PROCEEDINGS OF THE

INTERNATIONAL AGRICULTURAL MACHINERY WORKSHOP

THE INTERNATIONAL RICE RESEARCH INSTITUTE

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FOREWORD

Agricultural mechanization can play a vital role in helping small farmers increase their total food production. Its primary goal is to encourage timeliness of operations that will permit small farmers to take advantage of the potential of modern varieties and of crop intensification.

Both national research organizations and IRRI have developed rices that produce in 100 to 1 10 days a grain yield equal to or greater than that of traditional rice varieties requiring 130 to 150 days. When this grain of 30 to 40 days due to shortened growth duration is coupled with mechanization, which can reduce turnaround time from about 4 weeks to as little as 1 week, time for growing an additional crop is available.

Suitable agricultural engineering technologies make possible crop intensification by performing promptly such operations as land preparation, threshing, and planting, thereby markedly reducing turnaround time between the harvest of one crop and the planting of the subsequent crop. Proper engineering techniques for in-soil placement of chemicals can also increase the crop production efficiency of fertilizers and pesticides. Likewise, low-cost pumps can provide supplemental irrigation during periods of critically low soil moisture.

In recent years emphasis has been placed on the tailoring of agricultural engineering technology to local farming needs and industrial capabilities. Engineers have also become more sensitive to potential problems of labor displacement. The Agricultural Engineering program of the International Rice Research Institute has developed during the past decade a range of designs matched specifically to the small farm environment of developing countries. More recently, resources have been allocated to the development of a suitable mechanism for the transfer of the developed technology to local manufacturers in countries where such technology is to be used.

This Industrial Extension Workshop was convened at IRRI to discuss the results of an intensified technology transfer effort initiated in 1974 and to suggest means for improving the program. Agricultural engineers, manufacturers, and scientists from 16 countries with a broad range of interest in manufacturing, engineering research and development, and the economic and sociological aspects of farm mechanization participated in the deliberations. Along with the broad consensus that industrial extension is an indispensable element in the IRRI small farm machinery development program, specific recommendations to improve the delivery system were made. Several recommendations were subsequently incorporated into the extension activities of the IRRI program.

In workshop discussions, significant differences were noted in the level and composition of mechanization in different nations and in the means available to translate basic design information into viable, low-cost, locally produced machines which are widely accepted by farmers. Strengthening of national institutions and expanding the capabilities for research and development of agricultural machinery for small-scale farmers and for extension of the technology to the local manufacturing sector in those countries participating in the small machinery network were identified as priority areas. A clearer set of guidelines was also developed to direct the efforts of the IRRI farm machinery program and national institutions.

The strong support expressed by the workshop participants for the IRRI program and the small machinery network suggested that many opportunities exist to improve the efficiency and effectiveness of the IRRI program through a continuing exchange of information and ideas with agricultural engineers, scientists, and institutions involved in similar work.

N. C. BRADY
Director General, IRRI

IRRI FARM MACHINERY DEVELOPMENT PROGRAM NETWORK

Goal is to help rice farmers get suitable equipment

The Agricultural Engineering Department participates in IRRI's effort to increase world rice production. The Engineering program helps small to medium size rice farmers in the developing countries obtain improved agricultural equipment that is technically and economically suited to local needs. These machines can contribute to increased food production through increased yields, reductions in field and post-production losses, increased cropping intensity, and improvement in quality and value of agricultural products. Appropriate machines can also reduce costs - a direct benefit to the low-income rice consumer.

Organization

Network of projects extends to 10 countries

A network of 11 formal collaborative projects with organizations in 10 countries outside the Philippines extends this help to farmers through the local farm machinery industry. A basic tenet of the program is that mechanization based on local production conserves foreign exchange, expands opportunities in rural-based industries, strengthens linkages between agriculture and other sectors of the economy, and enhances training opportunities in small-scale manufacturing.

The core program in the Philippines has continued to focus its attention on research and development activities that cannot be effectively carried out by the network cooperators because of limited staff and resources.

Provides opportunity to test and improve technology under local conditions

The know-how developed by IRRI is transferred to the network cooperators, who are in a better position to test and improve the technology under local conditions before passing it on to local cooperating manufacturers. It is clearly impossible for the core program to develop machines that are suited to the wide range of conditions found in all developing countries, but feedback from the network has helped greatly in assigning project priorities and identifying problem areas of widespread significance.

Information interchange and training are part of program

The flow of information between IRRI and network members is maintained through a periodic exchange of progress reports and newsletters. In addition, personal correspondence and visits are used to communicate more location specific information. IRRI holds a 2-week training course on the design, operations, and maintenance of IRRI-designed machines twice each year for the staff of network cooperators and cooperating manufacturers.

Funding

Industrial extension is funded by USAID and IRRI

Network projects fall into two categories - USAID funded industrial extension projects and IRRI core budget funded industrial extension subcontracts. There is a difference in the scope and level of funding for these two types of projects. The USAID projects are staffed by teams located in Pakistan, Thailand, and the Philippines. Each team consists of an IRRI industrial extension engineer and about six direct hire support staff.

Public or private in-country organizations host subcontract projects

IRRI's machinery development program was funded by USAID until the end of 1974 when support was shifted to IRRI's core budget. IRRI's contract with USAID permitted subcontracting of extension projects in countries outside the Philippines, and the term "subcontract" is still used even though these small extension projects are now core-funded. The subcontract projects are hosted by public or private in-country organizations that have objectives congruent with those of IRRI's machinery development program. Modest funding is provided to support the execution of the project by supplementing salaries, travel expenses, and direct costs. Overhead and administrative expenses are usually absorbed by the cooperating organization.

Projects

Pakistan and Thailand projects give technical assistance to neighboring countries

The projects in Pakistan and Thailand are collaborative and have several support staff from the counterpart organizations participating in project activities. These programs are regional and provide technical assistance to neighboring

countries. Their basic objective is to identify manufacturers that are interested in producing IRRI – designedmachines and to provide them with technical support. As a part of these basic activities, the project staff conducts economic and market evaluation studies to determine which machines offer the greatest potential for adoption, conducts tests to determine the performance of IRRI-designed machines under local conditions so that adaptive design and development can be performed as needed, and provides business and management guidance to manufacturers entering production with IRRI-designed machines.

Philippines extension team backstops others with technical and logistic support

Like the extension teams in Pakistan and Thailand, the project in the Philippines promotes use of IRRI-designed machines and provides technical assistance to local manufacturers, but it also serves in two additional roles. The extension team in the Philippines backstops the other two extension teams with technical and logistic support. A third area of responsibility is to manage the IRRI core budget-supported subcontract programs and other industrial extension-related efforts not handled by extension teams in Pakistan and Thailand. The Philippine Industrial Extension Program is oriented toward providing technical assistance to manufacturers since the continuing efforts of IRRI Machinery Development Program staff preclude the need for as much promotion and product adoption as in Pakistan and Thailand.

Subcontract programs aid in local manufacture of IRRI-designed machines

The objective of the subcontract programs are to promote and assist the local manufacture and marketing of IRRI-designed machines, to test and evaluate the performance of these machines under local conditions, to encourage adaptive and applied research on problems related to agricultural mechanization, and to foster the exchange of information dealing with agricultural machinery.

Unfunded linkages have also been developed with several organizations in Asia, Africa, and Latin America. As in the case of subcontract projects, organizations with interests in promoting the use of appropriate small scale machines is involved. Typically, one staff member of the cooperating organization works on a time-available basis in assisting IRRI's industrial extension efforts.

