors could be used on their farms. I think probably, and most importantly, it was not only the cooperation of the farmers but also of the Indian agricultural engineers who worked with me in the project and of the Peace Corps volunteers, that enabled us in that period of time to demonstrate that there is an important functional role for tractors in the small-farm enterprises in India.

This leads me into the paper that I prepared in advance for this conference. I realize that there will be some repetition of the comments that I have already made regarding the work in India, but I will broaden the subject by discussing some of the experiences we have had in introducing tractors of less than 25 hp in other countries as well.

Implements Increase Production

The improved agricultural implements and tools such as those developed by Allahabad Agricultural Institute, and which are sold throughout India by the Agricultural Development Society, make it possible today to double the effective cultivated area commanded by a pair of draft oxen. The use of the combination of soil-turning plow, disk harrow and seeding machine increases both the command area and the quality of the work done, resulting in increased crop yields. With extensive promotion by the government extension service and by development agencies, these implements have been tried and adopted by many farmers and are now in production by many small manufacturers in India and other countries.

There are serious limitations to improved, animal-drawn implements. Perhaps the most serious from the farmer's point of view is that the complete set of implements costs about the same amount as the animals that can be displaced. In addition, the single pair of animals cannot provide adequate threshing or irrigation capacity at the higher production level, so the farmer must invest in engines with pumps and threshers as he intensifies his production. Once farmers have mastered the use and care of improved, animal-drawn implements and pump

engines, the transition to tractor operation is a modest step.

Interest in the small tractor arises from two basic hypotheses about agriculture in developing countries. The first is that the small farm enterprise is essentially a permanent institution. While the data are fragmentary, it appears that farms in the developing countries are becoming smaller due to population pressure and official action, in spite of the obvious economic advantages of larger-scale enterprises. As a corollary to this first hypothesis, it is speculated that a small farmer with independent control of a small tractor will have a greater return from his enterprise than by shared use of a more efficient, larger machine. The second hypothesis is that the comparatively large number of small farms in the developing countries would enable economies of scale in the manufacture of small tractors that could negate the usual relationship of costs for various tractor sizes. This latter assumption is not crucial but it has considerable significance in view of the size stratification of farm enterprises in India or Honduras, to cite two examples (Tables 1 and 2).

This led to the question: What would be the performance of small tractors on Indian farms? The Ford Foundation provided a grant to Allahabad Agricultural Institute to study this question.

TABLE 1. All-India Farm Power Spectrum.

Farm Size (acres)	*Power Source*	*Farms*		*Area*
		Number (thousands)	*Percent*	*(percent)*
0–5	Hired	31,076	62.3	19.0
5–10	Bullocks	9,646	19.3	20.3
10–25	Small tractors	6,843	13.7	30.8
25–50	Small tractors	1,795	3.6	17.9
50+	Large tractors	514	1.0	11.8

TABLE 2. Farm Size in Honduras and Distribution by Number and Area.

Technology	*Farm Size (ha)*	*Farms*		*Area*	
		(number)	*(%)*	*(ha)*	*(%)*
Hired	0–2	72,417	37.1	75,118	2.8
One animal pair	2–5	52,330	26.8	163,561	6.1
Small tractors	5–20	47,478	24.3	468,983	17.6
Japanese, 4-wheel	20–50	15,184	7.8	461,464	17.5
Conventional tractors	50+	7,908	4.0	1,485,849	56.0
Total		195,297	100.0	2,655,095	100.0

Source: 1976 Agricultural Census.

The Tractor Evaluation Project

Under the Tractor Evaluation Project, as mentioned earlier, four tractor types and matching implements were purchased from commercial production and were placed on representative farming enterprises. The project provided full backup servicing, spare parts, equipment adaptation, and adequate capacity to monitor performance and ensure a simulation of normal farm use. The project provided initial operator training and necessary assistance for maximum use of the equipment.

Systematic performance monitoring and testing under real field conditions was conducted through the full period of farm use. At the end of the three-year project, data were available from 29 farmers for periods of 15 to 30 months of tractor use.

The tractors were selected to represent Japanese, European, and U.S. engineering practices and implement options. Both walking and riding types were obtained. In many cases, improved animal-drawn implements were modified and attached to provide the farmers with the equipment of their conventional practices. By purchase of commercial machines, the project acquired equipment more quickly and at lower cost than by local development. The expected suboptimum performance of imported equipment was considered a negligible factor. The initial selection of equipment and spare parts provided for a wide range of study (Table 3).

The farmers were selected for their reputation as progressive managers and for their expressed interest in cooperating with the project. The village-level workers of the government extension service were asked to nominate a small group from which the project staff selected the cooperating farmers. The farmers were from the 3 to 5

TABLE 3. Recommended Tractor Specifications, Tractor Evaluation Project, India, 1966–1969.

	I	II	III	IV
Tractor style	Walking	Walking	Riding	Riding
Engine horsepower	5	10	10	15
Weight (lb)	325	650	1,000	1,500
Drive wheel size (in.)	4×10	6×16	6×16	8×24
Wheel tread minimum (in.)	14	24	32	37
Wheel tread maximum (in.)	24	36	36	48
Clearance (in.)	6	8	10	16
Wheelbase (in.)	. . .	. . .	48	60
Front wheel size (in.)	. . .	. . .	4×10	4×10
Turning radius (in.)	. . .	. . .	66	84

Source: *Progress Report No. 5 — Recommendations of Specifications for Tractors of Less Than 15 Horsepower Which Are To Be Used in India,* Tractor Evaluation Project, Allahabad Agricultural Institute, October 1966.

percent of the size class in which are usually found the innovators of a community. One of the facts discovered in the selection process was that practically every village included one or two farmers who had strong interest in having a small tractor.

The farmers were trained in the care and operation of equipment and in the maintenance of service and performance records. The farmers were required to purchase all of the fuel and oil used but no rent was charged for the use of the equipment in return for their agreement to maintain records and cooperate in occasional detailed performance measurements for the various implements. Also, as the equipment was on loan to the farmer, it was expected that he would continue to maintain his work animals for use after the project was completed. A team of three Peace Corps volunteers and four Indian agricultural engineers was used in farmer training, operational support, and compilation of the performance records. After the tractor was assigned to the farmer, he made the decisions regarding its use; the field staff offered recommendations upon request but had little to do with decisions regarding use.

Three kinds of measurements were compiled during the project. The farmers maintained a simple, continuous record of tractor use, servicing, and other observations. The operating records were collected weekly and were summarized by the project staff. One engineer was assigned to each tractor type with the task of making comprehensive, precise operating studies for all tools. These performance tests were used as a standard in reviewing the farm performance and also as a basis for equipment comparison and adaptation. One engineer worked full-time in adapting the improved animal-drawn implements for use with the project tractors. Performance data were collected and the adaptations were offered to the farmers as optional equipment. The adaptation work had second priority in the project, but the staff was sufficiently capable to permit a considerable time for this activity.

What Was Learned?

The farmers used the tractor more than was expected, reaching 500 hours per year in the second year of use. In the first year they specialized in tillage, hauling, and water pumping. In the second year they tried threshing and planting. Also in the first year they did a considerable amount of custom work, often tillage for a neighbor in exchange for use of his oxen at planting time. Generally the farmers shifted to complete tractor use on their own or family land.

Innovations, particularly more intensive land use, were being attempted throughout the project. One of the most interesting observations was that all farmers sold their oxen after a month or so of tractor use. A few farmers replaced the oxen with milk animals, and others noted that the sale of fodder was an additional source of farm income.

All farmers reported an increase in production which resulted from a combination of more double-cropping and increased yields. Before the use of tractors, the farmers had realized about 130 percent crop intensity on their land. Tractor use raised crop intensity to 150 to 180 percent and farmers indicated the intention of going beyond 200 percent if they could continue to have tractor power. All farmers claimed increased per acre yields because they were using better seeds, more fertilizer, more irrigation, and better timing of field work. Attribution of the yield benefits to tractor use rather than the other inputs was not attempted although there is apparently a strong interdependency (Table 4).

The placement of tractors on farms was according to the ratio of 1 to 3 acres per engine horsepower. Initially we lacked confidence that the farmers were reporting their farm acreages accurately, and we were uncertain of the optimum size relationship. As the project developed we learned that the farmers had underreported their land holdings. As the farmers mastered the use of tractors, they tended to concentrate the use on an area of 1 to 2 acres per engine horsepower. A few implements were used more extensively for custom work. Another factor tending to reduce the command area was the shift to more double-cropping. It appears that one horsepower per acre may be the design basis for intensive farming in the project area.

The impact of tractor use on hired labor was one of the more surprising observations of the project. Because

TABLE 4. Small Tractor Performance Summary, Tractor Evaluation Project, India, 1966–1969.

Years of tractor use	1–3	3–5	5–10
Land area controlled, A/hp	4	4	3
Cropping intensity, %	150	200	225
Irrigation pumping (hr)	200	250	300
Tillage (hr)	125	175	225
Carting[a] (hr)	50	50	50
Seeding (hr)	....	50	150
Threshing (hr)	....	25	100
Spraying (hr)	....	25	50
Miscellaneous (hr)	25	25	25
Hired out (hr)	100	100	....
Total hours	500	700	900

[a] Does not include travel to market or nearby villages for family, social, or similar purposes.

Source: John S. Balis, *Progress Report No. 14 — Summary of the Project*, Tractor Evaluation Project, Allahabad Agricultural Institute, March 1967.

it was anticipated that the farmer would stop using hired labor after relying on tractor power, the farmer was trained as the tractor operator. However, in practically all cases, the farmer trained his permanent hired-man to operate the tractor within a month or so after receiving the tractor. This arrangement gave the farmer more status, more freedom to go to town and, as it turned out, more access to scarce supplies of improved seed and fertilizer. At the same time the greater yields contributed to a higher salary for the permanent hired-man and some increase in daily wage rate work. This phenomenon was unexpected and it was not detected in the first year; consequently, baseline data were not collected for thorough analysis.

The project staff was adequate for all training, servicing, data collection, and analytical functions, plus considerable study of equipment adaptation. The training program eventually evolved into a three-day initial program for the farmer, followed by one-day programs for each field implement. The farmer service and data collection requirements were accomplished in weekly visits after the first season of tractor use. Daily visits were necessary only during the first week. At any time the farmers could inform the project headquarters of special needs, by mail or by visit using bus service, and an engineer could be on his farm the same day or the next day.

Locally made implements were adapted to all tractors for the common and improved cultural practices. All of the imported implements were demonstrated to all of the farmers, but many implements were not accepted because it was difficult to adapt the farm enterprise to their use. For example, a reaper was available for one tractor but farmers were unaccustomed to the early harvest necessary to minimize field shatter losses. In other words, the farmers would have been satisfied with much simpler tractors and implements, at least through the first five years of tractor use.

There were some equipment servicing problems. For example, one farmer replaced the crankcase oil of a diesel tractor with so-called filtered oil rather than new oil. Another farmer continued to use a cultivator after bending a standard by hitting a rock. Two operators were hurt seriously and machines were occasionally operated with loose bolts or poor adjustment for the particular field conditions. The fact was that the farmers did follow the instructions as they understood them. It was possible to develop a training program that worked from the third to fifth grade education of the farmers. It was interesting to note that the final list of service problems included nothing different from the University of Illinois study of Maintenance of Sixty Farm Tractors.

How to Use the Experience

The Tractor Evaluation Project demonstrated the functional utility of small tractors on small farms. Evaluation of the data indicates that a simple tractor and implements would have been adequate for the first five years of tractor use, if not for the life of the tractor. The limited data, however, call for speculation about the economics of small tractor use. From the information available, it appears that the economic analysis is also site specific and should be undertaken in each locality of interest.

The intensive servicing provided by the project was an important aspect, making this study different from numerous other attempts at introducing small tractors in developing countries. The initial training and service requirements were found to be high but they decreased rapidly as farmers gained mastery of the equipment. A specialized mobile field crew for the first season may be the strategy for setting up a profitable commercial enterprise within a reasonable length of time. By eliminating the adaptation aspects and the data collection work of the project, it probably would have been possible to introduce more than fifty tractors within a radius of 25 kilometers during a single year with the seven field staff of the project.

Use of high-yielding varieties should be an established practice before tractors are introduced because high-yielding varieties offer a potential that improved management and tractor power may use to advantage. The initial use of high-yield technology also proved to be a reliable substitute for the farmers' having established the commercial linkages necessary for the purchase of fuel, oil, and other supplies. This is not a serious constraint to small tractor introduction, however, as more than 90 percent of Indian wheat acreage is now in high-yielding varieties.

The benefits of small tractor use in some other areas of the world may exceed the benefits observed in India. There are areas in Central and South America where weeds are a serious problem and where land is not cultivated for lack of enough animals or large tractors. Many of these plots are limited by the terrain and are quite likely to be best suited to small tractor operations.

Based upon the Tractor Evaluation Project, it appears that a team of two demonstrators or servicemen might assist a dealer in placing 20 tractors on farms in one season. If each of these farmers were designated as a so-called model farmer and thereby provided some help to interested neighbors, it might be possible to expect each tractor to stimulate the sale of one or two additional tractors the next work season. If sales grew at the rate of three per year for each tractor in the population,

a commercially viable enterprise could be established rather quickly.

Micro- and macro-economics remain largely unexplored. The microanalysis appears to be favorable based upon the potential for sizable production increase. Further, a quick comparison of simple, small tractor prices with the costs of draft animals and irrigation pumps reveals essentially equal prices. The macroimpact is perhaps even more interesting. A rapid increase in agricultural production is sought by all developing countries. The prospect of achieving this with local industrial enterprise is very attractive. The prospects of the agricultural segment's being a net employer and of an expanded consumer market are additional benefits.

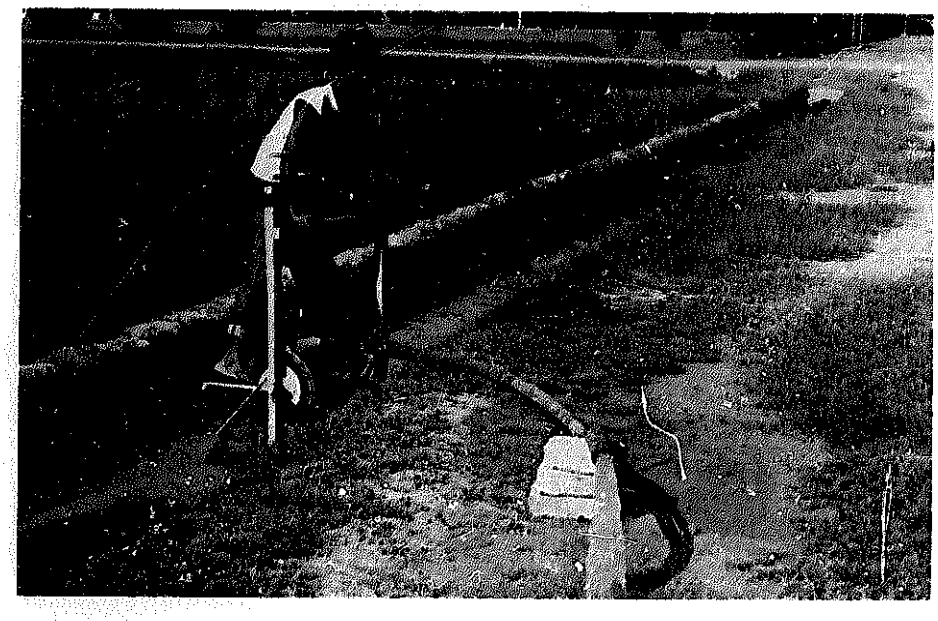
There are a number of U.S. small tractors that have the functional requirements indicated by the Tractor Evaluation Project. A further study of these tractors to determine their economic parameters is needed to provide the firm basis for the investment decisions that are necessary to set up a tractor industry.

In conclusion, I would like to refer back to the slides that were shown and the remarks I made regarding the project to train tractor drivers at Allahabad Agricultural Institute. I wish we had a tape recording of the little ceremony we had to recognize the cooperation of these farmers at the end of the project. They said many nice things about me but, more importantly, it would have been good to have a record of their impressions of how useful this equipment had become. Perhaps I can illustrate by telling the story of the farmer who came to me very early in the project and asked if he could get a tractor. I indicated that all the tractors had been assigned. Perhaps he thought I was trying to hold him up for some money under the table because he reached into his dhoti (trousers) and pulled out a huge wad of money. That really was a surprise. Why would a poor farmer from a remote village come to Allahabad to get a tractor and carry probably all of his life's savings along with him?

So I said, "Look, I don't have a tractor, but if you could tell me why you came, you'd really help me out." He said, "I have three sons. I gave the oldest son an education, which is what I was supposed to do, and he actually got through the secondary school and is working with the state government now — but you know, that fellow doesn't provide any money for me or my wife; in fact, every time we have a harvest he comes and demands his share of the harvest. The second son has heard this oldest son tell stories about the movie houses in the city, and so forth. I couldn't afford to give him a very good education, but I did get him through the fourth or fifth grade, and now he's off somewhere and pulling a rickshaw and sleeping under the railway bridge. Now, if I don't do something to get a tractor on my farm, I'm afraid I'm going to lose a third son, and I know I can't farm in my old age."

That is what really made me see the importance of small tractors in Indian agriculture.

Some of the developing nations are manufacturing their own small-scale implements that are specifically designed for the crops and farming techniques common to the locality. One of the more useful devices is the power tiller, above, being used for puddling at the International Rice Research Institute at Los Baños in the Philippines. Below, a foot-powered pump is efficient for irrigation of paddy fields.