PERSONS INVOLVED IN THE IRRI FARM MACHINERY DEVELOPMENT PROGRAM NETWORK

USAID Industrial Extension Projects

Mr. John A. McMennamy
IRRI, P. O. Box 933
Manila, Philippines

Dr. Amir U. Khan
IRRI-Pakistan Agricultural Machinery Program
c/o LAPSA, P. O. Box 1237
Islamabad, Pakistan

Mr. P. Stewart Barton
IRRI-Thai Machinery Development Program
G.P.O. Box 2453
Bangkok, Thailand

Industrial Extension Subcontract Program Offices

Dr. K. N. Singh
Agricultural Engineering Dept.
G.B. Pant University of Agriculture & Technology
Pantnagar, Distt. Nainital
Uttar Pradesh, India

Ir. Dadang Tarmana, Project Officer
Directorate of Food Crops Production
Department of Agriculture
Pasar Minggu, Jakarta
Indonesia

Mr. Ayob bin Sukra, Branch Head
Agricultural Engineer
Water Management & Central Workshop
MARDI, Bat Berkunci No. 202
Pejabat Pos Universiti Pertanian
Serdang, Selangor, Malaysia

Dr. Sung Kum Han, Director
Institute of Agricultural Engineering & Utilization
Office of Rural Development
Suweon, Korea

Mr. M. Suri, President
Suri Research Foundation
B-14 Greater Kailash
New Delhi - 110 003
India

Mr. S. Kathirkamathamby
Superintending Engineer
Engineering Research & Development Division
Department of Agriculture
Peradeniya, Sri Lanka

Dr. Kazi M. Badruddoza
Executive Vice Chairman
Bangladesh Agricultural Research Council
130-B Road 1, Dhanmandi
Dacca - 5, Bangladesh

Ing. Rolf Kaeser
Assistencia Technical a la Industria
Apartado Aereo 8053
Cali, Colombia

Mr. B. B. Khadka
Director General
HMG Dept. of Agriculture of HMG of Nepal, Harihar Bhawan
Pulchowk, Lalitpur, Nepal

PARTICIPANTS

ASTIKA, K. S. Dept. of Anthropology, Faculty of Letters, University of Indonesia, Jakarta, Indonesia

BAHGAT, A. Consultant Agricultural Engineer, The Ford Foundation, P. O. Box 2344, Cairo, Egypt

BARTON, P. S. Industrial Extension Engineer, International Rice Research Institute, G.P.O. Box 2453, Bangkok, Thailand

BINSWANGER, H. Economist, ICRISAT, 1-11-256, Begumpet, Hyderabad 500 016 A.P., India

BOSSHART, R. P. General Manager, Instituto de Pesquisas IRI, Caixa Postal 258, 66000 Belem, Para, Brazil

BRADY, N. C. Director General, The International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines

CASTILLO, G. Department of Rural Sociology, University of the Philippines at Los Baños, College, Laguna, Philippines

CHAKKAPHAK, C. Head, Workshop and Service Section, Agricultural Engineering Division, Ministry of Agriculture and Cooperatives, G.P.O. Box 2453, Bangkok, Thailand

CHANCELLOR, W. Professor, Department of Agricultural Engineering, University of California, Davis, California 95616, USA

CLAY, E. J. A/D/C Associate, The Agricultural Development Council, P.O. Box 98, Ramna, Dacca-2, Bangladesh

DIAS, M. D. P. Somasiri Huller Manufactory, 18, Parkrama Avenue, Kohuwala, Nugegoda, Sri Lanka

DUFF, B. Associate Agricultural Economist, Agricultural Engineering Department, The International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines

FRANCISCO, E. Consultant, Management Staff, Department of Agriculture, Diliman, Quezon City, Philippines

HAN, S. K. Director, Institute of Agricultural Engineering and Utilization, Ministry of Agriculture and Fishery, Suweon, Korea

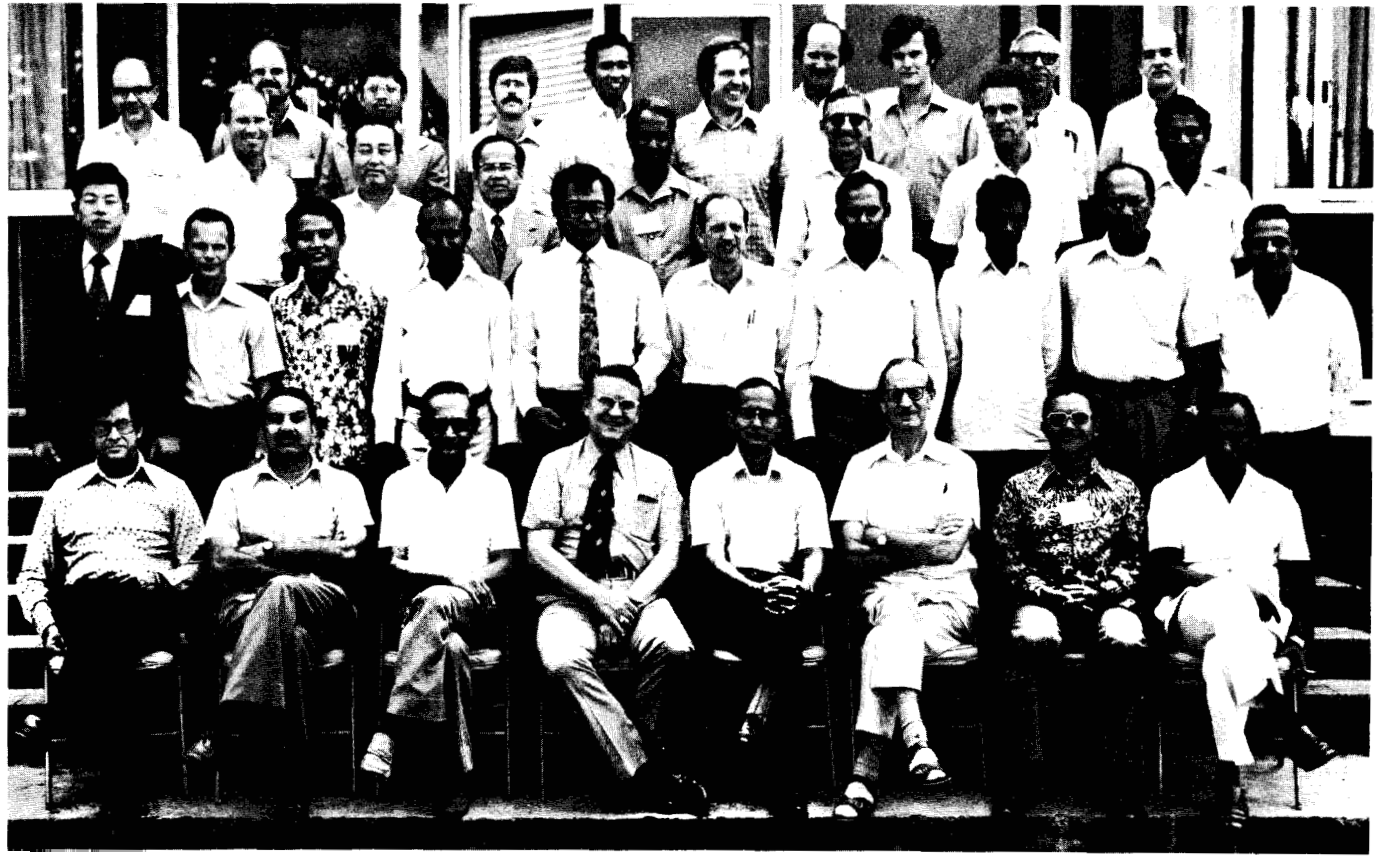
KAESER, R. SENA/ASTIN, Asistencia Technica a la Industria Metalica, Apartado Aereo 8053, Cali, Colombia

KHAN, A. U. IRRI-PAK Machinery Development Program, P. O. Box 1237, Islamabad,Pakistan

KISHIDA, Y. President, Shin-Norinsha Co., Ltd., 7,2-chome, Kanda Nishikicho, Chiyodaku, Tokyo, 101 Japan

KUETHER, D. O. Associate Agricultural Engineer, Agricultural Engineering Dept., The International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines

LANTIN, R. M. Acting Dean, Institute of Agricultural Engineering and Technology, UPLB, College, Laguna, Philippines



Front row left to right: Amir U. Khan, M. M. Suri, Elizardo Francisco. Nyle C. Brady, Hla Tin, Charles J. Moss, R. Dadang Tarmana, and M. D. P. Dias. *Second row left to right:* Yoshisuke Kishida, Don O. Kuether, Yuwono S., A. K. M. Moniruzzaman, Ayob Bin Sukra, P. S. Barton, Gajendra Singh, Bal Krishna Shrestha, Chak Chakkaphak, and Ahmed Bahgat. *Third row left to right:* Robert P. Bosshart, Sung Kum Han, Tien-Song Peng, V. R. Reddy, Gerald Thierstein, Rolf Kaeser, and K. N. Singh. *Fourth row left to right:* William Chancellor, L. Merrick Lockwood, Hector Sanvictores, John A. McMennamy, Reynaldo M. Lantin, Edward J. Clay, J. Bart Duff, Hans Binswanger, Marvin Parker, and Nelson Wall.

LOCKWOOD, L. M. Adviser, AATC, Bangladesh Agricultural Research Council, 130-8, Road 1, Dhanmandi, Dacca-5, Bangladesh

McMENNAMY, J. A. Associate Agricultural Engineer, Agricultural Engineering Department, The International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines

MONIRUZZAMAN, A. K. M. Director, Appropriate Agricultural Technology Cell, Bangldesh Agrl. Research Council, 130-8. Dhanmandi, Dacca-5, Bangladesh

Moss, C. J. Agricultural Engineer & Head, Agricultural Engineering Department, The International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines

PARKER, M. USAID, Consultant, Farms Systems Development Corp., Philippine Veterans Bank Bldg., Port Area, Manila, Philippines

PENG, T. S. Specialist, Joint Commission on Rural Reconstruction, 37 Nan Hai Road, Taipei, Taiwan

REDDY, V. R. IRRI Agrl. Engineering Consultant, Hotel Indonesia, Room#233 (Second Floor), P.O. Box 2132/JKT, Jakarta, Indonesia

YUWONO S. P. T. Purna Sadhana, Bandun JI. Asia Africa 150, P. 0. Box 192, Kawat, Indonesia

SANVICTORES, H. Executive Vice-president, Agricultural Machinery Manufacturers & Distributors Association, Ind., & General Sales Manager, SEA Commercial Co., Inc., 3085 R. Magsaysay Blvd., Sta. Mesa, Manila, Philippines

SHRESTHA, B. K. Agricultural Engineer, Ministry of Food, Agriculture and Irrigation, Department of Agriculture, Harihar Bhawan, Pulchowk, Lalitpur, His Majesty's Government, Nepal

SINGH, G. Associate Professor & Chairman, Division of Agricultural and Food Engineering, Asian Institute of Technology, P. 0. Box 2754, Bangkok, Thailand

SINGH, K. N. Head, Agricultural Engineering Department, G. B. Pant University, Pantnagar, Dist. Nainital, U.P., India

SUKRA, A. B. Head, Agricultural Engineering, Water Management, and Central Workshop Branch, Malaysian Agricultural Research and Development Institute, Bag Berkunci No. 202, Pejabag Pos Universiti Pertanian, Serdang, Selangor, Malaysia

SURI, M. M. President, Suri Research Foundation, B-14, Greater Kailash, New Delhi-48, India

TARMANA, R. D. Agricultural Engineer, Directorate of Food Crops Production, Department of Agriculture, Pasar Minggu, Jakarta, Indonesia

THIERSTEIN, G. Agricultural Engineer, ICRISAT, 1-1 1-256, Begumpet, Hyderabad 500 016, A.P., India

TIN, H. Assistant Director, Agricultural Mechanization Department, Ministry of Agriculture & Forest, No. 452, Prome Road, Rangoon, Socialist Republic of the Union of Burma

WALL, N. Economic Development Laboratory, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Georgia 30332, USA

STATUS OF AGRICULTURAL MECHANIZATION IN BANGLADESH

L. MERRICK LOCKWOOD
ADVISER, APPROPRIATE AGRICULTURAL TECHNOLOGY CELL
BANGLADESH AGRICULTURAL RESEARCH COUNCIL
130-B ROAD 1, DHANMANDI, DACCA, BANGLADESH

SUMMARY

In Bangladesh most agricultural operations are carried out using traditional implements and methods which do not rely on mechanization. Mechanization is most evident in irrigation technology where low-lift pumps and shallow and deep tube wells are being introduced on a wide scale to provide water during the dry season for an additional crop. A second area where mechanization is having a significant impact is in the rice processing industry where manual methods of rice processing are being replaced gradually by mechanized equipment.

Problems that must be dealt with when introducing mechanization at the farm level are the small land holdings (typically less than I ha), problems in organizing cooperatives to share equipment, and development of the infrastracture necessary to supply spare parts and maintenance for equipment.

Bangladesh has abundant resources in its industrial sector to manufacture equipment, and there are a number of organizations and institutions for research and development. Clear guidelines are needed, however, regarding the best choice of technology and methods of bringing these to the farmer in an integrated system that provides the necessary support in the form of training, maintenance, and supply of spare parts.

INTRODUCTION

Bangladesh is a fertile, alluvial flood plain with an extensive network of more than 24,300 km of rivers, streams, and canals formed by the river systems of the Ganges, Brahmaputra, and Surma. Of the total area of 14 million ha, 9 million are cultivated, with rice being grown on 7 million.

The climate of Bangladesh during the summer is warm and humid while the winter is cool and dry. During summer, monsoon rains and melting snow from far upstream cause the rivers to

swell and overflow. Usually one-third of the land area becomes flooded during this time.

In Bangladesh there is a wide variation in cropping practices; however, for rice three major cropping seasons can be identified.

The aus crop is broadcast sown sometime during March to May and is rain fed. Harvesting is carried out from June to August. Yields of this crop are low compared with the other two seasons.

The aman crop is presently the major rice crop of Bangladesh. Aman rice is transplanted after the aus harvest. Aman harvest takes place from October to January.

The boro crop is grown in the dry season and depends upon irrigation. Traditionally, boro rice has been grown in low-lying areas where the water table is high enough to allow manual irrigation of small areas. A major thrust in agricultural development in Bangladesh has been the introduction of mechanized irrigation programs that are bringing large areas of land under cultivation which previously remained unused during the dry season.

Besides rice there are several other crops of importance in Bangladesh. Jute, which is the major export of Bangladesh, is planted on about 0.5 million ha. Tea, another important export commodity, is planted on about 0.03 million ha, about 0.16 million ha of sugarcane are planted, and 0.2 million of vegetables. Cultivation of wheat is expanding and now totals about 0.16 million ha during the dry season; other winter crops are oilseeds, pulses, and legumes.

Irrigation has expanded rapidly over the past few years. In 1975-76 it was estimated that about 1 million ha (11% of the total rice area) were irrigated. Cropping intensity for rice is 1.47.

Bangladesh is populated by about 500 people per square kilometer. Out of a total population of about 70 million in 1974, it was estimated that about 91% lived in rural areas. And of a total labor force of about 25 million, agricultural labor accounted for about 14 million or 56% (Census Commission 1974).

Size of individual farms is small. Over 50% of the farms are less than 1 ha and over 95% are less than 5 ha (Bureau of Statistics, 1972).

CURRENT STATUS OF MECHANIZATION

Most agricultural operations in Bangladesh use traditional methods that rely on manual labor or animal power. Only in the cases of irrigation and rice processing has there been a significant impact from mechanization.

Land preparation

Virtually all land preparation is carried out with bullock–drawn plows. Subsequent operations use bullock–drawn or manual equipment for pulverizing and leveling the soil. Over the years different programs have been introduced to improve local implements or to introduce mechanized methods. To the present these have not had a significant impact in other than isolated areas.

The first concerted effort to introduce and evaluate mechanized cultivation was by the Bangladesh Agricultural Development Corporation (BADC). After the cyclone of 1970, BADC procured 125 tractors and 569 power tillers under the emergency Agricultural Rehabilitation Program in the cyclone–affected areas. This program was directed at solving an immediate problem and there were no long–term objectives regarding strategy and long–term evaluation of the impact of the equipment.

BADC drew up a pilot project after liberation to assess the feasibility of mechanization in selected areas of the country. Seventeen tractors and 79 power tillers were distributed in units of four or five each.

A third scheme for mechanized cultivation in war–affected area's was drawn up in July of 1972. This plan provided 500 tractors and 750 power tillers for emergency agricultural rehabilitation in war–affected border areas and flood–affected areas of Sylhet district. After repeatedly revising this scheme it was decided to sell the tractors and power tillers to the private sector.

Besides the efforts by BADC and other institutions and agencies of the Bangladesh government, a number of foreign organizations have experimented with the use of tractors, power tillers, and improved bullock–drawn implements. These are scattered efforts and can not, as yet, form the basis for major policy decisions in this area.

A basic problem encountered by the different programs has been the difficulty of setting up training, maintenance, and parts supply systems. For this reason none of the programs have yet been able to maintain working equipment in the field for a significant period.

Planting and transplanting

Planting and transplanting are almost exclusively manual operations. Some light, manually operated seed drills are manufactured in Bangladesh but they do not find widespread use. There is interest in finding a suitable seed drill that could be used for rice (aus), wheat, and jute.