Custom Tractor Operations in the Far East

WILLIAM J. CHANCELLOR

Professor of Agricultural Engineering
University of California
Davis, California

A pattern of small farms dominates the agriculture of most areas in South and Southeast Asia. The use of efficiently applied tractor power on small farms, however, permits farm labor to be devoted to tasks of more intensive production, and offers the advantage of more timely tillage and crop establishment than would have been possible with traditional power sources. The tractor contractor system makes it possible for farmers with small holdings to use large or expensive agricultural equipment units of high efficiency to serve their needs. Thus, the tractor contractor system appears to be well suited to the existing pattern of agriculture in South and Southeast Asia.

Information on the features of tractor contractor systems was gathered in Thailand, Malaysia, Sri Lanka, the Philippines, and India during several studies from 1968 to 1976 (3, 5, 14). Detailed data on these systems in both Thailand and West Malaysia were obtained through a survey conducted between August 1968 and May 1969 (3). The survey was financed by a grant from the Agricultural Development Council, Inc., and was cosponsored by the Agricultural Engineering Division of the Rice Department in Thailand, and by the Faculty of Agriculture, University of Malaya, in Malaysia. The survey involved 432 interviews, primarily with tractor sales agents, tractor contractors, and farmers who hire tractor service.

Features of the Tractor Contractor System

Government-operated tractor stations first introduced the ideas of tractor tillage and of the contract system of operation to meet the needs of farmers with small holdings. Charge rates were at a level of potential economic feasibility for private contractors, and farmer demand exceeded government station capacity, which influenced private tractor contractors to go into business and lessened the need for tractor station activities.

Tractor power was an integral part of the new agricultural production technologies being adopted. This power permitted the rapid tillage required for double-cropping of rice, and provided the large tillage forces necessary in upland soils for the production of crops such as maize and cotton.

The use of efficient tractor power on small farms saved many hours of heavy tillage labor and improved the timing of the tillage process, causing farmers to undertake new income-producing activities in order to meet the costs of hired tractor tillage. With the saving in manpower, farmers took advantage of other under-utilized agricultural resources (land, water, and well-developed agricultural skills) to generate additional income by increasing the scope and intensity of their production enterprises.

For those interested in tractor ownership (usually farmers with above-average holdings), the potential of cash income from tractor services was the main factor that made the idea of tractor purchase economically feasible. As a result of the use of rural savings for tractor purchase and of the cash-earning potential of new tractor-aided agricultural production technologies, tractor marketing firms with access to overseas fund sources became interested in drawing on these sources to provide credit for tractor sales to farmers.

Short-term credit contracts for tractor sales influenced tractor buyers to seek a maximum amount of contract work in order to meet repayment schedules. This provided an incentive for them to achieve efficient operation by: (a) operating the tractor many hours each day, using several drivers per tractor[1]; (b) traveling from one location to another to extend the working season of the tractor; (c) actively soliciting jobs from farmers or paying commission agents to do this; (d) maintaining low rates for work done, to encourage more farmers to use their services; and (e) repairing the

[1] The practice of associating several drivers, a mechanic, and perhaps a business agent with one large tractor, results in an operating system for which the capital-to-labor ratio is much smaller than it would be for systems in North America where one or two tractors of the same size might be owned and operated by one farmer. This pattern of using modern, efficient technology with low capital-to-labor ratios in settings with low labor wages and scarce capital resources, accomplishes the same objectives as those toward which "intermediate technology" developments are aimed (7). However, with the custom tractor the technology itself is already developed, and it is only the business structure that is modified to make the total system more "appropriate" for the economic surroundings.

tractor and equipment as quickly as possible after mechanical breakdown, to minimize loss of working time.

The opportunities for farmers to use tractor tillage spread rapidly throughout most agricultural areas because of competition among tractor owners in offering services at low cost. Continuing efforts by agricultural extension personnel were thus not required in this activity.

Extensive use of tractors provided the basis for the expansion of allied industries and businesses such as: (a) manufacture of tractor implements; (b) manufacture of tractor accessories and repair parts; (c) tractor repair workshops; and (d) tractor sales businesses.

The new tractor-aided agricultural production technologies and allied industries and businesses fostered a demand for technically trained participants, and farmers who gained some free time through the use of tractor contract services were thus able to obtain such training.

The Custom Tractor System

Internationally based tractor manufacturing and sales firms offered tractors for sale on 18- to 24-month credit contracts requiring 33 percent down payment. After having hired tractor service for several years, some farmers with larger holdings used their savings, or those of their family, to meet the down payment for tractor purchase. Purchase was made just prior to the tillage season. The tractor was delivered with an introductory operating demonstration, the promise of one or more free service visits, and a 6- to 12-month guarantee.

The tractor, driven by the owner and his relatives, was used to till the owner's fields and then was taken out to till the fields of others in the community who had checked the quality of work done and then engaged the tractor owner's service.

When the tractor arrived at the customer's farm, soft spots in the field were pointed out to the driver and the tractor began to work, with the hiring farmer staying to observe. When the work was completed, the tractor owner and farmer determined field size from records or by measurement, and payment was made in cash within a few days of completion of the work.

When the tillage season ended in the owner's community, he moved the tractor and driving crew to an area where tillage was still in progress, sometimes as much as 100 km away. There the owner sometimes contacted farmers to solicit work, or he sometimes used the services of a commission agent to locate contracting farmers, for which he paid an amount equal to about 5 percent of the contract charge. Cash payments for tillage services permitted tractor owners to meet fuel, repair, and driver wage costs while away from home. Minor repairs were done by the owner himself but a repair workshop was frequently used for major repairs.

When the demand for major tillage work ended the tractor was put in storage. It was not used until the next tillage season except for brief periods to thresh rice by treading or to shell maize, when these activities were required in the owner's community.

Both larger (45 to 70 hp) four-wheel tractors and two-wheel (8 to 11 hp) power tillers participated in tractor hire services in Thailand and Malaysia. Table 1 describes the systems in these countries. The small monetary loss shown for four-wheel tractors in Thailand and two-wheel tractors in Malaysia was probably not immediately perceived by tractor owners as it was due to somewhat more rapid depreciation of the tractor than was expected. The smallness of these losses reflects a common characteristic — that is, farmer-owned tractors tend to be managed for financial feasibility rather than for profit-making. The substantial profit shown for four-wheel tractors in Malaysia was linked to the fact that a sizable number of these were operated as profit-generating investments by their owners.

Labor Displacement and Utilization

Farmers in both countries were able, within one or two years, to readjust their farming operations to make use of the labor released by hiring of tractor service for tillage. The very diverse kinds of adjustments made are described in Table 2.

The high proportion of labor going into more intensive agricultural activities in Malaysia was strongly influenced by the development of irrigation for expanding the area suitable for double-cropping rice. Also, replanting programs aimed at increasing the productivity of rubber stands contributed to labor absorption opportunities. In Thailand research and extension programs aimed at expanding maize, cotton, and bean acreage contributed to productive agricultural labor absorption opportunities. These examples show how organized programs can influence the redirection of released labor with agricultural skills when tractor tillage becomes available. On the other hand, it may have been the presence of these agricultural opportunities that permitted tractor use to become economically accepted and established in the first place.

In addition to the centralized programs for agricultural development, recognition must be given to the high level of enterprise and skill displayed by farmers in making use of under-utilized resources in their immediate localities and in combining these resources with their

TABLE 1. Economic Parameters of Custom Tractor Operations.

Item	Thailand (av val)[a]	Malaysia (av val)	
Holdings of farmers hiring tractors, ha	9.3	2.3	
Experience with tractor service, yr	4.8	4.6	
Proportion never discontinuing service, %	87	90	
Proportion changing contractors hired, %	83	74	
Proportion reporting contractor arrived as scheduled, %	56	79	
Most common tillage operation hired	disk	rotary	
Proportion of fields tilled in a dry condition, %	75	21	
Proportion of farmers finding work quality satisfactory, %	63	84	
Value of tractor service to farmers per unit cost, %	167	151	
Proportion of farmers paying cash for tractor service, %	63.9	61.2	
Proportion of farmers able to meet tractor charges from new income sources, %	82	81	
Proportion of tractor contractors who are farmers, %	90	81	
Holdings of tractor contractors, ha	20.6	4.6	
Average tractor age, yr	3.7	3.8	
Months of tractor work per year	5.07	3.84	
	4-wheel	*4-wheel*	*2-wheel*
Number of tractors per owner	1.71	2.03	1.39
Drivers per tractor	2.6	1.6	2.0
Tractor working hours per day	17.2	9.8	9.0
Field area served per year (single operation), ha	258	152	27
Annual operating hours per tractor	1,360	1,042	395
Maximum radius of operation, km	100	88	12
Proportion of operating time spent traveling, %	24	17	10
Proportion of working season used for tractor or implement repairs, %	26	15	16
Annual repair costs per tractor, $	638	332	74
Contract charge per rated horsepower hour, $	0.038	0.069	0.155
Tractor work required per hectare per crop, rated hp hr	271	279	131
Annual profit per tractor, $	−561	1,370	−50

[a] Values pertaining to tractors in Thailand refer only to four-wheel tractors of 45 to 70 hp.

TABLE 2. Disposition of Working Time Made Available by Hiring Tractor Tillage.

Item	Percentage of Mentioned Activities	
	Thailand	Malaysia
Labor allowed to become idle	2	3
Labor displaced from rural to urban work	8	9
Labor going into agricultural work that would ultimately lead to its displacement from agriculture[a]	25	13
Labor going into agricultural intensification that would not lead to labor displacement from agriculture.		
This block of labor use was constituted in part by:	65	75
(additional field crops on same or newly cleared land)	(29)	(23)
(fruit or vegetables on same or newly cleared land)	(11)	(18)
(increased livestock enterprises)	(15)	(4)
(tapping rubber)	(1)	(11)
(more intensive field and crop maintenance)	(3)	(13)

[a] Labor utilization changes involving (a) rental or purchase of established farm land for farm size expansion, (b) the hiring out of the farmer or his family for agricultural work, or (c) the dismissal of presently hired workers, would tend to add to the available agricultural labor supply without increasing agricultural labor demand. Thus, it is expected that this would ultimately have the effect of displacing a similar quantity of agricultural labor to nonagricultural jobs.

newly found working time to increase agricultural productivity.[2]

The overall system response to the import of one tractor-year is illustrated in Figure 1, for conditions found in Thailand. This response had the following results:

1. An expenditure of $1,257 in foreign exchange for the tractor, fuel, and so on, and an intake of $1,570 in foreign exchange sales of additional agricultural products.

2. An increase in net national business income of $2,621: $1,441 from tractor sales, operation, and so on, and $1,180 from services connected with the added farm production engendered.

3. A net loss by agriculture[3] of $738 and a net loss of employment for persons in agriculture of 1,140 man-days. This last point in isolation would be an unsatisfactory result for the agricultural sector. The only way to improve this situation is for the agricultural sector to sell the 1,140 man-days of unused labor. If this labor were sold at the off-peak agricultural wage of $0.58 per man-day the monetary loss would almost be recovered. However, the increased business associated with tractor supply and operation was one of the possible sales areas for the labor available from the agricultural sector. Specific labor-engaging opportunities connected with the supply of one tractor-year amounted to 527 of the 1,140 available man-days. The activity of tractor driving alone (usually done by rural labor) accounted for 343 man-days at approximately $1.00 per man-day (considerably above the basic agricultural wage). The 527 man-days did not include the employment possibilities connected with the merchandising of spare parts and fuel or with interest generation and tax utilization. In addition, the operations connected with the new farm product value increase in market channels presented additional opportunities for the sale of some of the 1,140 man-days available from the agricultural sector.

[2] A study of 53 small farms served by custom tractor operators in Pakistan indicated that while the change to tractor tillage was associated with an increase in net income from 85 to 245 rupees per acre and an increase in cropping intensity from 81 to 126 percent, 18 tenants and one permanent laborer were released. At the same time, however, hired labor increased by 18 full-time-equivalent workers (13).

[3] This loss actually might have been partially offset by reduced expenses for draft animals and animal- and hand-powered implements, which were not considered here.

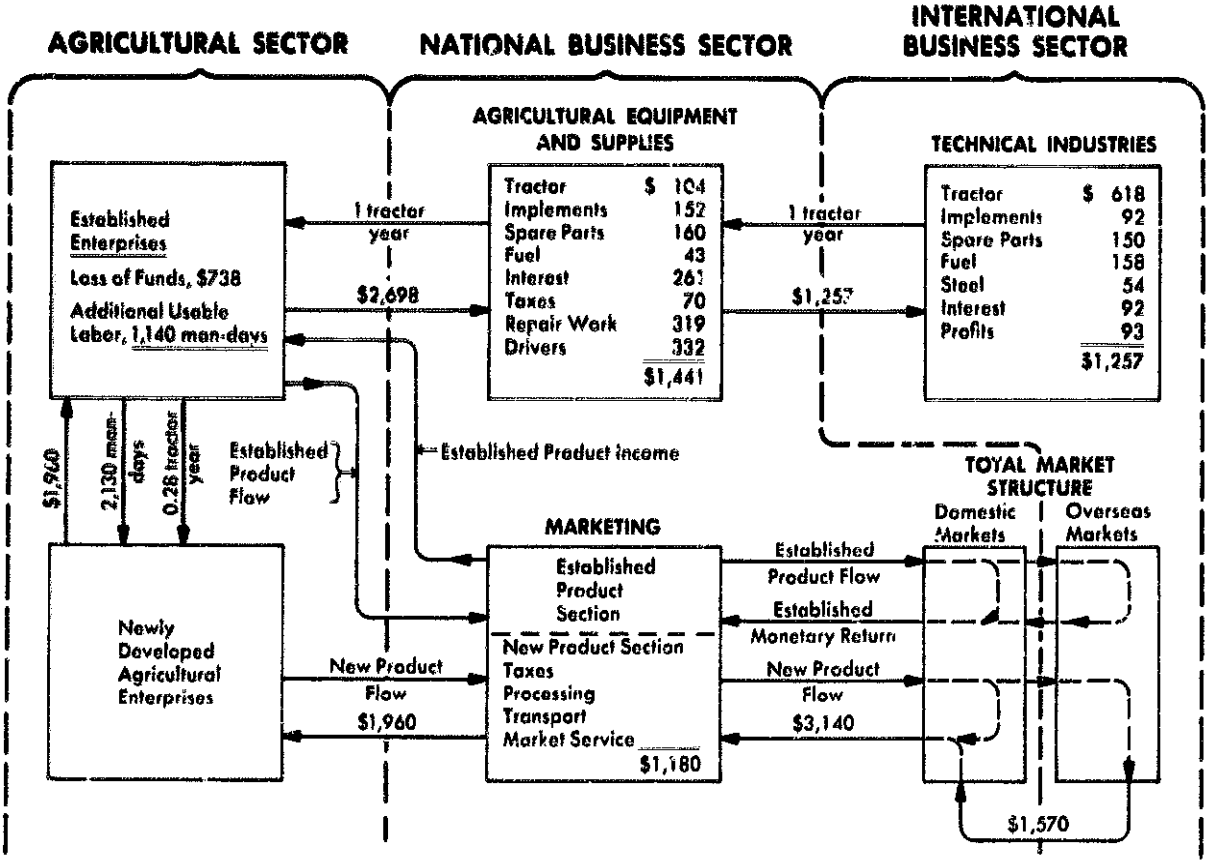


FIGURE 1. Estimated Economic and Labor Transfers Due to the Use of One Tractor-Year in Thai Agriculture.

Benefits from Tractor Use

For the conditions surveyed in Thailand and Malaysia in 1968–1969, and in specific locations in Thailand, the Philippines, and Sri Lanka during 1976 (3), potentials for benefits from tractor use were linked to possibilities for increasing total agricultural production. Examples are: (a) increase of land under cultivation by clearing of brush or jungle; (b) irrigation developments permitting double-cropping of areas previously single-cropped; (c) changes from traditional varieties to high-yielding varieties; (d) changes from low-value crops to high-value crops such as vegetables.

Use of tractors under such circumstances: (a) released labor from traditional tasks so that it could be used on the additional land for new crops, or for the more intensive management of high-yielding or high-value crops; (b) permitted rapid tillage required for double-cropping; and (c) allowed tillage of rough upland areas not manageable with traditional animal-powered implements.

Even though potential for such benefits may prevail, the feasibility of using custom tractor operations to obtain these benefits depends not only on having all of the economic structural elements in place to carry out the transfers and exchanges illustrated in Figure 1, but also on balanced distribution of the benefits from increased production to every participant in this elaborate economic structure (4).

In the instances cited, these requirements call for: (a) foreign exchange earnings, as well as remittance; (b) road networks for tractor movement and product transportation; (c) markets at stable and reasonable prices for the new production generated; (d) availability of fuel, spare parts, and repair services throughout the area served; (e) stable and reliable channels for communications and monetary transfers; (f) a "business sense" on the part of all participants and the avoidance of unreasonable profits, taxes, or diseconomies by all; (g) social norms that permit itinerant service operators to be accepted with a reasonable amount of trust, and actions by all parties to maintain such trust.

Private Versus Custom Operation

Private ownership and use of tractors as practiced in the Asian countries has been studied mainly under two conditions. The first is when the land farmed by the owner requires sufficient tractor use to economically justify the full capacity of the tractor. Under such circumstances it is frequently possible that farm income is sufficient to repay loans incurred in tractor purchase. An example of the relationship between farm size and optimum tractor size[4] in a developing country and where timeliness costs are only moderately important, is as follows (2):

Farm size (tilled ha)	4	8	16	32	64
Optimum tractor size (hp)[5]	5.76	9.11	15.24	27.0	50.2
Annual tractor cost per ha ($)[5]	38.46	29.32	23.27	19.51	17.34
Annual use (hr)	191	241	289	326	351

From these figures it appears that:

1. Typical power levels for conventional four-wheel tractors (20 hp and above) are not optimum for many small farms under the regime of private ownership and use.[6]

2. Even when the optimum tractor size is employed on small farms, the costs per unit work done are greater than those for optimum-sized tractors on larger farms.