Irrigation

Most of the planning efforts in agricultural mechanization have been focused on irrigation. A variety of program have been developed to provide farmers with water needed to grow additional crops during the dry season. Several irrigation projects under the Bangladesh Water Development Board control the ground water level in large tracts of land covering thousands of hectares. In one project (Dacca-Narayanganj-Demra), water is gravity fed from canals to the fields, while in others (Ganges-Kobadak, Chandpur) water is lifted from the canals with pumps.

The Bangladesh Agricultural Development Corporation has been in charge of a scheme for introducing deep tube wells and low-lift pumps of 2 cusec capacity for use by farmer cooperatives. Problems in organizing large cooperatives to provide the necessary maintenance, distribute the water equitably, and ensure timely payments for the equipment have led to a shift in interest to smaller irrigation units. It is expected there will be rapid expansion in the use of 1/2 cusec pumps powered by 5 to 6 hp diesel engines both as low-lift pumps and for shallow tube wells.

In spite of the problems encountered in selecting and introducing technology for irrigation, there has been a steady expansion in this area of agricultural mechanization. Table 1 gives a districtwise breakdown of use of low-lift pumps, shallow tube wells, and deep tubewells in 1975 (Ministry of Agriculture, 1976).

Manually operated shallow tube wells for irrigation (MOSTI) have also expanded in use within the past few years. Hannah (1976) points out that MOSTI have been in use in Bangladesh for years and that in the 1975-76 dry season 36,000 MOSTI were used to irrigate 8,000 ha, which is 15% of the area irrigated by other ground water technologies. Hannah also gives details of the distribution of MOSTI in Bangladesh (Table 2).

Although considerable attention has been given to the development of improved manually operated pumps for irrigation, farmers have adopted the standard Number 6 cast-iron pump that is commonly used in different parts of the country to pump drinking water.

Table 1. Distribution of low-lift pumps (LLP), shallow tube wells (STW), and deep tube wells (DTW) for 1975.

District	LLP	STW	DTW
1. Dinajpur	420	247	96
2. Khulna	986	221	5
3. Bogra	836	690	120
4. Rangpur	939	208	146
5. Mymensingh	5,609	377	707
6. Rajshahi	1,557	235	162
7. Jessore	588	212	273
8. Chittagong H.T.	333	-	-
9. Barisal	3,762	23	-
10. Dacca	3,823	261	455
11. Sylhet	3,852	5	4
12. Pabna	857	189	101
13. Faridpur	1,643	116	84
14. Kushtia	339	141	138
15. Noakhali	1,153	-	61
16. Comilla	3,574	185	575
17. Chittagong	3,162	24	40
18. Tangail	980	252	357
19. Patuakhali	1,163	-	-
Total	35,576	3,386	3,324

Weeding

Weeding is performed primarily with traditional hand implements produced by local artisans. An effort has been made to introduce a rotary, hand-pushed weeder for use in row planted rice fields. This design, which originally from Japan, has been adopted to a limited extent in one or two areas of Bangladesh but has not yet made a significant impact on the country.

Crop protection

Pesticides are procured and supplied through government channels up to the retail level in the village. Manually operated back pack sprayers €or applying pesticides are both imported and made locally.

Table 2. Location of manually operated shallow tube wells for irrigation by districts as of April 1976.

District	Number
1. Dinajpur	816
2. Rangpur	2,665
3. Bogra	13,879
4. Rajshahi	984
5. Pabna	220
6. Kushtia	383
7. Jessore	257
8. Khulna	25
9. Faridpur	2
10. Dacca	2,060
11. Tangail	286
12. Mymensingh	12,954
13. Noakhali	30
14. Chittagong	1,500
Total	36,061

Harvesting and threshing

Hand harvesting with sickles made by local blacksmiths is common. Threshing is handled using a combination of hand beating and treading with cattle. Japanese-type pedal threshers are manufactured by a few local firms and are in limited use in a few areas, but there is not a large demand for these machines.

Drying

Cereal grains as well as other agricultural commodities are dried by spreading them in the sun. Mechanical drying of agricultural commodities is almost nonexistent. There is keen interest in developing this capability to cope with increasing yields (and thus increasing drying demands) of the boro and aus crops which are harvested during the wet period. Owners of the larger rice mills are also anxious to obtain dryers so they can avoid the usual necessity of closing the mills for 2 to 3 months in the rainy season due to lack of sun for drying after parboiling.

Processing

Of the more than 10 million tons of paddy produced in Bangladesh annually, an estimated 80% to 90% or more is processed manually with dhenkis (foot operated mortar and pestle) by women in rural households. In recent years some of this rural processing has shifted to small "Engleberg" mills with approximate capacities of 1/4 t/h.

Rice consumed in urban areas and that for ration shops is processed mainly in major mills. These mills typically have capacities of 1 to 2 t/h; however most use the same Engleberg husking machines as the smaller rural mills. While husking mills in rural areas do not undertake parboiling, the major mills include it in their processing. Major mills and husking mills both make extensive use of manual labor for grain handling. Table 3 gives a districtwise breakdown of these two types of milling techniques in Bangladesh.

Table 3. Distribution of rice mills in Bangladesh.

District	Husking mills	Major mills
1. Dinajpur	360	40
2. Khulna	423	15
3. Bogra	413	7
4. Rangpur	308	6
5. Mymensingh	308	5
6. Rajshahi	427	7
7. Jessore	440	-
8. Chittagong H.T.	71	-
9. Barisal	443	2
10. Dacca	308	7
11. Sylhet	924	24
12. Pabna	305	-
13. Faridpur	291	1
14. Kushtia	227	-
15. Noakhali	508	1
16. Comilla	329	1
17. Chittagong	1,138	21
18. Tangail	119	-
19. Patuakhali	70	1
Total	7,472	138

Local artisans

Virtually all present agricultural implement needs of farmers in Bangladesh are met by local artisans, such as blacksmiths and carpenters. Higher quality metal tools for digging and cutting are available from shops in towns and cities if the farmer is willing to pay the higher cost. These implements are either imported or manufactured locally in more capital intensive facilities.

Small rural and urban workshops

Cities, towns, and many villages have workshops that provide maintenance and repair facilities. They can also manufacture spare parts for motor vehicles and industrial equipment such as rice and oil mills. In the larger urban centers there exists a much wider range of industries. Their maintenance needs are met by a multitude of small workshops equipped with lathes, drill presses, welding equipment, and in many cases more sophisticated equipment such as milling machines and shapers.

Manufacturers

Most of the larger cities of Bangladesh have metal working firms equipped with foundries and machine shops which are capable of producing a variety of products from castings and stock material.

Large-scale industries

The Bangladesh Machine Tool Factory is being developed to supply machine tools for the needs of the country. It is expected this factory will also produce a wide range of other products, including hand tools and agricultural implements. It will have the necessary tooling to produce high quality castings, forgings, and precision machined parts which would otherwise have to be imported.

A sister concern of the Machine Tool Factory is the Bangladesh Diesel Plant, which currently assembles Deutz engines. Plans are to gradually shift to local manufacture of up to 70% of these engines. So far most of the engines are used in the irrigation program of the Bangladesh Agricultural Development Corporation.

Manufacture of agricultural equipment at present

Pumps. Most centrifugal pumps used with low–lift pumps and shallow tube wells are manufactured by local firms (Bangladesh Machine Tool Factory, KSB Pumps Ltd., Ittefaq Industrial Corp. and several small manufacturers). In the near future it is likely that the turbine pumps used in deep tube wells will also be manufactured indigenously. A number of large and small manufacturers produce the cast iron pumps used for drinking water tube wells and MOSTI.

Engines. One firm (Ittefaq Industrial Corporation) manufactures the slow speed engines commonly used to power rice mills, oil mills, and sawmills in rural areas where electricity is not available.

Mill equipment. A number of local manufacturers produce components or complete mills for processing rice, pulses, oilseeds, and flour.

Small agricultural implements. The introduction of simple agricultural implements such as pedal threshers, weeders, and seed drills has been pioneered by the Comilla Cooperative Workshop. A number of workshops now manufacture these items; however, there is yet not a large demand on a country–wide basis due to their high cost. A few manufacturers produce quality metal digging and cutting tools that are more durable than those made by the local blacksmiths. Similar tools are also imported and marketed throughout the country.

POLICIES RELATING TO MECHANIZATION

Swarnivar program

The Swarnivar (self–sufficiency) program has been adopted by the Bangladesh government to develop self sufficienty at the village level. The government's commitment to this program will have an effect on both the scale and location of industries with an emphasis on small–scale operations in rural areas. The Swarnivar Program also focuses on the needs of the small farmer and is likely to generate pressure for the development of small–scale agricultural equipment.

Industrial investment schedule

The Bangladesh government periodically publishes a schedule which identifies industries in which investment is encouraged through easing of taxes and facilitating the procurement of import permits.

Import taxes and tariffs

Import duties on agricultural equipment are 15%, compared with duties to 100% and more for most other items. In addition, manufacturers may apply for tax concessions on certain raw materials which are used in the manufacture of agricultural implements.

Rural electrification

The government has undertaken an intensive program to electrify rural areas. The first phase is electrification of the more than 400 thana [a/] centers throughout the country. Electric power will open a number of new possibilities in irrigation, drying, and processing which otherwise remain too costly for farmers.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Several institutions in Bangladesh are actively involved in research, development, evaluation, and extension.

Bangladesh Agricultural University is developing programs in the departments of Farm Power and Machinery, Irrigation and Water Management, Food Technology, and Marketing and Cooperation. They are addressing different aspects of agricultural mechanization. These include the development of improved hand implements, village level food processing, and small-scale drying and storage of agricultural products.

Bangladesh University of Engineering & Technology's departments of Mechanical Engineering, Chemical Engineering, and Water Resources Development are involved in projects related to agricultural mechanization. Included are fabrication of a prototype IRRI thresher, an investigation of parboiling methods, and a study of irrigation methods in use in Bangladesh.

The Agricultural Engineering Division of Bangladesh Agricultural Research Institute has worked to develop a variety of agricultural implements including plows, seed drills, weeders, threshers, and dryers.

The Bangladesh Rice Research Institute has an Engineering Division that will focus attention on the mechanization aspects of rice production.

[a/] A political subdivision.

Within the Bangladesh Agricultural Research Council the Appropriate Agricultural Technology Cell has been established to coordinate and promote efforts to select agricultural technologies that are suited to the needs and capabilities of Bangladesh.

The Integrated Rural Development Program has programs in selected thanas of Bangladesh for the development of rural areas through activities based on cooperatives.

Under the IRRI/BARC industrial extension program, arrangements are being made to fabricate prototypes of the 6-8 hp diesle tiller with steering clutches, portable thresher, grain dryer, and diaphragm pump. So far one prototype of the smaller petrol-powered tiller has been fabricated by Bengal Agricultural Implements and Steel Products, Ltd. The Mechanical Engineering Department of the Bangladesh University of Engineering and Technology is currently fabricating a prototype of the power thresher. Ittefaq Industrial Corporation and Prantik Engineering are both interested in manufacturing the diesel tiller and the Farm Power and Machinery Department of Bangladesh Agricultural University has also expressed interest in obtaining IRRI equipment designs.

FUTURE DIRECTIONS

The possible role of mechanized cultivation in Bangladesh has yet to be evaluated comprehensively. An alternative to mechanization would be the introduction of improved bullock-drawn implements. Exhaustive field tests and evaluation of suitable prototypes are needed before final conclusions can be reached.

Irrigation programs will continue to expand. There is a need to reduce the variety of imported engines being used to standardize the system of maintenance and spare parts supply. A possible solution would be local manufacture by several industries of an engine selected for simplicity of design, maintenance, and repair.

Rice processing and drying deserves close attention, as a major expansion in the demand for these processes is likely within the next few years. Careful choice of technology now will avoid delays and inefficiencies in the future development of this sector.

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CURRENT STATUS OF MECHANIZATION IN THE PHILIPPINES

HECTOR A. SANVICTORES
EXECUTIVE VICE-PRESIDENT. AGRICULTURAL MACHINERY
MANUFACTURERS & DISTRIBUTORS ASSOCIATION, INC.
RM. 802, ARAZA BLDG.. PASEO DE ROXAS. MAKATI, METRO MANILA

AGRICULTURAL DEVELOPMENT INDICATORS

There are many indicators describing the general level of agricultural development in a country. This paper will concern itself with five:

1) extent of irrigation,
2) intensity and pattern of cropping,
3) level and growth of farm income,
4) labor absorption, and
5) rate of farm mechanization,

Extent of irrigation

Around 1.7 million ha or 13.93% of our total cultivated land area and 15.88% of the total cropped area are under irrigation.

A survey conducted by the Bureau of Agricultural Economics showed there are 1.49 million ha of rice under irrigation, planted mostly to the modern varieties (1.2 million ha).

The revised listing of national irrigation systems operated and maintained by the National Irrigation Administration (NIA) as of December 31, 1976, shows 123 irrigation systems covering a service area of 44,000 ha distributed among the country's 11 regions. In 1975 there were 116 systems covering a service area of 438,000 ha.

The present national irrigation system serviced 356,000 ha in the wet and 221,000 ha in the dry season during agricultural year 1976, at a cost of P3.7 million. Compared to the 97,000 ha in 1955 (Table 1), the area covered has increased considerably.

In addition, acccrding to NIA, a communal irrigation system covered 372,000 ha in 1975, as compared to only 26,000 ha in 1955. Irrigation pumps water 123,000 ha, compared with only 3,000 ha in 1955.

Table 1. Cumulative areas irrigated, 1955 – 77.

Year	NIA	Communal system	Irrigation pumps
		hectares	
1955	97,497	26,000	3,000
1960	171,867	107,000	7,000
1965	206,581	201,000	8,000
1970	303,681	250,000	25,000
1975	402,034	372,000	123,000
1977	444,388		

Source: National Irrigation Administration.

NIA's goal to increase the country's total irrigated rice area to 2.5 million hectares, at a cost of ₱19B, by the year 2000.

Intensity and pattern of cropping

According to the Census of Agriculture by the National Census and Statistics Office (1971), more farms practiced successive cropping than intercropping (Table 2a). Out of 2.35 million farms in the survey, only 331,000 (14.0%) practiced intercropping while 859,000 farms (36.5%) practiced successive cropping. Out of the total, 338,000 (14.4%) practiced both intercropping and successive cropping while the remainder, 827,000 (35.1%) practiced neither.

The popularity of successive cropping over intercropping has persisted. Recent interviews with the Bureau of Agricultural Extension (BAEx) Agricultural Programs Division indicated this trend is due primarily to economic reasons, especially in the case of rice farms. Generally, these experts pointed out, farmers prefer to plant successive rice crops rather than intercrop because rice is the biggest profit-maker.

In the Philippines today, according to the Agricultural Programs Division of BAEx, around 80% of the farms plant two crops a year. Crop rotation and intercropping are less popular, primarily because of economic considerations. A significant improvement in cropping is noted. Table 2b shows that in 1971

Table 2a. Extent of intercropping and successive planting, July 1970 to June 1971.

Cropping practice	Number of farms	Percent of total
No intercropping or successive planting	826,616	35.1
Intercropping only	330,614	14.0
Successive planting only	858,869	36.5
Both intercropping and successive planting	338,370	14.4
All farms	2,354,469	100

Source: National Census and Statistics Office. The 1971 Census of Agriculture. Manila.

Table 2b. Land utilization, July 1970 to June 1971.

Item	Area
1. Physical area planted to crops:	hectares
a. With interplanting and/or succession cropping	4,099,700
b. Without interplanting and succession cropping	2,324,450
c. All farms	6,424,150
2. Total area interplanted and planted to succession crops	2,436,890
3. Intensity of land use for:	percent
a. Farms with interplanting and/or succession cropping7	59.4
b. All farms [b/]	31.9

[a/] Derived by dividing item (2) by item (1a) multiplied by 100.
[b/] Derived by dividing item (2) by item (1c) multiplied by 100.

the intensity of land use for all farms was 37.9%, while for farms with intercropping and/or successive cropping, it was 59.4%.[1] Presently, cropping intensity in irrigated rice areas can be as high as 95%.[2] The role of high-yielding varieties of rice has made multiple-cropping possible and increased land use intensity.

Level and growth of farm income

At the aggregate level, the growth rate of farm income is high. The share of the agricultural, fishery, and forestry sector to Gross National Product (GNP) was valued at 19.46 billion pesos in 1976, from 17.46 billion in 1974 and 18.22 billion in 1975.[3] The ratio of this sector to GNP is nearly constant (if not increasing relative to the share of the industrial sector). This implies a growth rate of 4.3% between 1974-75 and 6.8% between 1975 and 1976.[4]

Labor absorption

In a country with a high population growth rate, the growth rate of the total labor force is also high. The same is expected of farm labor.