3. The cost factors used in the above calculations were those prevailing when average custom rates for the same amount of work per hectare amounted to only $14.60 per ha (3). Thus private ownership and use — even when tractor size is ideally suited to farm size — tends to be a more costly way of obtaining tractor services than is custom service. Consequently, custom operation of tractors can be financially feasible under conditions of sufficient economic stringency where private ownership use, particularly on small farms, is unworkable. Custom rates per unit of work done can be lower than costs of ownership for private use because, in custom work, the total annual hours of work (over which annual fixed costs are spread) are generally much greater than those with private use. The mean of average values for four-wheel tractors doing custom work in Thailand and Malaysia was 1,200 hours annually.[7] This may be compared with the much lower values appearing in the foregoing table of optimum values for private use, as developed with cost and technical data which were also means of averages for these two countries.

---

[4] $H' = \sqrt{LW(C + LD)/AK}$ in which H' = optimum horsepower rating of tractor; L = land area worked each year by the tractor; W = rated horsepower hours of tractor work required each year by a given unit of land area; C = tractor operation costs proportional to time (mainly drivers' wages); D = timeliness coefficient, cost per unit land area per hour of delay in completing the tractor operation; A = ratio of annual fixed charges to initial tractor cost; K = initial cost of tractors per rated horsepower.

[5] Costs shown are exclusive of crop timeliness loss costs (D = $0.025 per ha hr) and are computed with energy costs at $0.02 per hp hr; fixed costs AK at $13 per ha yr; labor costs C at $0.30 per hr; and work required per ha W at 272 hp hr.

[6] In some cases in India where high-yielding varieties were grown on irrigated land, a 30 hp tractor could be financially feasible (though not necessarily optimum) on a 12 ha farm.

[7] This is similar to a figure of 1,396 hr per yr custom tractor operations in Nueva Ecija Province in the Philippines (11).

The second common condition of private tractor ownership and use is that in which cash savings are used for tractor purchase. Because four-wheel tractor sizes available in the market have in the past had some minimum (frequently 35 hp), rich farmers with small acreages tended to obtain uneconomically large tractors. Farm income often was not enough even to pay for operation and repair costs of the tractor and it quickly fell into disrepair. Smaller tractor sizes are now becoming available, although their price per horsepower for internationally traded brands tends to be somewhat higher than for larger tractors.

Private ownership and use ensures the availability of tractor power at the time when the farmer requires tractor services. Thus, most farmers strive to own their tractors despite higher costs. Because low cost is so very important to small acreage farmers who seek ownership of tractors, they will accept tractors of very simple design, provided that performance is not impaired by such design. This tendency toward ownership for private use is strengthened by any reduction in availability, reliability, quality, or inexpensiveness of custom tractor services, and by increases in the economic productivity of a given farm operation.

Farmers with small holdings frequently offer custom services as a way to achieve financial feasibility of tractor ownership. Generally the pattern of operation is to offer custom services until the tractor cost has been recovered, and after that to operate the tractor for private use only.

Where new tractor supply is much less than demand and where there are long waiting lists of prospective purchasers, or where prices of used machines are far greater than those for new machines, farmers who do obtain tractors hesitate to do extensive custom work because this would more rapidly wear out the tractor, causing the problem of acquiring a tractor to occur more often. This same rationale on the part of tractor owners prevails when spare parts or repair services, or both, are difficult or expensive to obtain. These two factors — shortage of new tractors or nonavailability of spare parts and repairs — thus tend to discourage tractor owners from offering custom services and, therefore, lead to under-utilization and consequent poor economic performance of tractors in the hands of low acreage farmers.

Additional factors that tend to discourage custom tractor service in some areas are a lack of cash by farm households during the tillage season or a tendency of households to avoid expenditures so as to minimize cash outlays (1).

Tractor Ownership by Private Groups

Because tractors represent large capital items in most Asian agricultural economies, some means for grouping the resources of several persons is usually necessary for tractor purchases. Very frequently this grouping takes place along family lines. In many cases, the grouping is only for concentrating funds, but sometimes a more extensive structure is involved among the participants. During the survey in Malaysia, several private groups of three to five persons were encountered which had been formed for tractor purchase and mutual use. Two main forms were noted. In one, all members were of about the same age and landholding status, and driving, repair work, and operating costs were equally shared. In the other form, one person was uniquely qualified to be in charge of the tractor operation, and charges for his services were uniformly shared among the group. In both group forms, members were closely linked by family, friendship, or locality. These sorts of ownership arrangements are also discussed by Lönnemark (10) as they pertain to a European setting.

Cooperative Ownership and Operation

During the 1968–1969 survey in Thailand and Malaysia, numerous observations were made on attempts at offering custom tractor services through farmers' associations which functioned as government-sanctioned or -sponsored cooperatives. The farmers' associations in Thailand were operated strictly by the farmers themselves, with the guidance and assistance of the agricultural extension officer in the area. These groups were eligible for loans of $1,214 which usually just covered the down payment on the tractor. Some associations sold shares among their members to get funds for tractor service. Even when the loan was secured, the selling of shares was frequently necessary to obtain operating capital. Because of the sizable amount of attention required for tractor operations, management duties were usually divided among several members. The tractor then was operated in contractor service to members of the group, and frequently to nonmembers.

Most of the farmers' associations encountered in Thailand had only been operating tractors for one or two years, and nearly every one was having problems of one kind or another. The main problems were:

1. Neither drivers nor the member in charge of maintenance had much technical experience, so repair cost and time wasted during tractor breakdown were unusually great.

2. The member in charge of finance had to be contacted when any expenditure — large or small — had to be made. The coordination among several people required for each decision on tractor operations generally made these decisions cumbersome and delayed.

3. Frequently members were served on a first-come,

first-served basis, which necessitated extensive travel by the tractor.

4. Because fertilizer credit accounts were frequently used in the associations, many members chose to add the tractor service fee to their credit account. Tractor operations then became cash deficient.

5. Nonmembers (neighbors of members) often requested tractor service, thus delaying the tractor in its progress to the next member's field. The tractor supervisor at times found it necessary to serve nonmembers first in order to get sufficient cash to continue tractor operations.

6. Members' fields were all grouped in a given area, and all required service at approximately the same time. The limited tillage season available for service to members frequently left a number of members' fields unserviced, and the tractor income from servicing members' fields was insufficient to meet credit repayments.

7. The tractor was then usually sent to other districts to continue work to earn additional income, which meant that many members hired outside contractors, while their jointly owned tractor was busy servicing fields of nonmembers and distant farmers. This pattern was quite different from that envisioned at the time of tractor purchase.

Farmers' associations that had accumulated experience in tractor operation had successfully used the following methods to resolve some of the above-mentioned problems:

1. Requests for tractor service were sought ahead of time, and then arranged in blocks so that tractor travel was minimized.

2. Training was arranged for the head driver. He then supervised the technical aspects of other drivers' work and took care of tractor maintenance. This resulted in significantly lower repair costs and breakdown times.

3. One person was placed in charge of all scheduling, supervising, and financing of tractor operations and was paid a commission for this work. This avoided unauthorized collections by drivers and other members.

4. Credit accounts were not permitted. In exchange, slight reductions in the charge rate were sometimes made for members, which tended to keep members loyal to their own tractor.

A few farmers' associations in Thailand were found that had surmounted their problems, but only through energetic, well-thought-out management practices. Despite all the problems that a farmers' association could expect when starting a tractor contracting project, there appeared one important reason for going ahead with such a project under certain conditions. These conditions occurred in areas where tractor service had not been offered before, such as some of the wetland rice areas in Thailand. Tractor contractors had usually by-passed such areas because of problems with getting the tractor stuck and of securing cash payments from rice farmers with low incomes. The use of farmers' associations to allow these farmers to obtain their own tractor service permitted pioneering of tractor work in these areas. Such pioneers in other areas have been followed by itinerant tractor owners who undercut the charge rate of the association's tractor and doomed the association's project to economic failure. However, at the same time, this brought low-cost tractor service to a large number of farmers in the area — something that might not have happened had it not been for the seemingly unsuccessful pioneering tractor project by the farmers' association.

In Malaysia, the promotion of farmers' associations has received very strong support from government agencies, to the extent of providing trained extension personnel to serve as day-to-day staff of the association in some of the areas. Again, different patterns of management and operation were employed, and similar problems occurred. In some instances, strict accounting procedures resulted in the early repossession of the tractors, which proved disappointing to all those concerned. In other areas, however, very intensive tractor management and organization efforts were made, and tractor service proved to be a successful and important feature of the association's program. One successful operation encouraged other nearby associations to follow a similar pattern. Some features of this pattern are described below.

1. The membership was divided into "small agricultural units," each consisting of 50 or more families in one area.

2. Prior to the tillage season, the families in each unit prepared a request form for the entire unit, listing individually all fields that were to be served and the time when service would be required.

3. The board of directors of the association, with representatives from each unit, then decided on the order in which units would be served. Usually units making early requests for early service would be served first, but an order of service was established and announced publicly so that units to be served last could hire outside contractors if necessary.

4. A supervisor was appointed for each tractor or group of tractors working together. The supervisor was in charge of all decisions about the tractor(s) under his jurisdiction and was responsible for carrying out the work specified on the work request forms which had been approved and scheduled by the board of directors. Only the supervisor was authorized to collect money for the work done by the tractor.

5. The approved work request forms were duplicated

in their completed form, and one copy each was sent to the association office, the tractor supervisor, the tractor operators, and the chief of each "small agricultural unit." This same form had blanks where the agricultural unit chief, the tractor operator, and the tractor supervisor would all sign when the work was completed.

6. After fuel costs, drivers' wages, and minor repair costs were deducted from the gross tractor income, 5 percent was deducted from this balance and paid to the tractor supervisor as his wage for services.

7. Credit accounts were permitted for tractor service and were handled in conjunction with fertilizer credit accounts.

8. The drivers were sons of members, and received one week's training from the commercial firms from which the tractors were purchased. Two drivers were used per tractor, and were paid on an hourly basis.

9. The tractors were purchased with special low-interest, government-sponsored loans available to the association for a limited time and in limited amount.

10. The number of tractors was insufficient for the needs of the farmers in the association. Therefore, the association had taken on the agency for selling two-wheel tractors to both members and nonmembers in the area.

The success of this particular association in providing tractor services depended on many factors, a major one being an intensive effort at thorough management, utilizing the knowledge of persons trained in such management to assist others in this work. A very large amount of time was spent by members and officers in executing these management procedures, but apparently this nonmonetary investment was worthwhile.

During more recent observations in 1976, it appeared that private ownership of tractors — for both custom service operation and private use — had become so common that tractor operation by farmers' associations had ceased to grow.

Government Stations for Custom Operation

As found in the 1968–1969 survey in Thailand and Malaysia, government-sponsored tractor stations were instrumental in introducing the ideas of tractor use and contract operation. Farmers tended to feel that, since the tractors were owned by the government, tractor service should be provided to them either free or at a partially subsidized cost. When tractor services were charged at a rate high enough to allow private contractors to make money, these contractors tended to enter the area. When lower rates were charged, there was less activity on the part of private contractors until the demand greatly exceeded the tractor station capacity.

The usual procedure was for a group of farmers with adjacent lands to join together to petition the station for service. After the petition was received, station personnel surveyed the work site and arranged for the date of tractor service and the kind of equipment to be dispatched. In Malaysia, payment for tractor services frequently was made directly to administrative government offices and forwarded to the central treasury. The only return to the station was through its annual appropriation for operating budget. Thus, drivers and other station personnel were not responsible for collecting money. However, this sort of budget management encouraged station managers to operate only the portion of their tractor stock that was in the best mechanical condition. Basically, management was aimed at providing the most service from a fixed operation budget regardless of the value of the tractor inventory (supplied from a separate budget). Profit earning by tractor stations was not among the primary objectives considered in establishing these stations.

Besides encouraging the start of tractor contract operations, these tractor stations sometimes served as both an initiator and a check on commercial tractor service charge levels, especially in the early stages of contractor activity. Generally, tractor service from government stations was distributed evenly to farmers with all sizes of holdings.[6] Sometimes, however, service was restricted to those participating in certain extension programs aimed at establishing new production areas or introducing new crop types.

During the 1968–1969 survey in Thailand and Malaysia, three large private or semiprivate firms were found which bought or processed maize, tobacco, and sugar cane, respectively. These firms offered custom tractor service to farmers who later would sell them their crops for processing and marketing. In the case of tobacco and sugar cane, these firms were the sole buyers for the crop in a given area and thus were able also to extend credit for tractor service costs. Repayment was accomplished through deductions from crop sales payments.

In all three instances, however, these firms found that their costs for operating tractor custom services, per unit of work done, tended to be higher than the going charge by independent tractor custom service operators — once such operators became established. Thus, after some time these firms discontinued these services in favor of the independent operators. In one instance, certain independent operators were put under contract to furnish these services in the name of the firm so that the credit aspects mentioned above could be continued.

[6] It was found in one instance in India that a public sign-up register, indicating the sequence in which farmers would be served helped farmers anticipate the timeliness of services that would be provided, and helped avoid problems with influential persons requesting service out of sequence.

Logistics Problems of Large Operators

Farmers' associations, government tractor stations, and large processing and marketing firms all suffered major economic and management problems in offering custom tractor services. The extent of these problems was such that they could not compete with small-scale, independent operators. The reason for this state of affairs was determined when an economic model of the system was made which included factors related to travel distances and costs, as well as the probability of a given tractor's being able to service a given proportion of fields at any distance from home, and so on (3). Manipulation of this model, which contained actual parameters found in the 1968–1969 survey, showed that the major problem was that of communication between customer and tractor owner. A 60 to 70 hp tractor could service the land of more farmers than the tractor owner was likely to know personally. Thus, he had to seek work in areas where he was not well acquainted, and under such circumstances he could not find many jobs in any one spot. This meant that travel time and cost per unit work done increased as he got further from home. These problems became magnified as the number of tractors at any one central location increased, not only because these tractors operated at a greater average distance from home compared with the single tractors, but also because tractors from large, centralized operators, when operating some distance from their base, had to compete for work with tractors from the locality itself, for which communications could be made on a personal acquaintance basis.

Large, centralized operations also faced more complex administrative problems usually involving many more formalities. Single-tractor operators were usually family-managed and employed family members, so problems of trust, responsibility, and reliability arose less frequently than in a more impersonal organization. Twenty-four-hour-per-day operation also was more administratively complex under formal administration than under family management. Family-managed tractors usually had the decision-maker in the operating crew or in daily contact with the crew. This, in combination with more close-to-home operation, provided a distinct advantage over the more extended and structured management networks associated with larger groups of tractors. On-the-spot bargaining, charge rate adjustment to suit various field conditions, and avoidance of contracts to till extremely rough fields, could be done more realistically when the decision-maker was in the field. In all the above respects, the operator with one or two tractors found himself in a better management position than a formally organized agency with numerous tractors operating from a centralized location was able to provide.

Tractor Sizes for Custom Operators

Tractor sales agents serving Thailand and Malaysia initially offered mainly tractors in the 25 to 35 hp range, since these represented the smallest units manufactured by the companies represented, and small tractors were thought to be most suitable for small farms with small fields. However, as custom service became the main method of tractor operation, buyer demand rapidly shifted to the 45 to 70 hp models — almost to the exclusion of the smaller tractors. The reason for this shift was that operators quickly discovered that driving labor costs, management efforts, and repair charges were little different for a small tractor than for a large one, but that the rate of income was directly proportional to tractor size. Thus, under the stringent economic conditions in which tractor use became established, only the more economically viable operations using the larger tractors were able to survive. In addition, the larger tractors were better able to handle disk-plowing operations under the rugged conditions on recently cleared land or for rubber planting.

It was found that even 70 hp tractors, when equipped with appropriate implements, could serve field sizes as small as 0.16 ha without undue reduction in operating efficiency. This meant that farmers with small holdings or small field sizes, or both, were not excluded from service by the choice of 45 to 70 hp tractors.

In areas having irrigation developments to permit double-cropping of rice, soils have gradually become softer. Under these conditions the larger tractors have increasingly encountered traction problems. Two-wheel tractors in the 7 to 12 hp range, when equipped with special wheels, have been able to operate on soils impassable to the larger tractors. Thus, there has been a market for these very small tractors as well, even though they were not as economical to operate as were the large tractors. Even in these small sizes, the capacity of such tractors generally exceeded the work requirements on holdings of the purchasing farmer, and their costs (including loan repayment) exceeded his rate of income generation from farming operations. Purchasing farmers, therefore, found it necessary to operate even these small tractors in custom service until the loan was repaid. This helped make tractor service available to the farmer's neighbors, and basically improved the economy of tractor use for all concerned by spreading fixed costs over a greater number of acres served. However, because of the general characteristics of two-wheel tractors, they did not travel to areas very far from home. Consequently, their annual usage was approximately 400 hours — a factor contributing to their higher operating cost per unit work done.

As time has passed, various developments in Thailand and Malaysia have affected tractor sizes sought by farm-

ers. In both countries there has been a great deal of management experience and knowledge gained on tractor use and on crop productivity increase. In Malaysia, where rice prices have remained very strong, farmers in double-cropping areas have found themselves in a sufficiently good economic position to afford small four-wheel tractors in the 15 to 25 hp range. These tractors are more convenient because the operator can ride. Management skills have helped minimize the high costs that might otherwise be associated with such tractors. Nevertheless, these tractors are frequently operated in custom service on a localized basis — more or less replacing the two-wheeled tractors in this pattern. Tractors of this size, when equipped with a wetland rotary tiller, special tires, and special wetland wheel extensions, can cope with most soft rice fields.