In 1965, the labor force was placed at 10.76 million. This grew steadily until 1968, declined somewhat through 1969-70, grew again in 1971 and 1972, and declined in 1973 when it was estimated to be 14.56 million. By 1976, the labor force was already around 16.24 million (Table 3a and Fig. 1).[5]

Traditionally, and as can be expected in a predominantly agricultural country, the agricultural sector has been absorbing a major portion of the labor force.

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[1] National Census and Statistics Office (NCSO), "1971 Census of the Philippines: Agriculture," Summary Report, Manila, p. 97.

[2] Bureau of Agricultural Extension (BAEx), Agricultural Development Program.

[3] National Economic and Development Authority (NEDA), "Philippine Economic Indicators," Vol. V, No. 6, June 1977. (At constant 1972 prices).

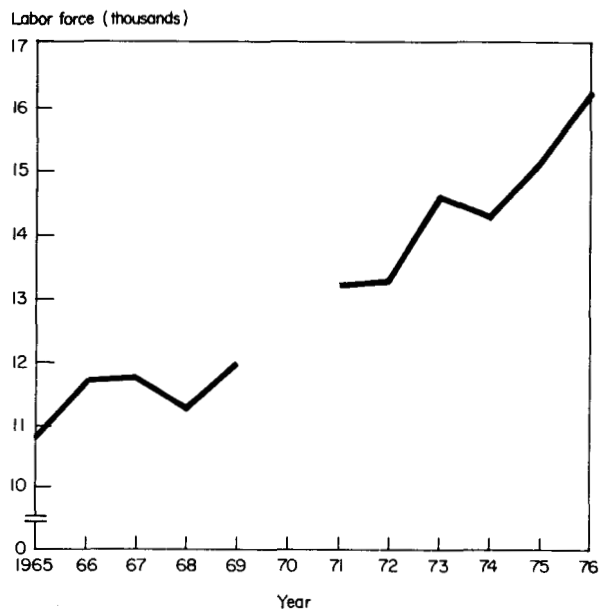
[4] Ibid.

[5] NEDA, op. cit., p. 53.

Table 3a. Size of the labor force, 1965-1976.

Year	Labor force
	(000)
1965	10,764
1966	11,757
1967	11,776
1968	11,371
1969	12,046
1970	-
1971	13,241
1972	13,294
1973	14,559
1974	14,283
1975	15,161
1976	16,244

Source: National Economic Development Authority Yearbook 1976. Manila.

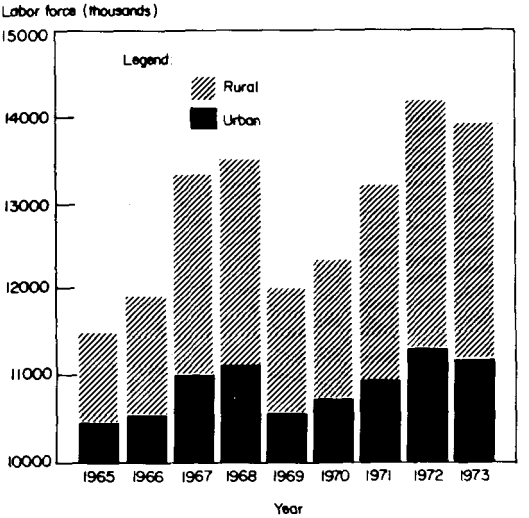


1. Growth of the labor force, Philippines, 1965-76.

Table 3b. Labor force distribution by sector and employment status, 1965-73.

Year	Total	Urban			Rural		
		Employed	Unemployed	Total	Employed	Unemployed	Total
				percent			
1965	11,491	26.2	3.5	29.7	65.5	4.8	70.3
1966	11,886	26.4	3.5	29.9	66.4	3.7	70.1
1967	13,274	25.8	3.9	29.7	66.0	4.3	70.3
1968	13,534	26.6	3.9	30.5	65.1	3.9	69.5
1969	12,046	28.1	2.8	29.9	66.1	4.0	70.1
1970	12,297	29.3	2.4	31.7	63.1	5.2	68.3
1971	13,220	27.2	2.7	29.9	68.0	2.1	70.1
1972	14,200	26.4	3.7	30.1	66.7	3.2	69.9
1973	13,886	28.7	2.5	31.2	66.8	2.0	68.8

Source: Department of Labor: 1973 Yearbook of Labor Statistics.



2. Urban-rural labor force distribution, 1965–1973.

By examining the distribution of the labor force between urban and rural areas (Table 3b and Fig. 2), the important role played by the agricultural sector is apparent. Around 70% of the labor force is concentrated in the rural areas.6/

In some areas at the height of the land preparation, planting, and harvesting seasons, farm labor cannot cope with the high level of demand. During these times, the role of farm machinery and equipment becomes vital. With higher cropping intensity due to modern rice culture, timeliness of operations is imperative and possible only when labor is supplemented by machines. Modern farming techniques have increased labor requirements, particularly in plant care such as weeding, fertilizer, and insecticide applications.

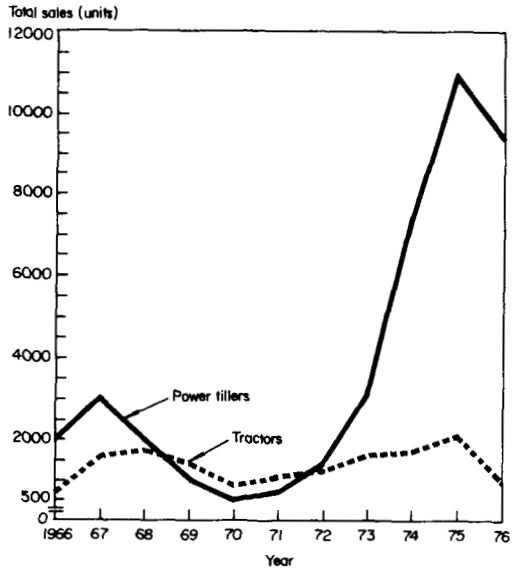
Present government programs to encourage small – and medium – scale industries (cottage and home industries), the green revolution campaign, tree planting, and the regional dispersal of industries will increase demand for farm labor.

CURRENT STATUS OF MECHANIZATION

Use of machinery over time

Farm mechanization began in the sugar industry. Today this industry uses various forms of farm machinery and equipment, from small power tillers to large four – wheeltractors.

6/ Ibid, p. 22.



3. Annual tractor and power tiller sales, 1966–67.

With rice in 1965, farm mechanization started together with the introduction of the high-yieldingvarieties. About this time also, the popularity of modern methods of farming was rising fast.

At the outset, the preference of farmers for smaller, low-cost types of farm machinery and equipment became readily evident. A study made by Porter[7/] supports this observation.

Through time, power tillers have dominated the mechanization of ricelands. The power tiller has increasingly become an important farm input in Philippine agriculture. The palay sector has been making extensive use of power tillers and has turned out to be its biggest market. Porter's study revealed that though 52% of his sample[8/] were sing power tillers, an additional 25% would like to.

[7/] Porter, D., "Survey of Farmers," BOI working paper for the Agricultural Machinery Sector Survey (UNDP/IRRD Technical Assistance Project), Manila, February 1974.

[8/] In this sample of 1,842 farmers note the following:

1) its bias in favor of palay farms (83% of the total),
2) sample farms are larger than average (in excess of 3.5 ha),
3) a high proportion (57%) is irrigated, and
4) most employ farm machinery.

Table 4a. Annual power tiller sales and portion of sales financed through CB–IBRD Program, 1965–76.

Year	Total sales, No.	Financed through CB–IBRD	
		No.	% of total sales
1965	1,509[a/]	–	–
1966	1,932	126	7
1967	3,058	724	24
1968	1,873	228	12
1969	910	34	4
1970	475	42	9
1971	680	109	16
1972	1,408	330	23
1973	3,120	322	10
1974	6,721	377	6
1975	11,077	805	7
1976	9,352	–	–

[a/] Estimated cumulative total of power tillers sold between 1960–65.

Sources: F. Juarez and B. Duff. Changing Supply and Demand Patters for Power Tillers in the Philippines. Philippine Society of Agricultural Engineers. 1977.

The Economic Monitor, August 29, 1977.