In Thailand a different pattern has emerged with many local manufacturers producing very low-cost two-wheel tractors and some four-wheel models of up to 25 hp. This, in combination with the rise in price of imported tractors, has caused a partial shift to private ownership and use of these small machines, with custom service being limited to local areas only.

Providing Repair and Maintenance

In both Thailand and Malaysia, the key to providing custom tractor operators, with local facilities for repairs and for supplying spare parts, has been the nature of the credit sales contract. In most cases the credit was provided by the tractor distributor. This meant that the distributor's financial status depended on the productivity of the tractors in the field, and it was the distributors who were in a position to obtain spare parts supplies and train mechanics — which they proceeded to do very effectively. Furthermore, sales arrangements called for local sales agents to receive much of their income from the monthly payments made by tractor owners. Thus, when a tractor needed repair, the sales agent and distributor felt the impact financially along with the tractor owner. This impact was particularly severe when the breakdown occurred during a critical work season and especially when the tractor was working on a 24-hour-per-day schedule. Consequently, the nature of the credit sales contract caused each of the three parties to be motivated to perform its respective function, to get the tractor back into operation as rapidly as possible.

Distributor training of mechanics was aimed at upgrading the staffs of allied local sales agents. However, after some time a number of these mechanics started their own repair businesses. Although this placed an additional training burden on the distributors, it also allowed local capital to be mobilized by the mechanics to help increase total repair capacity. This ultimately benefited both distributors and sales agents by helping to keep an increasing number of tractors in productive operation.

Where government loan programs were offered for tractor purchase, two special program features helped ensure provisions for repair and maintenance: (a) loans were approved for only those makes that were locally represented by a sales agent with adequate supplies of spare parts and with an appropriate number of trained mechanics; and (b) purchases were made only from local sales agents and at prices negotiated with them. This allowed each agent sufficient profit to maintain his repair facilities.

The training of tractor drivers could, by reducing the incidence of tractor breakdown, easily save more than the cost of training of each driver during his first year of work. And once the driver was trained, he would be able to make savings year after year, bringing a strong return many times greater than the funds invested in his training. Government agencies realized this and instituted various training programs ranging in duration from 8 hours to 3 months. In all cases, the number of applicants far exceeded the openings available, and the number of graduates was far below the total of new tractor drivers and mechanics entering the field each year.

In early programs in Malaysia, persons selected for training were those hoping to find jobs in these new activities, but positions frequently went to relatives of tractor owners and not to those receiving training. However, as time went by, some of those who received training earlier tended to lead their communities in adopting mechanical tillage.

Procedures for selecting trainees tended to concentrate training on those who were already involved in tractor operation, either through their family connection or through their membership in a farmers' association that owned a tractor. It was found that when the chief driver of a farmers' association received training, he could effectively supervise and train subordinate drivers.

Energy Aspects of Custom Operations

In each instance where the author has encountered custom operations in the Far East, there has been an accompanying change to increased agricultural productivity, and this increased productivity has permitted tractor use to become financially feasible. At the same time, the use of tractors has permitted the pattern of increased productivity to become operationally feasible. It is impossible to determine which came first, which is cause and which is effect, or which one is more essential. In each instance the increase in productivity involved the more intensive use of agricultural land — Asia's most critical agricultural resource — and the expenditure of more fuel or electrical energy (5, 14).

Using economic parameters from the 1968–1969 survey, the cost of energy delivered to farming operations, per rated horsepower hour, was 5.37 cents for custom operated tractors, 10 cents for water buffalo, and 80 cents for a working man. It might be expected that changes found in 1976 would be those that took place in the direction of using tractor energy to displace man and animal energy. Despite this expectation, it was found that changes toward increased productivity actually increased demands for both tractor power and manpower, with animal power remaining mostly unchanged. The use of energy from tractors was applied very judiciously, mainly for tillage. Data from three cases studied in Thailand, Sri Lanka, and the Philippines in 1976 indicate that on-farm tractor use consumed, on the average, an energy equivalent of 37 liters of diesel fuel per hectare, and that this amount represented only 15 percent of the average total fuel and electrical energy use associated with the productivity-increasing technology, with most of the remaining 85 percent of the energy use going to fertilizer production and crop processing (5). The role of custom tractor operations in these cases was to supply energy at high rates of flow at the appropriate time to make the new production-increasing technology feasible from a scheduling standpoint, and to do this in a manner that was economically feasible.

Summary

Custom tractor operation is a management method by which the technology embodied in capital-intensive single tractor units can be made available to low-acreage, capital-short farmers of the Far East in a manner that is economically and technically efficient. This technology has made available to these farmers the resource of field-work energy at costs lower than they had known previously and at rates of flow that far exceed anything they had experienced before. This new resource, with its special cost and flow characteristics, has permitted farmers to reorganize all of the production resources at their command to achieve increased levels of productivity.

Custom tractor operation requires the development of an extended technical-social-economic structure — all parts of which must function efficiently, and all participants in which must share in the benefits gained. Because of the complexity of such a structure and because of the large number of interdependencies involved, there are numerous opportunities for the structure to perform with a reliability level less than that required to meet the time-dependent needs of crop production operations. Experience in the Far East has shown, however, that it is possible, with orderly and cooperative human performance combined with attention to management detail, to develop and maintain an effective and efficient system structure so that custom tractor operation can satisfactorily meet the field-work needs of low-acreage farmers.

However, as these farmers have been able to increase their productivity and have achieved an improved rate of capital accumulation, they have generally chosen to invest this capital in small tractors for private use. Although this usually involves higher costs per unit of field work done, it does give farmers greater independence and increased control over their production resources. The history of countries with a fully developed agriculture has indicated that these increased levels of operational independence and control have been accompanied by further increases in productivity.

Custom tractor operation can thus be recognized as a passing phase in the technological development of agriculture — a phase that permits the introduction of low-cost, high-flow-rate energy as a production resource under economic conditions where ownership of tractors, even small tractors, for private use would be financially infeasible. As such, custom tractor operation has been a means of accelerating agricultural productivity through the use of this energy resource.

REFERENCES

1. M. H. Billings, "Inquiry into Custom Tractor Hire Practices by Tractor Owners in Punjab-Haryana," Memo, USAID AG/EC, New Delhi (Apr. 1971).
2. W. J. Chancellor, "Selecting Optimum-sized Tractors for Developmental Agricultural Mechanization," Transactions, American Society of Agricultural Engineers 11(4):508 (1968).
3. W. J. Chancellor, "A Survey of Tractor Contractor Operations in Thailand and Malaysia," Agricultural Engineering Department, University of California, Davis (May 1970). *Or see* condensed version, "Mechanization of Small Farms in Thailand and Malaysia by Tractor Hire Services," Transactions, American Society of Agricultural Engineers 14(5): 847 (1971).
4. W. J. Chancellor, "Social and Institutional Factors in Mechanization of Agriculture in Thailand and Malaysia by Tractor Hire Services," American Society of Agricultural Engineers SP-01-72, pp. 22–26 (1972).
5. W. J. Chancellor, "The Role of Fuel and Electrical Energy in Increasing Production from Traditionally Based Agriculture," Occasional Publication, East-

West Food Institute, East-West Center, Honolulu, Hawaii (Nov. 1977).

6. M. L. Esmay and L. Faidley, "Ownership Patterns for Tractors and Machinery," *in, Agricultural Mechanization in Developing Countries*, M. L. Esmay and C. W. Hall, eds., Shin-Norinsha Company, Ltd., Tokyo (1973).
7. B. F. Johnston and P. Kilby, *Agriculture and Structural Transformation*, Oxford University Press, New York (1975).
8. M. I. Kolawole, "Economic Aspects of Tractor Contracting Operations in Western Nigeria," Journal of Agricultural Engineering Research 17:289–294 (1972).
9. S. C. Len, "Rice Mechanization Developments in West Malaysia," Agricultural Engineering Paper No. 14, Rice Research Center, Bumbong Lima, Province Wellesley, Malaysia (Dec. 1968).
10. H. Lönnemark, "Multi-Farm Use of Agricultural Machinery," FAO Development Paper No. 85, FAO, United Nations, Rome (1967).
11. N. Orcino and J. B. Duff, "Technical and Economic Characteristics of Tractor Contract Operations in Central Luzon (Philippines)," International Rice Research Institute, Los Baños, Saturday Seminar Paper (June 30, 1973).
12. Royal Thai Government, Industrial Finance Corporation of Thailand, and U.S. Operations Mission to Thailand, "Thailand Farm Mechanization and Farm Machinery Market," Private Enterprise Division, USOM Agency for International Development, American Embassy, Bangkok.
13. M. Siddique, "Economics of Custom-Work Tractor Farming on Small Farms in Shahkot, District Sheikhupura (Pakistan)," Master's thesis, agricultural economics, West Pakistan Agricultural University, Lyallpur (1969).
14. G. Singh and W. J. Chancellor, "Energy Inputs and Agricultural Production under Various Regimes of Mechanization in Northern India," Transactions, American Society of Agricultural Engineers 18(2): 252 (1975).

Manufacturing and Marketing Farm Equipment for Africa by a North American Firm

E. WILLIAM HAKES

Director, Product Management, Implements and General Machines
Massey-Ferguson, Ltd.
Toronto, Canada

The subject that is under discussion here is overwhelming — related as it is to such a large and complex continent encompassing 47 countries, with an equal number of differing economies, and varying stages of agricultural development. To simplify the task, I would like to confine my remarks to what Massey-Ferguson's approaches are to providing agricultural mechanization in the developing countries in Africa.

I will discuss some of the products we sell, how we sell them and why, some of the support that Massey-Ferguson provides, and what our manufacturing philosophies are. I will conclude with some personal comments about the problems and opportunities facing African agriculture in the coming years.

The company that has become Massey-Ferguson had its beginnings in 1847 in Canada. In 1867, the first export order from Europe was received and we embarked on the road to becoming a multinational company. In 1977, our worldwide volume was $2.8 billion of which less than 7 percent was in Canada. Our products are produced in 92 factories in 30 countries — half of which are developing nations. In fact, about 30 percent of our total business takes place in the developing countries. Our products have been sold in Africa for over 50 years. Last year's sales in Africa amounted to about $170 million, or 6 percent of the worldwide total.

Basic Tools and Farm Equipment

Massey-Ferguson's farm machinery sales in Africa can be divided into three distinct groups: hand tools, animal-drawn implements, and modern tractors, implements, and harvesting machines. The basic tillage and cultivation tool for many subsistence farmers is the hand hoe which we produce in several sizes for distribution throughout Central Africa. We make about a million of them every year. We also produce a range of animal-draft implements in Africa. These include moldboard plows, cultivators, spike-tooth harrows, ridgers, and planters.

The sales and distribution channels of hoes and animal-draft machines differ from those for Massey-Ferguson tractors and tractor-related equipment. Because of the relatively low price and simple technology, these products are sold to wholesalers who specialize in servicing the local trader. The local trader is the supplier of cooking pots, cloth, blankets, matches, foods, and all manner of goods required by the rural population of developing countries. While the trader often sells the hoe, plow, or whatever, to the farmer for cash, he may frequently take payment in the form of maize, eggs, livestock, or some other commodity.

To simplify repairs of the animal-draft machines, a universal wrench is supplied which fits all of the nuts and bolts on the machine. Shares, sweeps, and tines are of standard dimensions and are stocked by the trader as well. Several improvements have been made to these machines over the years, but care has been taken to reduce obsolescence wherever possible by not changing the physical dimension of the parts.

Because of the need for these basic tools, we have had little trouble in shipping from one country to another — although freight costs can become prohibitive when long distance is involved. Among the interesting facets of selling animal-drawn tools is that colors often are very important. Green, which symbolizes fertility in tribal culture, is a popular color for animal-drawn implements, but color preferences differ among various tribes.

Before continuing, I would like to comment on the shortcomings of these kinds of products. We must not underestimate the hard work and plain drudgery of using hoes from dawn to dusk under a hot, African sun. Apart from hand-harvesting sugar cane, there are few tasks that are less enjoyable. The use of animal power and slightly more advanced tools increases the work that can be done in a day's time, but it does little to reduce the drudgery and the fatigue of the farmer at the day's end.

Problems in Using Animal Power

One of the basic problems in using animal power in Africa is that at the time when seedbeds must be prepared, the ground is at its hardest — at the end of

winter, or the dry season — and the animals may be in their poorest condition because of fodder shortages. The peak work requirement thus coincides with the lowest point in the animal's fitness cycle. Another problem is that draft animals consume great quantities of feed. Evidence of their consumption was provided recently by a Polish agricultural official who estimated that if Poland's present 2.5 million horses could be replaced by tractors, the saving in feed would be enough to raise 8 million pigs each year.

In the late 1960s and early 1970s, a number of agricultural experts felt that animal-drawn machines would decrease in quantity as tractor power took over. We have seen a leveling-off of sales of these tools, but have not yet seen a definite decrease in demand. Population growth, of course, has much to do with this ongoing demand. Perhaps another reason is the important role of oxen in the socioeconomic structure of many tribes. A man's wealth and social status are directly determined by the number of oxen he owns. The price of a bride is usually agreed upon in terms of a certain number of oxen. A man with many oxen can afford many wives, and it is usually the wives who have the task of using the hoes while the men discuss politics or some other vitally important subject. Young men and boys are often the ones who are delegated to till the land with animals and animal-drawn tools.

Why is a company like Massey-Ferguson interested in hand hoes or animal-drawn implements which represent far less than 1 percent of its worldwide sales volume? We believe that these products help farmers who have the desire to be more than just subsistence farmers. Animal-drawn plows or planters can often mean that the farmer — for the first time — can begin to do more than just barely feed his family. He may be able to move from subsistence into an exchange or cash crop economy, even if only on a small scale. In most areas, 3 to 10 hectares of land, well farmed, can produce a significant excess for sale or barter.

We have found that in an economic climate that provides a farmer with real incentives to improve and expand production, there is a definite progression from hand tools to animal-drawn machines, to used tractors and implements, to new tractors. Sometimes this progression takes place within a relatively short period of one lifetime; in other instances it will be generations in developing. Much depends on the policy of the government concerned, and the development of extension services, support facilities, and food marketing systems. I would like to discuss briefly some intermediate forms of agricultural mechanization — that is, what exists between animal power and 35 to 40 hp conventional tractors.

Intermediate Forms of Mechanization

Much work has been done, especially in Africa, in developing small tractors and winches to replace animals and which, it is hoped, will cost less than new or used conventional tractors. Among these are the Monowheel, designed in the United Kingdom and tested in Africa; the Kabanyolo in Uganda; the Tinkabi in Swaziland; the Snail, a light-weight winch; and the Spider, which is a winching tractor. Two-wheel tractors which are popular in Japan and China have also been tested in Africa.

The Monowheel, Kabanyolo, and Tinkabi are tractors designed to handle mounted implements such as a single- or two-furrow, 8- or 10-inch plow. Of these, the Swaziland-produced Tinkabi is probably closest to being a commercial success. The Snail is a self-propelled winch which pulls an animal-draft type of implement across the field on a cable, and the Spider uses the winch principle but, instead of having two wheels, is of a tricycle design permitting the winch operator to ride. The implement operator on the Spider must walk behind to control the implement. Most of these machines have been designed to be assembled locally from various power and transmission components.

The International Institute of Tropical Agriculture (IITA) at Ibadan in Nigeria has been experimenting with two-wheel, walk-behind tractors similar to those used in Japan. The IITA is working on a total farming system using a variety of tools and not just the mechanization aspect of tropical farming. They are studying crop selection and the use of various mulches to control weeds and conserve moisture, and have developed a row-crop planter which penetrates a heavy-growing mulch to deposit single seeds at even spacing.

My own company, and at least two of our competitors, have at various times built prototypes of small intermediate tractors for the developing world. In all of these intermediate machines, traction, stability, operator comfort, safety, and relatively high cost have been basic problems. With the added need for service and service training, parts, and sales network, no company has as yet found the way to a commercially viable project using intermediate-powered machines.

At present we are working with various research and government departments in the broad area of intermediate mechanization, and most of this work is taking place in Africa. It is not yet clear whether a commercially successful, inexpensive small tractor or tractor-like power unit which works well in the various crops and farming conditions of the developing world is possible. Two men, John Kilgour and C. P. Crossley, from the United Kingdom's National College of Agricultural Engineering, have written differing papers on the subject.

These have been published in the July-August 1976 and May-June 1977 issues of *World Crops*, and I strongly recommend the papers to those of you who are interested in this subject.

One of the factors that are hampering the widespread acceptance of intermediate technology by the small farmer is psychological. It involves status — these machines do not look like tractors. When the farmer has the desire and the financing to make the move from animal-drawn implements to mechanical power, he does not want a machine that appears to him, his family, and his neighbors to be something designed for a poor, marginal farmer. He would much prefer a good reconditioned, small, used tractor which everyone will immediately recognize as being superior, and the ownership of which will enhance his status.

From an economic standpoint, a used tractor with two or three used implements may cost about the same as a new intermediate machine with the tools to perform the same functions. The used tractor almost certainly has superior performance, compared to the intermediate machine. The fuel consumption of the two, to till equal amounts of land, will probably be lower in the used tractor because of more efficient traction with weight transfer. The skill required to operate the two machines and the training needed to acquire the skill will be about the same. In terms of service — the ease of repair and the availability of repair parts — the used tractor probably has an advantage.

Many of the full-line farm machinery companies have been selling in developing countries for many years. Massey-Ferguson has had distributors established for well over 50 years in most parts of Africa. We have trained operators and service people for many, many years, and because of the population of tractors and machines, the parts inventories to support them are far more available than those to support a few new, unusual, intermediate machines. In saying this, I do not contend that there are no immobilized tractors sitting in developing countries. These things happen, far too often, but they will almost certainly happen with parts for intermediate machines as well. When I read about the extensive problem of immobilized farm machinery in USSR and other planned-economy countries, I am led to believe that the multinational farm machinery companies are doing a reasonably good job of keeping their machines working. Our industry is working with the governments of several developing countries to improve the parts and service support to agricultural machinery. Training, which I will discuss later, is one way of improving the situation to a considerable degree.