Annual sales of power tillers from 1965–76 (Table 4a and Fig. 3) show an upward trend from 1965–67, a decline in 1968, followed by a plunge in 1969–71. After this, the general upward trend resumes and sales even shoot up in 1975. In 1976, however, there is again a decline. (These trends are discussed further under "Credit Programs").

The bulk of tiller sales by the Agricultural Machinery Manufacturers and Distributors Association (AMMDA) members in 1973 ranged from 7–9 hp. The trend toward higher horsepower continued in 1976, while sales of tillers with 6 hp and below comprised only 17% of total sales (Table 4b).

Gasoline–type tillers are still more popular than diesel types (Table 4c) and locally manufactured tillers command a growing share of the domestic market (Table 4d).

Land reform and credit programs have influenced the increase in power tiller sales.

Table 4b. Sales of power tillers by horsepower, 1974-76.

Horsepower	1974		1975		1976	
	No.	%	No.	%	No	%
6 and below	243	7	1,433	17	1,450	17
7 to 9	2,443	75	3,451	41	2.602	30
10 and above	582	18	3,493	42	4,616	53
Total[a/]	3,26[b/]	100	8,377	100	8,668	100

[a/] Total sale of 12 brands for 1974, 26 brands for 1975, and 35 brands for 1976.

[b/] Does not include Kubota special sale of 3,000 units in 1974 and 2,000 units in 1975 to the Department of Agrarian Reform.

Source: F. Juarez and B. Duff. Changing Supply and Demand Patterns for Power Tillers in the Philippines. Philippine Society of Agricultural Engineers. 1977.

Initiation of the CB-IBRD loan fund in 1965 in conjunction with other government and manufacturers' credit programs pushed sales upwards. Unfortunately, this trend was reversed in 1970, due to the effects of devaluation and import restrictions. Sales jumped to 6,721 units in 1974 (from 3,120 in 1973) with the release of the third loan. The 1976 decline resulted from the exhaustion of this loan.

Implementation of the land reform program in 1972 also affected sales. The division of large estates into small farms raised the demand for suitable small types of machinery, notably the power tiller.

Growth of the power tiller industry, however, presented a new challenge to manufacturers - the need to produce quality tillers at a reasonable price. The more brands marketed, the greater the need for every firm to utilize the most efficient production techniques to stay competitive.

Annual tractor sales from the early 1950s to the mid 1960s averaged slightly over 700 units, with the sugar industry as the major market. Sales accelerated in 1967 until 1968, after which they fell until 1970. They rose again in 1971; this continued until 1975 when peak sales were reached. In 1976, tractor sales fell (Table 5 and Fig. 3).

Table 4c. Sales of power tillers by fuel type, 1972-76.

Year	1972		1973		1974		1975		1976	
	No.	%	No.	%	No.	%	No.	%	No.	%
Gasoline	514	36	2,571	82	3,219	48	6,968	63	6,878	74
Diesel	894	64	549	18	3,502	52	4,109	37	2,474	26
Total	1,408	100	3,120	100	6,721	100	11,077	100	9,352	100

Source: F. Juarez and B. Duff. Changing Supply and Demand Patterns for Power Tillers in the Philippines. Philippine Society of Agricultural Engineers. 1977.

Table 4d. Sales of power tillers by source, 1972-76.

Year	1972		1973		1974		1975		1976	
	No.	%	No.	%	No.	%	No.	%	No.	%
Local	336	24	2,073	66	2,338	35	5,225	47	5,670	61
Imported	1,072	76	1,047	34	4,383	65	5,852	53	3,682	39
Total	1,408	l00	3,120	100	6,721	100	11,077	100	9,352	100

Source: F. Juarez and E. Duff. Changing Supply and Demand Patterns for Power Tillers in the Philippines. Philippine Society of Agricultural Engineers. 1977.

Table 5. Annual sales for four-wheel tractors and portion of sales financed through CB-IBRD Program, 1961-76.

Year	Total sales, No.	Financed through CB-IBRD	
		No.	%
1961	813	-	-
1962	994	-	-
1963	863	-	-
1964	950	-	-
1965	607	-	-
1966	664	72	11
1967	1,531	560	37
1968	1,630	265	16
1969	1,358	54	4
1970	978	150	15
1971	1,086	251	23
1972	1,216	472	39
1973	1,517	534	35
1974	1,666	641	38
1975	2,176	1,398	64
1976	1,074	-	-

Sources: National Census and Statistics Office; Agricultural Machinery Manufacturers and Distributors Association. Manila.

The Economic Monitor, August 23, 1977.

Note: The CB-IBRD program was supplemented by other programs,. notably that of DBP.

According to major distributors, palay and sugarcane farming account for almost 90% of tractor sales (Table 6). There has also been a swing away from the bigger tractors to the medium-sized models.[9/] In particular, a steep rise in sales of the versatile

[9/] Agricultural Machinery Manufacturers and Distributors Associatior (AMMDA).

Table 6. Tractor sales by crops.

Crop	% of sales
Palay	47
Sugar	41
Corn	5
Fruit	4
Other	3
All crops	100

Source: Agricultural Machinery Manufacturers and Distributors Association.

compact four-wheel tractor is being experienced by distributors. It suits medium-sized farms (10-25 ha), which comprise a major portion of all farms and its price is much lower than the big four-wheel type. In 1975, 372 of these compact four-wheel tractors were sold to farmers; sales for the first half of 1976 totaled 270.

Developments in agricultural science and technology greatly affect sales. The boom in sales from 1965 to 1967 was largely due to the introduction of the high-yielding varieties of rice, which made possible the realization of a highly profitable farm industry.

Government fiscal and monetary policies affect the sales of farm machinery and equipment. The tight policies in the late 1960s and the devaluation and import restriction in 1970 adversely affected the industry.

Government socioeconomic-political policies also affect sales. The land reform program that divided large estates into smaller farms boosted sales, especially that of the smaller machinery and equipment, like power tillers. The rice self-sufficiency program also helped raise sales levels.

Availability of: credit, which weighs heavily in sales, will be discussed under "Credit Programs."

In addition, the Census of Agriculture published by the NCSO in 1971 shows that 16,000 farms used 32,000 stripping machines, crushers, and shredders; 79,000 farms used 168,000 sprayers; 14,000

used 168,000 power – producingmachines, and 14,000 used 105,000 motor vehicles.

In Porter's study, 12% of the farms surveyed used threshers, with an additional 22% wanting to use them; 2% owned power sprayers, and another 11% wanted to use them. In addition to these, Porter also saw a large potential market for dryers and power weeders.

The growth of aggregate agricultural income and productivity can be traced to progress in science and techno-logy, and to a great extent, to farm mechanization. Modern inputs such as fertilizers, selected seeds, and pesticides have increased the intensity and pattern of cropping, which in turn require the use of farm machinery with farm labor.

Labor productivity in the agriculture, fishery, and forestry sector has been rising continuously, just as overall labor productivity is increasing. Looking at labor productivity in terms of net value added at current prices (Table 7) the agriculture sector shows that in 1963, the value was really low ($208). It

Table 7. Labor productivity measured in terms of net value added in dollars at current prices per employed person, 1963-73.[a/]

Year	All industries	Agriculture, fishing and forestry
1963	388	208
1964	403	216
1965	436	243
1966	458	261
1967	491	285
1968	534	322
1969	662	430
1970	775	-
1971	837	620
1972	915	631
1973	1,121	803

[a/] Peso-values were converted into dollar-values using 1963 as base year during which the rate of exchange was ₱3.9-$1. Otherwise, the floating rates beginning 1970 would grossly undervalue labor productivity figures.

Sources: National Economic and Development Authority; National Income Accounts; National Census and Statistics Office, Survey of Households; Department of Labor, 1973 Yearbook of Labor Statistics.

climbed slowly to $803 in 1973. Therefore, we can see the parallel movement between overall agricultural productivity and labor productivity.

Patterns of mechanization by major cereal crops

According to BAEx officials, farm machinery and equipment are centered in rice production, particularly in the irrigated areas, to achieve an even greater intensity of land use. Porter's survey showed that in 1972, palay farming accounted for 92% of power tiller sales. According to the same source, around 70-80% of land preparation in these irrigated areas is mechanized. The stages in rice production that use farm machinery and equipment are land preparation, irrigation, threshing, and milling.