Incentives for Production

The question of increasing food production, reducing drudgery, and maintaining or improving rural unemployment is not just a question of mechanization. Probably the most important factor is that farmers must have a strong incentive to produce at higher levels than those of subsistence farmers, who manage only to keep their families alive. Too frequently, the cheap food price policies of governments in developing countries result in little incentive to produce more food. Also, there must be markets for the extra production. This requires an entire transportation system of roads, trucks, railways, or other forms of suitable transportation. If roads, they must be all-weather ones, enabling a steady flow of food from the producer to the markets. There must also be some kind of storage and processing facilities and, of course, a system of retail distribution.

The entire system of facilities for efficient distribution of food within a country, and at a profit to the producer, can and does create many employment opportunities — many of which must be in the rural areas. As agriculture develops and prospers, the market for agricultural supplies — fertilizers, pesticides, herbicides, and machinery — expands, as do the rural markets for clothes, radios, bicycles, sewing machines, and all of the other products needed by a dynamic population.

Agricultural development is a complex system of hundreds of interrelated factors. Even in highly planned and tightly controlled economies, the course of agricultural development has not been smooth. But it must take place if we are to feed the ever-expanding world population.

What do large, multinational farm machinery companies do to assist in the mechanization of the developing countries? In Massey-Ferguson, we do many things, and I would like to touch on some of the most important.

Owner Training Programs

The company has always believed that agricultural development and expansion can only be achieved with the support of simultaneous programs of education and training in the production of agricultural machinery and its efficient utilization. To obtain the greatest productivity and longest life from agricultural machinery, the owner or operator must know how to operate, adjust, and maintain it. The training needed to provide this knowledge is particularly important in developing countries where many farmers have little or no prior experience of complex mechanical equipment. Massey-Ferguson provides this instruction through comprehensive owner-training programs. These programs include courses for distributors, agricultural advisers, and government personnel, on-site instruction in local classes and with mobile train-

ing units, and operators' manuals with other instructional material.

As with all mechanical equipment, normal wear and usage of agricultural machinery requires skilled mechanics and servicemen to make repairs and replacements. Well-trained and properly equipped mechanics are vital to the achievement of effective farm mechanization. Massey-Ferguson provides service training to dealers and distributors around the world — and to government and agricultural school instructors — in our many training centers, by sending out field technicians, and through special on-site programs, service manuals, technical bulletins, tool lists, wall charts, and other training aids.

The company also provides instruction for dealer and distributor parts personnel at training centers and through on-site classes conducted by our field parts specialists. We have a cadre of highly trained instructors who undertake specific training assignments on territory, and who are supplied with very carefully developed training aids and course material. We have a large training center at Stoneleigh in England, which has become the focal point of course content and training material development for most of the world. All of our travelling instructors are trained at Stoneleigh, and distributors send their staffs there for training and refresher courses on a regular basis.

We also train staff for various governments. An example of this was a recent request from a North African country to train 25 selected young men to become farm machinery mechanics, workshop supervisors, and trainees. All 25 trainees went to England for 32 weeks for instruction in elementary technical training at a technical college, and for practical field operation and workshop training at our Stoneleigh Training Center. They then returned to their own country for four weeks of carefully supervised on-the-job training.

At the end of this 36-week period this group was capable of performing all but the highest technical levels of fault diagnosis, repair, operation, and adjustment of farm machinery. Twelve of the most promising trainees were selected for 20 weeks of further training back at Stoneleigh. This session included further intensive technical training, as well as workshop management, personnel supervision, personnel recruitment and selection, and warranty and parts systems and procedures. Their final training was in instructional techniques and course development. The top four students were then given an additional four weeks' training in specialized systems. These young men are now back in their own country, managing workshops and training others.

We supplement our on-territory training instructors with fully equipped mobile training schools consisting of large trailer trucks, with the trailers fitted out as classrooms, complete with slide and moving picture equipment, cut-away models, their own electric generators, and so on. These schools are very effective in taking training to remote areas.

Massey-Ferguson distributors in most African countries have their own training centers, complete with classrooms, workshops, and fields for demonstrating and testing, and they use training aids and course materials prepared by Massey-Ferguson. They employ full-time trained instructors and often tie their training into the country's formal educational system.

Agricultural Advisory Services

Massey-Ferguson also has an agricultural advisory service, staffed with qualified agricultural experts. When requested, this group provides developing countries with guidance in the selection and application of farm machinery for specific projects.

Local Manufacturing Projects

Massey-Ferguson also participates in local farm machinery assembly and manufacturing projects in developing countries. At present we are involved in tractor assembly projects in Egypt, Morocco, and Libya, and we are currently negotiating with governments and commercial interests in several other African nations for assembly/manufacture and technical assistance. Our technical services and special operations divisions were formed to provide this special assistance to local manufacturing projects. For several years we have had a licensing arrangement with a manufacturer in Kenya that allows him to produce several of our implements locally.

It must be recognized that in almost every case where developing countries have gone into the local assembly or manufacture of tractors and fairly sophisticated implements, the costs are higher than for imported machines. The unit costs of producing one to three thousand tractors in a country with a just-emerging industrial base can never compare to the costs of producing 80 to 100 thousand tractors in a well-equipped, modern factory using highly skilled workers. However, local assembly and manufacture do reduce to some degree the cash outflow of the developing nation.

Farm machinery manufacturing tends to be more capital intensive than labor intensive. The amount of labor required varies inversely with the amount of capital invested in plant and machinery. Frequently we find that officials of developing nations insist upon the very latest technology available when establishing factories. For example, numerically controlled machines produce components much faster than less sophisticated machines can, and these advanced machines require far less manpower. This is a delicate area, involving national pride

and the personal sensitivity of people. A showcase tractor factory with the most modern equipment can be a matter of great importance to politicians. The fact that using less automated equipment to produce the same end product would generate more employment is often lost in the development of a project.

When a developing country decides to move into local manufacture, it usually invites several multinational companies to submit proposals. Competition is very high and not confined to North American or West European companies. Some East European companies are especially active in promoting their own tractors and know-how.

In the future, it is unlikely that the highly developed agricultural nations will be able to expand food production at the rate they have achieved since World War II. Little land remains that can be added to production and, while productivity gains can be expected from improved crop genetics, fertilizer, and mechanization, the real gains in food production must come in the developing countries. The developing countries have increased food production about 12 percent since 1972, but population has increased by 13.5 percent. Figure 1 illustrates the per capita food production of developed, centrally planned, and developing countries. Table 1 compares food production in millions of metric tons compared to population.

As we have said, if hunger is to be eliminated in this world, the future growth in food production must come from the developing world. Somehow, the developing countries must feed themselves. This will require agricultural mechanization, but mechanization is only one of the factors in this development. The progress will not be without problems, and some set-backs. Intelligent planning and implementation are needed.

Much of the future growth of companies such as Massey-Ferguson will be in the developing countries. We are aware of this, and we are equally aware of our responsibilities in participating in their development. But, as we have said, mechanization alone is not the answer. The timing, pace, and form of the introduction of agricultural technology must be planned and carried out in such a way as to avoid any social disruption and economic dislocation.

Farm mechanization and the displacement of labor in developing countries is a contentious issue which I do not intend to get into at this point. But I do commend to you two booklets — "The Pace and Form of Farm Mechanization in the Developing Countries" and "The Effects of Engine Power on Development and Employment" — which have been published by our company in an effort to present a balanced view of the problem.

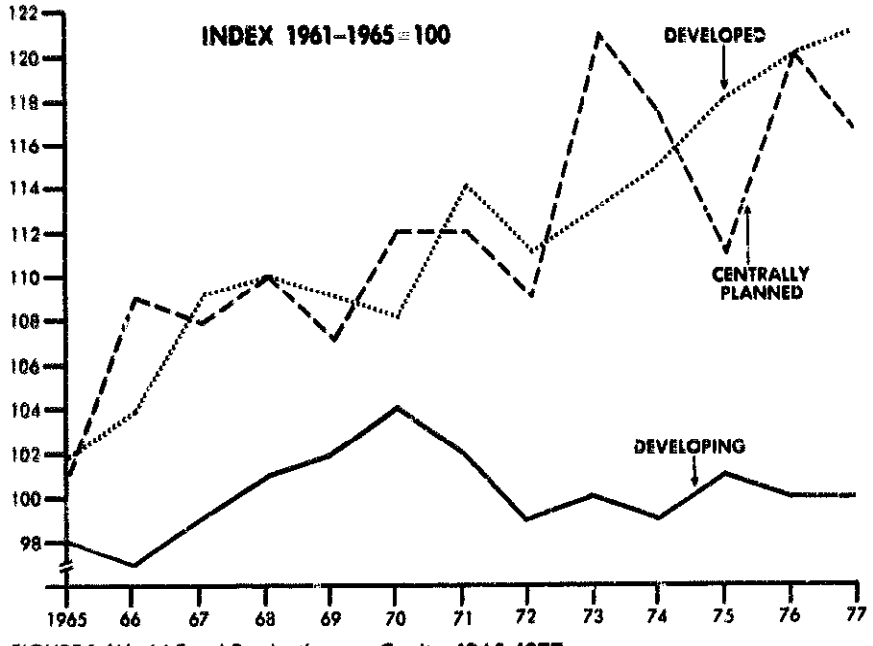


FIGURE 1. World Food Production per Capita, 1965–1977.

Audience Discussion

J. Casyao: This morning it was mentioned that agriculture is predictable. I believe that every action made by planners, particularly in the agricultural sector, will lead to a certain effect. We have been discussing the problem of agricultural technology for developing nations, and one solution that every speaker is trying to suggest is the mechanization of the small farms. I believe that this is not a new approach. For example, in the Philippines, as Dr. Khan showed us, locally manufactured agricultural machines already have been made available there, and Dr. Ralis told us about the efforts to mechanize India's farms since 1962. My question is, what is the present stage of success in the mechanization of small farms in the developing nations? Do you think that 100 percent of the farmers would go into mechanization with their 1 to 10 hectare farms despite the increasing price of oil, or should I say, the energy crisis?

J. S. Ralis: To expect that 100 percent of all farmers would do any one thing is really not very wise in terms of what technology will do. There will be some farmers who are best served by small tractors, there will be some who will be best served by improved animal-drawn implements, and there will be other farmers who, on the short term, will be best served by using tractor hiring and who, perhaps, on the longer term, will prefer to convert to their own, personally owned, power. I think that what our conference is really about, is sorting out what is appropriate technology and the thing that I would like to emphasize is that technology is inherently quite limited. It just does not work for everybody at all times. In fact, most of us take it for granted that the equipment on the dealer's showfloor in New York state is quite different from that in Indiana. When we go overseas we think everything is going to be the same and we are beginning to learn, with the experience of the last 25 years, what the subtle differences are, and about how many numbers are involved in different categories. We do not know enough, though, to determine exactly what is going to be needed. That is my philosophical attitude but I cannot give you real hard numbers.

W. J. Chancellor: In regard to some percentage figures, for Thailand and Malaysia, surveys have shown that, in one year, the tractors operated in custom hire serviced a number of acres that was approximately equal to half the number of acres under nonpermanent crops. This means that less than half of the work was done by tractors, but if we take this half and divide it by the typical number of operations per crop which tractors potentially might complete, it might be only half. This means that possibly 30 percent, or something of this sort, of the total potential work the tractors might have performed on the fields of these two countries, was actually done by the tractors. The average farm size for those hiring tractors in Thailand was about 10 hectares and approximately 4 or 5 hectares in Malaysia.

M. M. McLaughlin: I think that the extent of mechanization of small farms should depend on the small farm operator's perception of what good mechanization is going to do — in other words, his perception of the need for mechanization. I think many of us from outside these countries tend to feel that we have ways of deepening or intensifying the small farmer's perception of that need, and I do not believe that outside thought is necessarily bad. I think the real question is whether we approach our effort to deepen his perception from a marketing point of view or from the viewpoint of supply or of development — that is, by making an effort to understand his needs and help him move forward, not coming in from the outside with a sort of prepackaged formula.

D. E. Nestrick: I just wanted to thank Mr. Kishida and Mr. Hakes for insisting that the private, free enterprise, profit-motivated system is one of the best for food delivery systems. I wanted to ask Mr. McLaughlin whether I heard him correctly. I believe he said that American agriculture was terribly wasteful. I assume he meant that to be in terms of energy. The current figure that Dr. R. C. Ward from Colorado State University gives on the use of energy in agriculture — or in the food system, I should say — is about 16 percent of the energy use in the United States. But do not blame all of that on agriculture because 5.5 percent of that goes to the production of food and another 5 percent goes to the preparation of food in restaurants and away from home. I would then ask if that was what you meant or, if not, what was the basis of your assumption that American agriculture is extremely or terribly wasteful.

McLaughlin: First of all, I said the American food system, as all of you have pointed out, is terribly wasteful. I do not want to back away from the question. To me the American food system includes producers, processors, transporters, equipment suppliers, wholesalers, and retailers — and, as a matter of fact, consumers. The most waste probably occurs when you drive home from the supermarket with a 3,000-pound vehicle and forty dollars' worth of food. The waste is in the system in the United

States, not on the producers' end. I agree with that. On the other point that you made, I want to say something about post-harvest losses because it seems to me those figures vary. We get the FAO (Food and Agriculture Organization) figures, that 15 to 40 percent of the harvest is lost in some of the developing countries, after growing. Clearly, if some of that could be reduced, say if it could be cut in half, we have gone a long way toward solving the world food problem, at least temporarily. And it seems to me that post-harvest loss is one of the areas most susceptible to indigenous technological advance. I know that the FAO has funded some projects in Africa — training programs for local people on how to build pest-resistant storage structures, giving them their choice of maybe five systems. Back to your basic point, however, I think the big waste is in the food system, anywhere from the packaging of cereals in boxes that look pretty but do not contain very much nutrient value, on up to any number of examples we might name. Sometimes we think there ought to be some research that goes through the whole food system, to find out whether an unconscionable profit is being made at some intersect in the process. My guess is that there probably is no single place where this happens, and therefore we have an even bigger problem, because that means the whole system, except to the producer from the farm gate, is wasteful.

E. W. HAKES: I would just like to add that I think, wherever you look in terms of agricultural technology today, it tends to be petroleum-based and the whole question of farm machinery is an evolutionary rather than revolutionary kind of development. I think that probably for the next few years, certainly, the world will devote adequate petroleum resources to agriculture to produce food. I think the alternative of people going hungry is completely unacceptable to any nation in the world, and I think it is probably far better for urban people to walk to their jobs instead of taking their cars, than it is to ask the farmers to produce less for the sake of conserving some fossil energy.

Y. KISHIDA: I would like to comment on one thing. The agricultural mechanization system in Japan is often seen as using too much over its margin in the matter of energy. But I would like to say that the power necessary for producing one kilocalorie of farm product is smaller there than in America. According to a comparison by Yoshikuni Kishida in 1968, 4,000 kcal of food were produced per horsepower in Japan, compared with less than 1,000 kcal in America. At that time we used more than 3 hp of tractor per hectare, but still the energy used for food production was much less than here. And the basic constituent of designing machinery for the Japanese market already was concerned about the loss. In the case of the thresher, we have to design on the basis of a chart, to keep the loss of the grain at least under 0.2 to 0.5 percent. But I can see that in many cases the developing countries are restricted in their resources, and that means we still have to consider how we can save energy, how we can save materials to make the technology work.

MCLAUGHLIN: I think, with respect to U.S. agriculture, there is considerable research going on to lower the energy input. For example, some of the plant genetics research which is going into developing seeds that are photosynthetically more efficient or can fix their own nitrogen, biological pest control, anything that can reduce the petroleum input into pesticides or fertilizers would, it seems to me, improve the efficiency of U.S. agriculture from the standpoint of energy use. It would also benefit the small farmers in poor countries, because if you can build improvement into the seed, so it does not need to have a lot of fertilizer and irrigation water, you might be able to help them out too.

B. M. PEARSON: I was wondering, relative to the last comment that Mr. Hakes made, just what kind of research are the motorized manufacturers doing to eventually replace machinery that is operated with increasingly expensive and apparently scarce petroleum products?

HAKES: Well, I can only speak for one company. I do not presume to know what our competitors are doing in this field, and we all play it close to our vests because it would give us a decided commercial advantage if we were the first to bring out a new generation of tractors or combines or whatever, using something other than petroleum as the fuel. Over the last 10 years we have spent several million dollars looking at alternative types of energy supplies, testing them. We have also worked closely with a number of institutions that have developed new concepts in fuel, but at this stage, and because of the commercial nature of it, I really would not like to discuss the specific way that we are now spending our money. Perhaps one of my competitors here would like to comment.

CHANCELLOR: On that topic, you heard this morning about the use of alcohol as a motor fuel as derived from sugar cane in Brazil, and this is one possibility that is under investigation on a very large scale at this time. A second possibility, which I understand has been held in reserve by the people in Sweden, is the use of producer gas from wood chips as a tractor fuel, and units are available to be mounted on tractors to provide this power from wood chips if petroleum is not available. It causes

a reduction of power output to approximately 80 percent of the original level, and the tractor seems to be able to function normally. This sort of research is being carried out by a number of universities here, and IRRI (International Rice Research Institute) is working on this and I know at least one major company that is working on this method of supplying power to tractors without resorting to petroleum fuel.

HAKES: One comment about the Brazilian experiment — it uses alcohol as an additive to gasoline or diesel fuel, not as a replacement for them.

BALIS: I have been in Brazil for the last three years with IMBRAFA, the federal research organization for Brazil in agriculture, and the statement that I would like to make is this: They do have plans now to substitute alcohol for 20 percent of their gasoline consumption, by mixing it with gasoline, by the early 1980s. But this is not their total program. They are talking in terms of going into straight alcohol, and there are small engine manufacturers who are testing engines operating on anhydrous alcohol. And I just wanted to add this one point because it is very closely related to this subject. The major manufacturers or multinationals, I think, have a unique responsibility in terms of this, and I ask this question: Can the multinationals make decisions that would provide for deficiencies in individual nations, rather than in terms of a weighted average of the world? After all, the savings of a two-dollar gallon of fuel will buy a technological development that sixty cents in savings would not buy.

HAKES: I am not sure that I understand the last comment. You are asking, can we make decisions in respect to the individual countries rather than on a worldwide or countrywide basis? Yes, certainly we can. But to develop different products for each country increases the development cost and often increases the amount of toolage and capital investment required. We do have a very real responsibility to our shareholders to produce ongoing revenue for them. I would like also to say that our product development work comes from the profits that we do or do not generate, whereas some of the very, very interesting work that you saw today (and I do not discount it at all) was funded by institutions, foundations, and so on.

J. A. STEWART: One comment regarding fuel consumption. We have two tractors on our farm, one very large one and a medium-sized tractor, and I want to tell you that the farm machinery manufacturers who made those tractors have provided increased efficiency in fuel consumption. We use less diesel fuel per acre with the very large tractor than we did with the medium-sized tractor, and I think the companies are doing a magnificent job in trying to work out this energy situation. The question that I want to ask is for Dr. McLaughlin. He mentioned that if we have increased use of technology in the developing countries, this will help in the total food picture, and I believe he also mentioned, if I heard him correctly, that the North American continent would have to export increased supplies of food by the year 2000. I thought I heard the figure that we would have to double the exports. If I did, can we have the technology and the facilities to produce and export that amount of food?

MCLAUGHLIN: Yes, you heard me correctly, although I did not say "increased technology" in the poor countries but "increased agricultural production." The North American continent now exports about 100 million tons of grain a year. That is up from 35 million tons in the last 10 years, which is far more than double. But I think the real question is, if the numbers we are dealing with are accurate, and if the demand — the grain requirement — in developing market economies is going to go up 350 million tons by the end of the century, and if the current production patterns continue worldwide, then 100 million more tons will have to come from the North American continent. What I tried to say was, I think it is most unlikely that the North American continent can produce double the export grain and take care of its other ongoing consumption increases.

STEWART: I support this because, at the present time, for example, we are exporting over 50 percent of the soybeans that we raise in the United States and our storage facilities and our transportation facilities are now beginning to be taxed. I think your observation is correct and I think this is another serious point of attention if we want to participate in helping the total world food picture.

KISHIDA: As to how we can improve the energy consumption to promote mechanization, one great possibility another 20 years or so from now is utilization of the microprocessor. If we can compare a human being and a machine, human beings cannot utilize their power very effectively. And now the microprocessor and similar kinds of systems are rapidly down in price, so maybe in the near future every farmer can order one of these special systems direct from the factory. Then he can automatically make the system work as he desires for his individual farm. This kind of system can assist the operator in the developing country. Many people think this kind of tech-

nology is too sophisticated, too complicated, but I think this kind of technology is needed, certainly in the case of Japan and the United States, to improve the fuel consumption of tractors and other kinds of machinery. Many manufacturers are now working on it, in both Japan and the United States. Yesterday I visited one company, Dickey-John, which is doing research and is now selling such a product to increase the efficiency of utilization in tractors and other machinery. Maybe this kind of technology is one of the solutions to the problem of energy use.

J. K. CAMPBELL: I want to make a comment about efficiencies and energy. Beware when you listen to these, but I am going to give one to you anyway. If we look at rice production we find that in the United States we require about 6.3 million BTU's per ton of rice while in Japan they do it a little more efficiently at 6.2 million BTU's per ton. Then we go to Taiwan and it goes up to 8 million BTU's per ton and in India it is up to around 19 million BTU's per ton of rice. So you might say that the industrial countries of Japan and the United States are producing food more efficiently. That is true in regard to energy, but it is based in large part, particularly in this country, on fossil fuels. And I would recommend, to any who are interested in this matter, the very good book called *Energy and Agriculture in the Third World: A Report to the Energy Policy Project of the Ford Foundation.*

KISHIDA: I would like to add another comment about the pricing policy of farm products. The government of Japan heavily subsidizes farmers, even in this day and age. For example, this year the Japanese government spent 9 percent of the total gross national product on agriculture, but agricultural production provides only 4 percent of total GNP. With this subsidy, the Japanese farmer can get more income than the average U.S. farmer. The Japanese farmer has only 1.1 hectares for an average gross income of 5.5 million yen. I think I can say this is more than U.S. farmers receive, except for some on the bigger farms. This shows that small farmers, with suitable help from government, can get the better conditions that city people have. Other very good examples are Korea and Thailand. After the government started supporting the rice price, it dropped very quickly in both Thailand and Korea. Now, these two countries had the same problem as Japan — that is, a surplus of rice. All three countries have started regenerating the transplanting of the rice area, but this policy may be failing in the case of Japan because the Japanese farmer can easily increase the yield per hectare by 10 percent.

M. L. ESMAY: I interpret that as creating an effective demand among the small farmers, as was described here earlier. They receive an income that permits them to be in the economic stream and to satisfy their demands.

W. F. BUCHELE: First a statement and then a question. We have been talking about the Brazilian experience in the use of alcohol as fuel and how they will perhaps be completely on alcohol fuel by 1987. What has not been talked about is the even more ambitious project of going to the production of charcoal from forests, which will take care of steel production and other uses. And this leads me to my question. We have been talking about agriculture, but the forests are in much greater jeopardy than our agriculture. Now I know that the industry is doing quite well, building forestry harvesting machinery for cutting from 3 to 7 or 8 trees per minute, but I have yet to find much interest in building machinery for forestry. I am wondering what the panel feels about this subject of reforestation, now that we know how to cut the forests down.

CHANCELLOR: I might say that recently at Davis we started a forest engineering program, and among the research projects there now, we have had primary emphasis on planting systems. If you look at the current papers appearing in the American Society of Agricultural Engineers journal on the subject of forest engineering, there is much more interest now in planting systems, as opposed to harvesting systems as we saw earlier. And it looks as if the planting systems group is going to catch up, provided somebody does not think of something else to do with the land when the planter gets there.

KISHIDA: I would like to make another comment about multiple-cropping and its mechanization. I think that multiple-cropping is a kind of energy-saving measure to produce more food, especially in tractor-powered countries. But the need to design suitable machinery to mechanize the multiple-cropping method is great, because the concept of designing machinery for multiple-cropping requires a little different approach. Also, in multiple-cropping methods, machinery should be designed for groups of crops. In many cases in Europe and the United States their machinery system is designed for one crop. Perhaps a systems approach is needed to design a set of machines for mechanization of a group of crops. In the case of Asia, especially in tractor-powered regions, if they can introduce a multiple-cropping method, with the smallest possible investment in machinery, this is the best way to increase their income, and this approach to mechanization is very important.

Conference Summary

EARL D. KELLOGG

Associate Professor of Agricultural Economics
University of Illinois
Urbana, Illinois

For me to stand up here and tell you what you heard during this conference would be insulting to your intelligence, so I do not plan to do that. I would like to make some observations — or to indicate some things that I was surprised at, I guess I should say. One of those was that, it seems to me, we have conceived the notion that mechanization technology development transfer can be the same kind of process as the biological technology development transfer. I think that mechanical technology development transfer and its implementation is in some sense much more complicated than the biologicals are, and to carry the two examples in our mind sometimes does not serve us well. I think there are some fundamental differences. One difference in the development of mechanical technology and transferring it and implementing it in another place is that the proportion of the process that must be done by highly trained people — those with a Ph.D. or the equivalent — is less, it seems to me, than it is with biological technology.

Second, I think that emotion and government policy tend to be much more involved with the whole question of mechanical technology development and its implementation than with biology. The systems that are necessary to serve the purpose of support are more difficult for the mechanical technology than those for the biological technology. And I think another difference that will increasingly affect what happens is that private companies are able somehow to capture the gains of mechanical technology more easily and they play a bigger role than we have found in the biological technology development.

The discussions about whether to mechanize are not very useful. Farmers are mechanizing, there is no question about that. That is not to equate mechanization with tractorization, but many farmers, if not most, are mechanizing. We need to know more about the economic, social, and institutional effects involved in this process, and spend less time arguing with each other about whether it ought to occur or not, when it is already going on in force. I would suggest that another conference like this ought to consider some specific studies of mechanization as it has been adopted by farmers, because I think we argue with one another to a large extent because we are not talking about the same situation. We find ourselves in a paradox of being correct and yet disagreeing because we do not have the same basis for discussion.

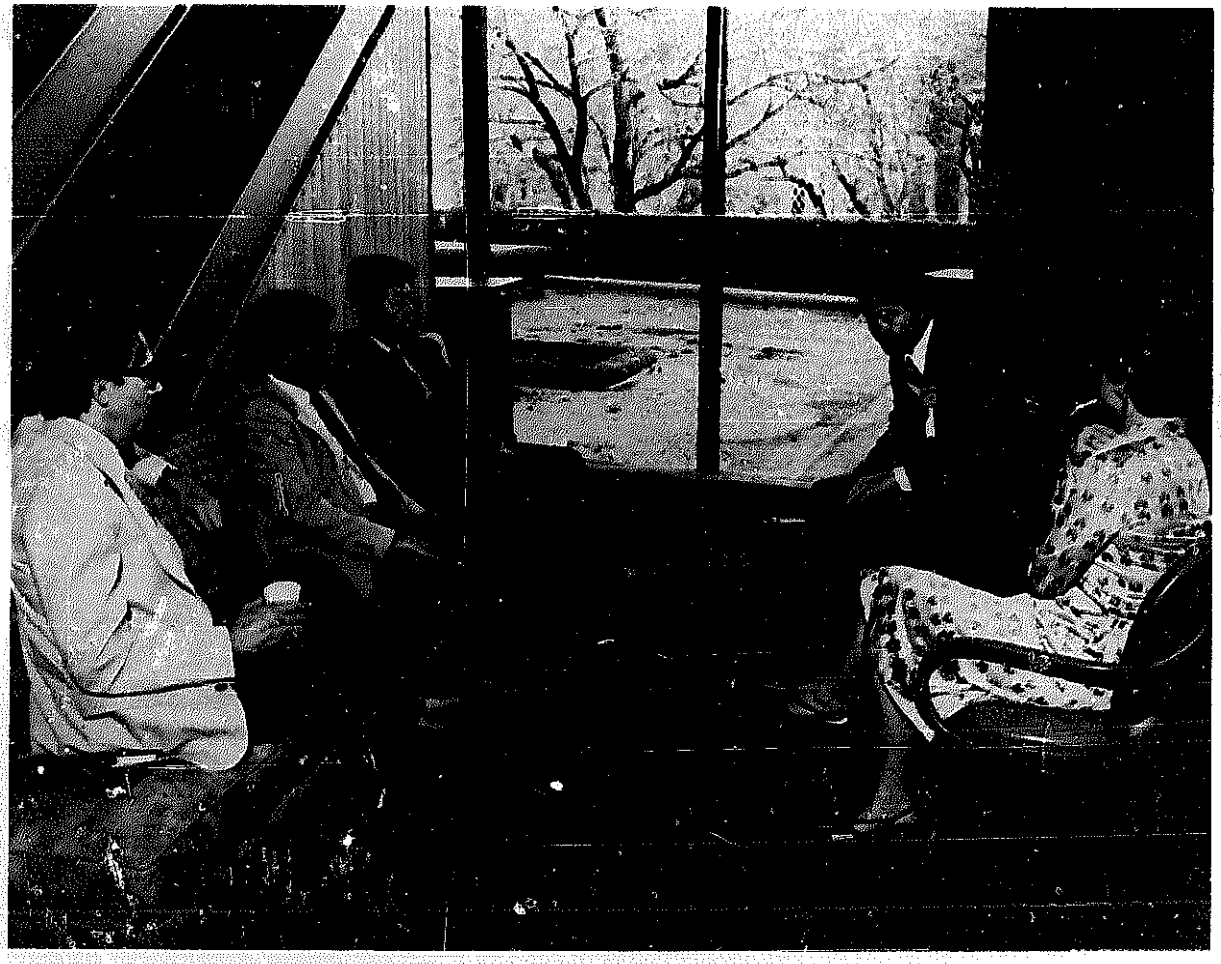
I guess I was surprised that we did not cover some of the more general topics that might have been more widely discussed because we do not have the great differences in specific situations. Some of these would have been, for example, the effects of price policy for agricultural commodities on mechanization. What causes the disequilibrium in the foreign exchange rate in terms of investment and in terms of development of mechanical technology, import taxation, quotas, and so forth? In other words, what kinds of policies cause individual farmers to perceive their costs differently from what society perceives as its costs of mechanization? Those kinds of topics, it seems to me, are easier to discuss than whether mechanization displaces labor, because that is a very local, specific kind of question.

It was surprising that we did not hear more about the nonagricultural benefits of mechanization. We heard a little bit about relieving some of the irksomeness of work, being able to transport more efficiently, making life a little nicer on the farm, and having some way of keeping the farmer's sons there. These are real benefits that are difficult to quantify, but that does not make them less real.

All production, of course, is meant to be consumed, and that is in a sense a consumption benefit. I liked Dr. Sen's answers during the opening session. His basic answer to several broad questions that were addressed to him was, "It depends." I think that, to a large extent,

is what I am trying to say. We have argued in some instances because it depends on which example you want to talk about. We cannot afford to fight with one another as economists and engineers, however. I think we should learn to get off each others' backs in general discussions, and do something together in particular, because solving the problems that we have in food production and technology development, be it biological or mechanical, is very difficult, as our national and international research centers are finding out, more and more. The sooner we begin to sit down and discuss these problems with each other, and try to understand each other better, the faster we will make progress in particular localities, and that is where we need the action.

At a briefing session in the conference headquarters are, from left, John S. Balis, Amir U. Khan, and Yoshisuke Kishida, with J. Terry Iversen and Pola F. Triandis of the University of Illinois, Office of Continuing Education for International Affairs. Many of the conferees from abroad planned to visit various agricultural equipment manufacturers, educational institutions, and research stations during their stay in the United States.



Appendices

Appendix I

PROGRAM

AGRICULTURAL TECHNOLOGY FOR DEVELOPING NATIONS
Farm Mechanization Alternatives for 1–10 Hectare Farms

University of Illinois at Urbana-Champaign
May 23–24, 1978

Tuesday, May 23

5:00-7:00 P.M.	Registration
6:00-7:00	Hospitality Hour
7:00-8:00	Banquet
8:00	Introduction of Program *Roy E. Harrington* Introduction of Keynote Speaker *Martha Savio*
8:15	ADDRESS: Agricultural Technology for Increased Food Production in Developing Nations: Problems and Opportunities *Samar R. Sen*
9:00-9:45	Audience Discussion

Wednesday, May 24

8:30-10:00 A.M.	PANEL DISCUSSION: The Socio-economic Impact of Farm Mechanization in Developing Nations *Earl D. Kellogg*, Discussion Leader
	Macro-Economics of Farm Mechanization *Folke Dovring*
	The Social Consequences of Mechanization *William C. Thiesenhusen*
	The Package Approach to Agricultural Improvement *Douglas Ensminger*
	Locally Manufactured Small Farm Equipment for Asian Farmers *Amir U. Khan*
10:30-11:45	Audience Discussion
12:00 NOON	Luncheon
1:15-4:00 P.M.	PANEL DISCUSSION: Developing and Marketing Equipment for Small Farms in Developing Nations *Merle L. Esmay*, Discussion Leader
	Agricultural Technology Transfer and Value Conflicts in Developing Nations *Martin M. McLaughlin*
	Introducing Farm Equipment to Small Asian Farms: The Experience of the Japanese Farm Equipment Industry *Yoshisuke Kishida*
	Introducing Tractors under Twenty-five Horsepower to Small Farms *John S. Balis*
	Custom Tractor Operations in the Far East *William J. Chancellor*
	Manufacturing and Marketing Farm Equipment for Africa by a North American Firm *E. William Hakes*
4:00-4:45	Audience Discussion
4:45-5:00	Conference Summary *Earl D. Kellogg*
5:00	Adjournment

Appendix II

BIOGRAPHIES OF SPEAKERS

JOHN S. BALIS is an agricultural engineer serving as chief of the Rural Development Division, Bureau for Latin America and the Caribbean, U.S. Agency for International Development, in Washington, D.C. He joined the Agency in 1967 and has served in various administrative, advisory, and technical positions in India, South Asia, Pakistan, the Near East, Sri Lanka, Jordan, Yemen, and Latin America.

He received Bachelor's degrees in agriculture and in mechanical engineering from the University of Wisconsin and a Master's degree in agricultural engineering from Purdue University, and undertook advanced studies in agricultural economics at Cornell University in 1973–1974.

After serving as assistant professor of farm power and machinery in the department of agricultural engineering at Purdue University, he joined the faculty at Allahabad Agricultural Institute, Allahabad, India, serving as professor of agricultural engineering during 1962–1967. During his tenure in India he undertook research in animal-drawn farm machinery and a study of small tractors, under a grant from the Ford Foundation.

WILLIAM J. CHANCELLOR is a professor of agricultural engineering at the University of California in Davis. He is a graduate of the University of Wisconsin and holds Master's and Ph.D. degrees from Cornell University.

During 1962–1963 he was a visiting professor of agricultural engineering at the University of Malaya, Kuala Lumpur.

He is a member of numerous scientific, professional, and honorary societies and has authored many technical papers in his areas of interest, which include agricultural soil mechanics, rice drying, forage harvesting, farm machinery systems management, energy use in agricultural production, international agricultural development, mechanization of agriculture in Asia, and information handling in agricultural tasks.

FOLKE DOVRING joined the University of Illinois in 1960 as professor of land economics. He holds the Ph.D. degree in economic history from Lund University in Sweden, his native country, and served on its faculty in agrarian history until 1953.

As a Rockefeller Foundation Fellow he studied in Rome, Geneva, and England before joining the staff of the United Nations Food and Agriculture Organization in Rome, as statistician and then economist. At various times he has served as a consultant to the United Nations Economic Commission for Europe, the U.S. Agency for International Development, U.S. Department of Agriculture, and the International Bank for Reconstruction and Development.

He is author of several books and numerous articles on land reform, world food problems, international finance, and related topics.

DOUGLAS ENSMINGER is a professor of rural sociology at the University of Missouri and president of Mid-Missouri Associated Colleges and Universities. He has degrees in agriculture and rural public welfare from the University of Missouri and the Ph.D. degree in rural sociology from Cornell University. He has worked in the areas of rural sociology and agricultural economics in Missouri and Indiana. During 1939–1951 he was with the U.S. Department of Agriculture, Bureau of Agricultural Economics and the Federal Extension Service. He served as coordinator of foreign training with land-grant colleges and universities and was a member of the United Nations Food and Agriculture Organization Latin America Extension Conference.

He was the Ford Foundation representative for India and Pakistan, 1951–1953, and for India and Nepal, 1953–1970. In 1972 he was co-chairman of the Bangladesh Emergency Relief Fund and later served on the Tanzanian Food Sector Team for the U.S. Agency for International Development. He has been a member of the Committee on Population and Food of the Food and Agriculture Organization and was chairman of its 1975 Symposium on World Population, Food, and Agriculture in Rome.

He has held many offices and board and committee memberships in professional, educational, and government organizations, national and worldwide. His publications include several major works on world agriculture, food problems, and development and he is presently writing a book on world hunger and poverty, as co-author with Paul Bomani, ambassador to the United States from Tanzania.

MERLE L. ESMAY is a professor of agricultural engineering at Michigan State University in East Lansing. He was graduated from South Dakota State University and earned Master's and Ph.D. degrees in agricultural and structural engineering from Iowa State University. He has held academic appointments at these institutions and

at the University of Missouri, and has served in administrative and advisory capacities with various technical and professional organizations.

In international affairs, he has worked as a consultant in Pakistan, Venezuela, Japan, Korea, Poland, Italy, and Taiwan, and has conducted research studies in Argentina and Pakistan. He served as chief of the Michigan State University–U.S. Agency for International Development Contract Team in Taiwan in 1962–1964.

He has worked with agricultural engineering educational agencies in Brazil, Japan, and Indonesia, and is the author of two books and many technical papers and bulletins in the fields of agricultural structures and agricultural mechanization in developing countries.

E. William Hakes is director of product management in the department of implements and general machines, Massey-Ferguson Limited, Toronto, Canada. He was graduated from the University of Colorado with a degree in economics and worked with Ford Motor Company in Detroit, Michigan, from 1953–1958.

He has worked with Massey-Ferguson for twenty years in various sales and marketing assignments in the United States, United Kingdom, southern Africa, and at the company's worldwide headquarters in Canada. From 1970–1974 he was director of marketing with responsibility for all sales and marketing in nine countries of southern Africa. Since 1974 he has visited several countries in both East and West Africa and many developing countries in Latin America and the Far East.

Roy E. Harrington has been a product planner in the product planning department of Deere & Company since 1971. He is an agricultural engineering graduate of the University of Missouri and is a registered engineer in the states of Illinois and Missouri.

He was a development engineer in the product development department of Deere & Company from 1950–1960, and from 1960–1966 was manager of the department. While in product development he received more than twenty patents on farm equipment.

From 1966 through 1971 he worked as an agricultural engineering consultant for the Ford Foundation in New Delhi, India, while on leave of absence from Deere & Company. He has visited research institutes, farmers, and dealers in Denmark, England, Germany, Italy, Spain, Russia, Japan, Taiwan, Indonesia, Kenya, Mexico, and Guatemala. He worked on the World Food and Nutrition Study of the National Academy of Sciences in 1976. He currently serves on the board of directors of the Quad-Cities (Illinois-Iowa) World Affairs Council, Inc.

Earl D. Kellogg joined the University of Illinois in 1971 as an assistant professor in the department of agricultural economics, specializing in basic economics and agricultural development. He was graduated from Kansas State University and holds the Ph.D. degree in agricultural economics from Michigan State University.

He served with the U.S. Department of Agriculture in 1972–1973 as rural development coordinator, participating in the development and coordination of rural development plans and serving as liaison between the Department of Agriculture and other federal agencies in the effort to extend some of their programs to rural areas in cooperation with the Department.

In international affairs, he has been a consultant to the Nigerian government in the development of their third Five-Year Agricultural Development Plan. He served as a project specialist in multiple-cropping at Chieng Mai University, Chieng Mai, Thailand, during 1975–1977.

Amir U. Khan is director of the agricultural machinery program for the International Rice Research Institute in Rawalpindi, Pakistan. His academic degrees, including the Ph.D. degree in agricultural engineering, are from Michigan State University.

He has engaged in research and design of farm machinery at Michigan State University, East Lansing; at the tractor and implement division of the Ford Motor Company, Birmingham, Michigan; at Voltas Limited, Ballard Estate, Bombay, India; and at Agrimac Industries, Rampur, Uttar Pradesh, India. He holds fourteen agricultural machinery patents in the United States, the Philippines, and India.

He has directed research and development of agricultural machinery programs for the Government of India, New Delhi, and for the International Rice Research Institute, Los Baños, Laguna, Philippines. He has served on advisory commissions and boards of various organizations engaged in agricultural development in Pakistan, India, and the United States, and he is the author of articles and papers on the mechanization of tropical agriculture and on appropriate technology for the developing countries.

Yoshitsuke Kishida is president of Shin-Norinsha Company, Ltd., Tokyo, Japan, which publishes *Farm Machinery* and *Agricultural Mechanization*, weekly and monthly journals, respectively, and various books on agricultural mechanization. He also is editor of *Agricultural Mechanization in Asia* which is published for the improvement of agriculture in the developing nations.

He has a degree in engineering from Waseda University, Tokyo, and worked for Satoh Zoki Farm Machinery

Appendix III

SPONSORS

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Agricultural engineering is the branch of engineering that serves agriculture — the oldest and largest industry in America and the world. It is directly concerned with the means for providing food and fiber to fill the basic needs of all mankind.

The American Society of Agricultural Engineers is devoted to the promotion of the science and art of engineering in agriculture, encouraging original research, fostering engineering education, and advancing standards of agricultural engineering. The Society develops, collects, publishes, and distributes engineering information through meetings, conferences, and printed materials.

The Society has helped explore a number of critical world issues in its recent national meetings and in special conferences. Its international relations committee helped in planning this conference.

INTERFAITH CENTER ON CORPORATE RESPONSIBILITY

The Interfaith Center on Corporate Responsibility is a national coalition of religious groups working together to convey their concern for social issues to the corporations represented in church investment portfolios. Members agree that, as investors in businesses, they also are part owners and therefore have the right and obligation to monitor the social responsibility of corporations, and to act, where necessary, to help prevent or correct corporation policy that produces social injury.

National Ministries of American Baptist Churches, a member of the Center, has urged that agribusiness companies develop technologies appropriate to patterns of food-raising in which small farms (under 10 hectares) may remain productive. They believe that food availability will improve if farm equipment is designed to perform in conjunction with small-scale farming methods and the use of draft animals. This concern was raised with Deere & Company in 1976. This conference is a follow-up of that concern and represents an important first in the area of corporate responsibility. It is the first time that a program of this kind, on an issue of importance throughout the world, has been funded by a corporation and jointly sponsored by a university, a professional organization, and the churches.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

The University of Illinois has for more than 100 years been among the nation's most distinguished state universities. To bring its threefold functions of teaching, research, and public service to the entire state, the university has expanded to include three campuses with more than 200 major buildings and nearly 56,000 resident students. Its library of more than seven million items makes it the fifth largest among all the nation's libraries. The oldest and largest campus is located at Urbana-Champaign. Chartered in 1867 under the auspices of the Morrill Act of 1862, which established the land-grant colleges and universities, the University of Illinois has been a leader in many fields, including agriculture. The University's department of agricultural engineering has for many years had a cooperative relationship with the farm equipment industry in the United States.

International activities in agriculture have included teaching, research, and continuing education. Since the early 1950s these have been expanded to provide technical assistance in world agricultural development. The University's commitment to international agriculture has included such projects as the International Soybean Program, the training of foreign specialists, and the building of agricultural institutions in developing nations. It has received a new impetus with the passage of Title XII of the International Development and Food Assistance Act of 1975, which provides for the involvement of U.S. universities in solving the food and nutrition problems of the developing nations. This legislation makes it possible for the University of Illinois and similar institutions, whose skills helped to make possible the remarkable advances and growth of U.S. agriculture in the last century, to apply their considerable research and teaching expertise in the effort to improve the current world food situation and to prevent the occurrence of even more serious shortages in the decades ahead.

Appendix IV

ATTENDANTS

ABDURAHAM, Mohamoud
International Soybean Program (INTSOY)
58 Mumford Hall
University of Illinois
Urbana, IL 61801
SOMALIA

AHMAD, Syed Iqbal
Graduate Assistant, Agricultural Engineering
319 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

ANDERSON, Bill G.
President
Homesteader Tractor
P.O. Box 207
Clinton, AR 72031

ANDERSON, Pete
Illinois Food Committee
P.O. Box 2674 Station A
Champaign, IL 61820

AVERY, John H.
Instructor
Southwest Wisconsin Technical Institute
Bronson Boulevard
Fennimore, WI 53809

BAIRD, P. D.
Member, Special Hunger Task Force
First Baptist Church
RR #4 Mossville Road
Peoria, IL 61614

BAKER, C. B.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

*BALIS, John S.
Chief, Rural Development Division
Office of Development Resources
Bureau for Latin America and the Caribbean
Agency for International Development
Department of State, MS 5308
2201 C Street NW
Washington, DC 20520

BARNETT, Bill
Civil Engineer
IFDC-TVA Reservation
Muscle Shoals, AL 35660

BATES, Lawrence W.
Assistant Professor, Economics
Eastern Illinois University
Charleston, IL 61920

BENSON, David R.
Graduate Student/Community Development
Southern Illinois University
1803 Sunset Drive
Carbondale, IL 62901

BENTLEY, Nolie (Mrs. Orville)
8 Concord Lane
Urbana, IL 61801

BENTLEY, Orville G.
Dean, College of Agriculture
101 Mumford Hall
University of Illinois
Urbana, IL 61801

BENTZ, Robert P.
State Leader, Administration
Cooperative Extension Service
117 Mumford Hall
University of Illinois
Urbana, IL 61801

BERNSTEIN, Joel
Project Director
National Academy of Sciences
4620 N. Park Avenue, Apartment 1507 W
Chevy Chase, MD 20015

* Speaker

Bockhop, C. W.
Professor and Head
Department of Agricultural Engineering
Iowa State University
1419 McKinley
Ames, IA 50011

Bondurant, Byron L.
Professor, Agricultural Engineering
The Ohio State University
2073 Neil Avenue
Columbus, OH 43210

Booker, Patricia
Area Manager, Peace Corps
1 North Wacker Drive
Chicago, IL 60606

Boulden, Lee
Clarke-Gravely Corporation
Gravely Division
1 Gravely Lane
Clemmons, NC 27012

Boehl, Wayne G., Jr.
Professor
Amos Tuck School of Business
Dartmouth College
Hanover, NH 03755

Brown, Everett
Pastor
Westminster Presbyterian Church
5300 Delmar Boulevard
St. Louis, MO 63112

Brown, William R.
Dean of Arts and Sciences
Rural Development Consultant
Central Connecticut State College
New Britain, CN 06050

Bruno, Jose
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
Peru

Buchele, Wesley F.
Professor
Agricultural Engineering Department
Iowa State University
239 Parkridge Circle
Ames, IA 50010

Buddemeier, Barbara (Mrs. W. D.)
3004 Meadowbrook Court
Champaign, IL 61820

Buddemeier, W. D.
Director, International Agricultural Programs
Associate Dean, College of Agriculture
113 Mumford Hall
University of Illinois
Urbana, IL 61801

Butler, J. L.
Research Leader and Technical Advisor
USDA-SEA-FR
Coastal Plain Experimental Station
Tifton, GA 31794

Cade, William M.
Staff Engineer — Overseas Engineering
International Harvester Company
7S-600 County Line Road
Hinsdale, IL 60521

Calavan, Michael M.
Assistant Professor, Anthropology
Department of Sociology
Illinois State University
Normal, IL 61261

Campbell, Joseph K.
Associate Professor
308 Riley-Robb Hall
Cornell University
Ithaca, NY 14853

Carpenter, James R.
Peace Corps — Agriculture
1 North Wacker Drive, Room 322
Chicago, IL 60606

Casyao, Jean
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
Philippines

*Chancellor, William J.
Professor, Agricultural Engineering
Department of Agricultural Engineering
University of California
Davis, CA 95616

Chavez, Arturo J.
Senior Technical Adviser
United Nations Development Program
1 United Nations Plaza
New York, NY 10017

Chowdhury, S. D.
Member, Bangladesh Planning Commission
9 Shamouly
Dacca 15, Bangladesh

Clark, Reverend Michael J.
Agribusiness Coordinator
Interfaith Center on Corporate Responsibility
475 Riverside Drive, Room 566
New York, NY 10027

Codrea, George Richard
Senior Program Officer
Volunteers in Technical Assistance (VITA)
3706 Rhode Island Avenue
Mount Rainier, MD 20822

Cohen, Alan M.
Director, Illinois Food Committee
P.O. Box 2674 Station A
Champaign, IL 61820

Cook, Gayla J.
Consultant, Agricultural Teams, Incorporated
P.O. Box 283
Ithaca, NY 14850

Craig, Eleanor, S.L.
Representative of Region VI
Member of ICCR
Sisters of Loretto
Nerinx, KY 40049

Crummey, Donald Edward
Visiting Associate Professor, African History
Department of History
309 Gregory Hall
University of Illinois
Urbana, IL 61801

* Speaker

Cuddihy, William
Economics and Policy Division
The World Bank
1818 H Street NW
Washington, DC 20433

Cummings, Ralph W., Jr.
Program Officer
International Agricultural Development Service
1133 Avenue of the Americas
New York, NY 10036

Dahl, Howard A.
Director
Concord, Incorporated
112 South 21st Street
Fargo, ND 58102

Darring, Gerald
Assistant Marketing Manager
OPICO
P.O. Box 849
Mobile, AL 36618

Davies, Kolanok
Agricultural Mechanics Program
c/o Ronald Heisner — Kishwaukee College
Malta, IL 60150
Nigeria

De Boer, Alvin John
Economist, Agro-Economic Division
International Fertilizer Development Center
P.O. Box 2040
Muscle Shoals, AL 35660

Deo, Susan R.
Wesley Foundation Hunger Task Force
Center for Advanced Study
912 West Illinois
University of Illinois
Urbana, IL 61801

Derr, Merlin
Export Marketing Administrator
Deere & Company
John Deere Road
Moline, IL 61265

DeWalt, Billie R.
Assistant Professor, Anthropology
University of Kentucky
Lexington, KY 40506

Diebold, Steven
Export Manager
Agro-Tierra Division of Kalamazoo
International, Incorporated
P.O. Box 271
South Haven, MI 49090

*Dovring, Folke
Professor, Land Economics
Department of Agricultural Economics
310B Mumford Hall
University of Illinois
Urbana, IL 61801

Dowding, Maurice
President
Dowding Tool Products
8950 Narrow Lake
Springport, MI 49284

Due, Jean M.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

Dunlade, Usman
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
Nigeria

Eickmeyer, Irvin A.
Manager, Product Planning and
Joint Ventures–Licensees
International Harvester Company
401 North Michigan Avenue
Chicago, IL 60611

Ellington, Lynn
Peace Corps — VISTA Representative
ACTION — University of Illinois YMCA
1001 South Wright Street
Champaign, IL 61820

El-Marsout, Yusef
Arab Development Institute of Tripoli, Libya
1118 22nd Street NW
Washington, DC 20037

*Ensminger, Douglas
Professor, Agricultural Economics
Department of Agricultural Economics
University of Missouri
Columbia, MO 65201

**Esmay, Merle L.
Professor, Agricultural Engineering
Department of Agricultural Engineering
Michigan State University
East Lansing, MI 48824

Esmay, Mrs. Merle
East Lansing, MI 48824

Faust, John R.
Professor, Political Science
Department of Political Science
Eastern Illinois University
Charleston, IL 61920

Fife, L. S.
Manager, Economic Research–Planning
International Harvester Company
401 North Michigan Avenue
Chicago, IL 60611

Finch, Edwin O.
Associate Professor, Agricultural Engineering
Purdue University
West Lafayette, IN 47907

Foley, Reverend Gerald
Executive Director
National Catholic Rural Life Conference
3801 Grand Avenue
Des Moines, IA 50312

Gale, Horace E.
Treasurer, National Ministries
American Baptist Churches in the United States
of America
Valley Forge, PA 19481

* Speaker
** Discussion leader

GARRIGUS, Upson
Professor, Animal Science and International Agriculture
Associate Head, Department of Animal Science
332 Mumford Hall
University of Illinois
Urbana, IL 61801

GARWOOD, Everett
Lutheran Missionary to the Philippines
Lutheran Church — Missouri Synod
500 North Broadway
St. Louis, MO 63102

GBETIBOUO, Mathurin
Graduate Student, Department of Agricultural Economics
Center of Economic and Social Research
University of Illinois
2315 South First, #201
Champaign, IL 61820
after July 10, 1978:
CIRES, Université d'Abidjan
Abidjan, IVORY COAST

GEGO, (-Ing) Arno
Director of Agricultural Engineering
Klöckner-Humboldt-Deutz Ag, Cologne
Deutz-Kalker-Strasse 18-26
D-5000 Köln 21, WEST GERMANY

GIDAY, Tilahun
Consultant
Agricultural Teams Incorporated
40 Marietta Street NW
Atlanta, GA 30303

GILL, William
Agricultural Engineering
The Ohio State University
30 Lee Terrace
Westerville, OH 43081

GLUSAC, Dusan
Researcher, Yugoslavia Maize Project,
International Agricultural Programs
College of Agriculture
113 Mumford Hall
University of Illinois
Urbana, IL 61801
YUGOSLAVIA

GODEC, Helga
Researcher, Yugoslavia Maize Project,
International Agricultural Programs
113 Mumford Hall
University of Illinois
Urbana, IL 61801
YUGOSLAVIA

GOERING, Carroll E.
Professor, Agricultural Engineering
100 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

GREENLEY, Oliver M.
Work with Self Help
100 12th Street NW
Independence, IA 50644

GREGORY, Wade F.
Program Leader — Developing Countries
ESCS-USDA
500 12th Street SW, Room 398
Washington, DC 20250

GRISLEY, William
Graduate Student/Research Assistant
Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

GUPTA, Brijen K.
Program Director
Council on International and Public Affairs
Box 5137 River Station
Rochester, NY 14618

HABERERN, John
Corporate Vice President
Rodale Press, Incorporated
33 East Minor Street
Emmaus, PA 18049

HAGENS, Elizabeth
Director, Acorn Midwest Communications
Governors State University
Park Forest South, IL 60466

*HAKES, E. William
Director, Product Management
Massey-Ferguson, Ltd.
200 University Avenue
Toronto, Ontario M5H3E4, CANADA

* Speaker

HANDLER, Paul
Resident Professor of Physics
Director of Population Dynamics Group
57A Coordinated Science Laboratory
University of Illinois
Urbana, IL 61801

HANNA, Tom
Product Engineer
Dowding Tool Products
8950 Narrow Lake
Springport, MI 49284

HANSELMAN, Paul M.
President
International Farming Systems, Incorporated
P.O. Box 832
Wheaton, IL 60187

HARRINGTON, Janet L.
Engineering Student
University of Illinois
(3500 27th Avenue Court
Moline, IL 61265)

*HARRINGTON, Roy E.
Product Planner
Deere & Company
John Deere Road
Moline, IL 61265

HARRIS, Tom
Forward Marketing Plans
Ford Tractor Operations
2500 East Maple Road
Troy, MI 48084

HATCH, Reverend Maynard F.
Member, Board of the Mid-American Baptist Region
Mid-American Baptist Churches
434 Baltimore
Waterloo, IA 50701

HAY, Ralph C.
Professor of Agricultural Engineering, Emeritus
and Consultant
University of Illinois
2108 Lynwood
Champaign, IL 61820

* Speaker

HEISNER, Ronald
Project Director
AID Nigerian Manpower Project
Kishwaukee College
Malta Road
Malta, IL 60150

HIMOE, Albert
Research Associate, Agriculture Department
160 Davenport Hall
University of Illinois
Urbana, IL 61801

HINKSON, Nelson C.
European Marketing Representative
Concord, Incorporated
Unterer Schreiberweg 38
Vienna 1190, AUSTRIA

HONG, Eun Hi
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
KOREA

HOWLAND, Ray C.
Executive Director
Self Help Foundation
P.O. Box 88
Waverly, IA 50677

HUNT, Donnell
Professor, Agricultural Engineering
104 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

IVERSEN, J. Terry
Head, Continuing Education in International Affairs
205 Arcade Building
University of Illinois
Champaign, IL 61820

JEDLICKA, Allen
Associate Professor, Organizational Behavior
School of Business
University of Northern Iowa
Cedar Falls, IA 50613

JENKINS, G. Willard
Manager, Utility Tractor Engineering
Product Engineering Center
Deere & Company
P.O. Box 270
Waterloo, IA 50704

JENSEN, Doris (Mrs. John)
Vice President
Agro-UTIL, Division of Kalamazoo International, Incorporated
P.O. Box 271
South Haven, MI 49090

JENSEN, John C.
President
Agro-UTIL, Division of Kalamazoo International, Incorporated
P.O. Box 271
South Haven, MI 49090

JILANI, Atiq A.
16514 Oxford Drive
Tinley Park, IL 60477

JILANI, Khalida (Mrs. Atiq)
16514 Oxford Drive
Tinley Park, IL 60477

JOGLE, Salad Mohamed
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
SOMALIA

JONES, Reece A.
Professor of Geography, Emeritus
Western Illinois University
Route 4
Macomb, IL 61455

JOSEPH, Barbara Ann
Graduate Student, Secondary Education
618 Daniels Hall
1010 West Green Street
Urbana, IL 61801
TRINIDAD

JUDY, Barbara (Mrs. William)
2207 Vawter
Urbana, IL 61801

JUDY, William H.
INTSOY Agronomist, Associate Professor
Department of Agronomy
N-50 Turner Hall
University of Illinois
Urbana, IL 61801

KAMAJOU, Francois
Faculty
University of Yaoundé (ENSA) B.P. 138
CAMEROON

KELLER, H. Peter
General Sales Manager
John Deere Intercontinental, Ltd.
909 3rd Avenue
Moline, IL 61265

**KELLOGG, Earl D.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

KHALILI, Ahmad Sasan
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
IRAN

*KHAN, Amir U.
International Rice Research Institute
IRRI-PAK, Agricultural Machinery Program
73-A, Satellite Town
Rawalpindi, PAKISTAN

KHAN, Mozammel H.
Graduate Research Assistant
330 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

KHONJE, D. J.
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
MALAWI

* Speaker
** Discussion leader

Kim, Kyeong Uk
Graduate Student, Agricultural Engineering
241 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801
Korea

Kirby, Joseph
Graduate Student, Agricultural Economics
University of Illinois
104 South Gregory, Apartment 33
Urbana, IL 61801

*Kishida, Yoshisuke
President, Shin-Norinsha Company, Ltd.
Farm Machinery Industrial Research Corp.
7, 2-chome, Kanda Nishikicho
Chiyodaku, Tokyo, 101 Japan

Kozel, Richard G.
Associate Professor, Mechanical Engineering
1513 University Avenue
University of Wisconsin
Madison, WI 53706

Kramer, Robert C.
Program Director
W. K. Kellogg Foundation
400 North Avenue
Battle Creek, MI 49016

Krutz, Gary
Assistant Professor
Agricultural Engineering Department
Purdue University
West Lafayette, IN 47907

Lari, Abolghasen Amini
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
Iran

Lee, Daniel E.
Assistant Professor of Religion
123 Old Main
Augustana College
Rock Island, IL 61201

Lembke, Walter D.
Professor, Agricultural Engineering
208 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

Leslie, C. William
Sales Representative
Brinly-Hardy Company, Incorporated
P.O. Box 1116
Louisville, KY 40201

Liburd, Ossie
Director of Agronomic Services
Agricultural Missions, Incorporated
475 Riverside Drive, Room 624
New York, NY 10027

Lynge, Morgan J., Jr.
Assistant Professor, Finance
470A Commerce West
University of Illinois
Urbana, IL 61801

*McLaughlin, Martin M.
Senior Fellow
Overseas Development Council
1717 Massachusetts Avenue NW
Washington, DC 20036

McMennamy, John Allen
Associate Agricultural Engineer
International Rice Research Institute
P.O. Box 933
Manila, Philippines

Madden, Patrick
Professor, Agricultural Economics
Pennsylvania State University
104 Weaver Building
University Park, PA 16802

Mansouri, Gholamreza
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
Iran

Marko, Paul N.
Head, Wheat Training
International Maize and Wheat Improvement Center
Londres 40 Apdo. Postal 6-641
Mexico City 6, Mexico

* Speaker

MARKS, Gerald M.
Director
U.S. Department of Commerce
2738 Lincoln Lane
Wilmette, IL 60091

MARLEY, Stephen J.
Professor, Agricultural Engineering
105 Davidson Hall
Iowa State University
Ames, IA 50010

MERCHANT, Nazir Mohammed
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
PAKISTAN

MILLER, Robert C.
Director of Agricultural Activities
WLW-Radio
901 Elm Street
Cincinnati, OH 45202

MITTAL, Vijay Kumar
Agricultural Engineer
Department of Agricultural Engineering
University of Illinois
Urbana, IL 61801
after May 28, 1978:
Punjab Agricultural University
9/2 P.A.U. Campus
Ludhiana 141004, INDIA

MORALES, Andres
Rural Development Consultant
Charles T. Main, Inc.
Southeast Tower Prudential Center
Boston, MA 02199

MSHELIA, Dasika
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
NIGERIA

NDANA, Elija
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
NIGERIA

NELSON, Rupert
Agricultural Missionary
American Baptist Foreign Mission Society
105 North Ninth Avenue
Bozeman, MT 59715

NESTRICK, Donald E.
Executive Board, American Baptist Men
Box 177
Jerseyville, IL 62052

NEUHAUSER, Paul
Episcopal Church — ICCR
Professor of Law
University of Iowa
Iowa City, IA 52240

NIELSEN, Reverend Ove
Assistant Executive Director
Lutheran World Relief
360 Park Avenue South
New York, NY 10010

OBARI, Khaled Said
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
SYRIA

OBIJOLE, Ibikunle
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
NIGERIA

OGUNTONA, Lawson Olukayode
Student
Nigerian Manpower Technical Training Program
c/o Agency for International Development
Washington, DC 20523
830 Edgebrook Drive, Apartment 110
DeKalb, IL 60115
NIGERIA

O'LEARY, Basil
Professor of Economics
University of Notre Dame
Notre Dame, IN 46556

OLSEN, J. Arnold
Clergyman
United Methodist Church
1768 North Maple Avenue
Decatur, IL 62526

OREDOLA, Masudi
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
NIGERIA

O'ROURKE, Bishop Edward W.
Bishop of Peoria
Catholic Diocese of Peoria
607 Northeast Madison
Peoria, IL 61603

PARK, Seung Woo
Graduate Student, Agricultural Engineering
330 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

PEARSON, Billy M.
Minister
Member, Conference Task Force on World Hunger
Central Illinois Conference of the United
Methodist Church
P.O. Box 29
Coal City, IL 60416

PERALTA, Palmera
Advocacy/Coordinator
Global Justice and Development
Lutheran Church in America
231 Madison Avenue
New York, NY 10016

PRUYNE, Reverend James
Campus Ministry
United Campus Christian Foundation
210 West Mulberry
Normal, IL 61761

RAO, Swamy
Senior Interregional Adviser on Engineering Industries
United Nations Industrial Development Organization
P.O. Box 837, UNIDO
Vienna, AUSTRIA

RAY, Howard E.
Rural Development Adviser
Academy for Educational Development
2526 East Blanton Drive
Tucson, AZ 85716

REESER, Lyle G.
Agricultural Consultant
Caterpillar Americas Co.
100 Northeast Adams Street
Peoria, IL 61629

RICHEY, Clarence B.
Professor Emeritus
Purdue University
2217 Delaware Drive
West Lafayette, IN 47906

RODDA, Erica (Mrs. Errol D.)
2208 Grange Circle
Urbana, IL 61801

RODDA, Errol D.
Professor, Agricultural Engineering
236 Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

RUBIN, Jenna
Ecological Agriculture Coordinator
Students for Environmental Concerns
1001 South Wright Street
Champaign, IL 61820

RUSHING, Vaudra M.
Program Counselor, United Methodist Church
Central Illinois Conference Council on Ministries
1211 North Park Drive, Box 2050
Bloomington, IL 61701

RUSSELL, M. B.
Consultant
International Crops Research Institute
Semi-Arid Tropics
Hyderabad, INDIA

Ryu, Kwan Hee
Graduate Student, Agricultural Engineering
University of Illinois
1934-C Orchard Street
Urbana, IL 61801
KOREA

Sakai, Jun
Associate Professor
Faculty of Agriculture, Mie University
C-21 Daigaku-Shukusha, 511 Kannonji-Cho
Tsu, Mie, JAPAN 514

Sandman, Robert
Central Illinois Association Minister
United Church of Christ
2508 North Sheridan Road
Peoria, IL 61604

Sani, Yusaf
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
NIGERIA

Sanin, Mario
Assistant Manager
The First National Bank of Chicago
1 First National Plaza
Chicago, IL 60670

Santas, John
Training Officer
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801

*Savio, Martha
Director, Corporate and Social Responsibilities
in Investments, National Ministries — American
Baptist Churches in the United States of America
Valley Forge, PA 19481

Saylor, Jerry
Manager, Economic Research–Agriculture
Deere & Company
John Deere Road
Moline, IL 61265

Schmidt, Stephen C.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

Schrag, Norman
Escort Officer
Department of State
Washington, DC 20520

Seed, John R.
Pastor, Trinity United Methodist Church
Springfield, IL 62702

*Sen, S. R.
41, Poorvi Marg
Vasant Vihar
New Delhi 110057, INDIA

Severns, Willard
Vice President
Land of Lincoln Soybean Association
Rural Route 1
Moweaqua, IL 62550

Sharma, Raj
Visiting Professor
Department of Economics
330 Commerce West
University of Illinois
Urbana, IL 61801

Siemens, John C.
Professor, Agricultural Engineering
100a Agricultural Engineering Building
University of Illinois
Urbana, IL 61801

Skromme, L. H.
Vice President for Engineering
Sperry New Holland
New Holland, PA 17557

Slater, Lloyd E.
Manager, Food and Climate Forum
Aspen Institute for Humanistic Studies
1919 Fourteenth Street, #811
Boulder, CO 80302

* Speaker

SMITH, Cynthia Jean
Assistant
International Agricultural Programs
University of Illinois
910 South First
Champaign, IL 61820

SMITH, Phyllis
Department of Agricultural Communications
University of Illinois
1836 Valley Road
Champaign, IL 61820

SOFRANKO, Andrew J.
Associate Professor of Rural Sociology in
Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

SPENCER, Kendall
Member of the Board of Directors
Concord, Incorporated
83B Westmoreland Drive
Vernon Hills, IL 60061

STEWART, Alberta (Mrs. John)
Stewart Seeds, Inc.
Rural Route 8, Box 227
Greensburg, IN 47240

STEWART, John A.
Stewart Seeds, Inc.
Member, National Board of American Baptist Churches
Rural Route 8, Box 227
Greensburg, IN 47240

STIKELEATHER, Larry F.
Manager, Product Planning
Agricultural Equipment Sector
Allis-Chalmers Corporation
P.O. Box 512
Milwaukee, WI 53201

STRASMA, Reverend James
Associate Pastor, Grace United Methodist Church
Member, Task Force on World Hunger
Central Illinois Conference of the United
Methodist Church
440 East Kellar Lane
Decatur, IL 62526

SUAREZ, Juan Carlos
INTSOY
58 Mumford Hall
University of Illinois
Urbana, IL 61801
Misiones, ARGENTINA

SUTHERLAND, Russell
Director, Product Planning
Deere & Company
John Deere Road
Moline, IL 61265

SWANSON, Earl R.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

*THIESENHUSEN, William C.
Professor, Agricultural Economics
Department of Agricultural Economics
University of Wisconsin
Madison, WI 53706

THOMPSON, William Neil
Associate Director, International Agricultural Programs
Director, INTSOY
113 Mumford Hall
University of Illinois
Urbana, IL 61801

THOMSON, Ralph
Director, Corporate Strategy, and Special Assistant
to the Chief Executive Officer
Control Data Corporation — Headquarters 11D
P.O. Box 0
Minneapolis, MN 55440

THORNTON, Dennis C.
Sales Manager
Earthway Products, Inc.
P.O. Box 547, Maple Street
Bristol, IN 46507

TING, K. C.
Graduate Resident Assistant, Agricultural Engineering
University of Illinois
406 East Clark, Apartment C
Champaign, IL 61820

* Speaker

Wilkinson, Robert H.
Associate Professor, Agricultural Engineering
Agricultural Engineering Department
Michigan State University
East Lansing, MI 48824

Williams, Sheldon W.
Professor, Agricultural Economics
305 Mumford Hall
University of Illinois
Urbana, IL 61801

Wilson, Brother John, O.P.
Intern at Eighth Day Center for Justice
22 East Van Buren
Chicago, IL 60605

Wismer, Bob
Technical Center
Deere & Company
3300 River Drive
Moline, IL 61265

Woelfel, Arlene
Staff Member
Illinois Committee for Responsible Investment
22 East Van Buren
Chicago, IL 60605

Yoder, Chaplain Larry
Lenoir-Rhyne College
Box 410 LR Station
Hickory, NC 28670

Yow, Kim-Van
Graduate Research Assistant
University of Illinois
307 East John Street
Champaign, IL 61820

Yunuso, Najume
International Student
Agricultural Mechanics Program
c/o Ron Heisner — Kishwaukee College
Malta, IL 60150
Nigeria

Ziorgen, Ralph H.
Marketing
Hefty Tractor Company
P.O. Box 188
Hartford, WI 53027

Single copies of this publication are free of charge.

Single copies and information concerning cost of quantity requests may be obtained from

Roy E. Harrington
Product Planning Department
Deere & Company
John Deere Road
Moline, Illinois 61265
United States of America