With corn farms[10/] 38% were using tractors and 13% power tillers. The additional farms that wanted the equipment were 9% for tractors and 23% for tillers. However, the average size of corn farms is small so that smaller types of machinery and equipment would be required. The much bigger farm machinery, such as the big four-wheel tractor, are not as popular with corn and other cereals as they are with sugar.

LOCAL MANUFACTURE OF AGRICULTURAL EQUIPMENT

Number and distribution of firms producing machinery and equipment

Sixteen years ago there were only 33 establishments manufacturing or assembling tractors and farm machinery.[11/] Of these, 19 were classified as large, 14 as small. These establishments employed 1,342 people -- 1,300 in the large establishments. Payrolls totaled P3.79 million, with 93.77 million originating from the large establishments and only 923,000 from the small.

In 1972, 61 establishments were manufacturing or assembling agricultural machinery equipment. Of these, 19 were classified as large firms. The industry then employed 1,665 people, with 1,505 in 19 large establishments and 160 in the small ones. These 61 establishments paid 99.11 million in wages and salaries,

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[10/] Porter, D., op. cit.

[11/] National Census and Statistics Office (NCSO), "1974 Annual Survey of Establishments: Manufacturing," p. 31.

the bulk of which came from the large manufacturing establishments.

In 1974, 15 large establishments[11] manufactured or assembled agricultural machinery and equipment. The establishments were employing an aggregate of 2,530 employees and paying them 119.29 million. The value of gross output was 9323.68 million, while the cost of materials used was 9142.27 million.

Presently, there are 60 power tiller firms operating in the Philippines.[12] These are composed of 38 manufacturers, 2 assemblers, 2 manufacturer-assemblers, 15 distributors and 3 manufacturer-distributors. They are classified into small, medium, and large, with medium capitalized firms from P1M - P4M, and employing 100-300 workers. Most of the small firms are in the Bicol Region, while the rest are in the Metro Manila area.

Policies relating to mechanization

This section deals with policies from two general viewpoints -- the private sector and the government.

The most important trend in the farm machinery and equipment industry is towards greater local manufacture.

The private sector's policies as cyrstallized and synthesized by the Agricultural Machinery Manufacturers and Distributors Association (AMMDA), are clear -- to promote farm mechanization in the Philippines. In particular, AMMDA members have pledged to 1) develop, select, and test the most appropriate equipment for Philippine agriculture; 2) ensure that the equipment is of high quality and capable of being profitably used by Filipino farmers; 3) help farmers purchase equipment at prices and payment terms that are fair; 4) educate users on the proper operation and maintenance of modern farm equipment; 5) provide parts and service support so equipment can operate profitably.

A farm mechanization policy draft has been prepared through the joint efforts of the Department of Agriculture, AMMDA., the International Rice Research Institure (IRRI), and the University

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[12] Juarez, F., and B. Duff, "Changing Supply and Demand Patterns for Power Tillers in the Philippines," paper presented at the Annual Convention of the Philippine Society of Agricultural Engineers entitled "Towards the Rationalization of Farm Mechanization in the Philippines," Manila. April 28-29, 1977.

of the Philippines at Los Baños. It deals with the following points: 1) selective mechanization, which has to do with the techniques and methods that will ensure a consistency between the social and private goals of increased levels of welfare, per capita incomes, and production; 2) a progressive farm machinery manufacturing program; 3) after-sales service and distribution standards; 4) joint ownership or usage of farm machinery; 5) local research and development of suitable agricultural machinery; 6) establishment of an Agricultural Machinery Testing and Evaluation Center (AMTEC); 7) credit and support programs; 8) a recognized industry association (AMMDA); and 9) an Agricultural Mechanization Development Program (AMDP).

Credit programs

The Philippine experience has shown how necessary an integrated credit program is for farm mechanization. Availability of credit and the level of sales and use of machinery and equipment have moved together.

The most important credit program is the CB-IBRD Loan Fund, which is now on its fourth term. The release of the fourth loan should bring about a rapid increase in the sale of machinery and equipment.

The boom in sales, particularly among tractors and power tillers, came simultaneously with the release of the first three CB-IBRD loans amounting to $5M, $12.5M, and $30M. Similarly, the drop in sales in 1976 resulted from the exhaustion of the third loan.

Other government institutions involved in providing credit for farm mechanization are the Land Bank of the Philippines, Development Bank of the Philippines, Farm Systems Development Corporation, Agricultural Credit Administration, and National Grains Authority.

Presently, an extensive interagency credit program is being finalized by the NGA, CB, LBP, PNB, DBP, DLGCD, RBAP, AMMDA, BAP, and PCAP to finance the acquisition of intermediary post-harvest equipment, especially portable mechanized threshers and dryers for sorghum and rice mills.

To some extent Central Bank Circular No. 473, which requires commercial banks to set aside 25% of their loanable funds for agricultural credits effective June 30, 1975, will also favorably affect farm mechanization.

Several pressing problems continue to affect agricultural credit. The more important ones have to do with 1) lack of credit itself, 2) the slow rate of processing loan applications, and 3) the collateral orientation of some credit institutions.

Tax and tariff policies

The government tax and tariff policy on farm machinery and equipment is to keep the effective rates to a minimum to facilitate implementation of the farm mechanization and the food self-sufficiency programs in accordance with national goals.

Presently, a 10-30% ad valorem tariff is imposed on imported farm machinery and equipment. A 7% sales tax on imported machines remains in effect.

This policy of encouraging the importation of farm machinery and equipment is only transitory. However, Filipino investors have now started to put up "mini"manufacturing enterprises[13/] to locally build power tillers and their spare parts, tires, plows, harrows, planting machiners, fertilizer spreaders, rice threshers, irrigation pumps, and rice mills with complete accessories. Because of this, the rapid growth of the local farm machinery manufacturing and assembling industry is expected. However, so as to advance our technical knowledge, joint ventures and licensing agreements with relatively more advanced firms abroad should continue to be encouraged.

Joint ownership systems

Financing large capital outlays becomes much easier through joint ownership systems. Such is true with communal irrigation systems as well as farm machinery and equipment.

One of the major incentives for buying and owning a tractor or a power tiller is the benefit of using it for custom service or rent-a-tractor service, especially if the owner's farm is small. According to an AMMDA report, 80% of the tractor buyers in the rice area rented out tractors after tilling their own farms. Buyers of four-wheel tractors who rent their services after tilling their farms are able to realize a payback period of 2-1/2 - 3 years on their investment. Few investment opportunities of this nature are available to the rural sector.

[13/] Bureau of Agricultural Extension (BAEx), op. cit.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Basic research on farm mechanization is undertaken by the Bureau of Plant Industry, the Central Luzon State University, the International Rice Research Institute, and the Institute of Agricultural Engineering and Technology of the University of the Philippines at Los Baños (INSAET/UPLB).

The BAEx evaluates farm equipment and machinery based on the requirements of local conditions. If necessary, the local manufacturer is advised to modify its product before it is produced commercially.

The Agricultural Machinery Testing and Evaluation Center (AMTEC) will set reasonable standards of machinery quality, conduct performance tests, evaluate after-sales service support, and initiate standardization of agricultural machinery components for interchangeability of parts. AMTEC is a joint undertaking of the University of the Philippines at Los Baños, and the Department of Agriculture with INSAET/UPLB as the implementing unit. INSAET/UPLB has also been designated by the Philippine Government as the national institute affiliated with the Regional Network for Agricultural Machinery (RNAM), a UNDP project participated in by eight Asian countries.

FUTURE DIRECTIONS

It is hoped that the complete local manufacture of farm machinery and equipment can be realized soon. This is aimed at fully mechanizing the agricultural industry to raise aggregate productivity as well as farm labor incomes, attain self-sufficiency in food, and in general, to contribute to the country's socioeconomic development.

By that time, local manufacturers should have become more highly competitive in relation to foreign firms, which instead of being banned, should serve to induce local firms to adopt more efficient production techniques resulting in the availability of reasonably priced and high-quality farm machinery and equipment. Also, joint ventures with foreign firms and licensing tie-ups will eventually lead to gradual technological transfer. This way, farmers can be assured of the best in terms of machinery and after sales service and parts.

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AGRICULTURAL MECHANIZATION IN INDIA

M. M. SURI
PRESIDENT, SURI RESEARCH FOUNDATION
8-14. GREATER KAILASH-I, NEW DELHI-110048. INDIA

INTRODUCTION

India has great variety in terrain and climate. It has the world's highest snowbound Himalayan Mountains, expansive river-fed tropical plains, the wet forest regions of Assam in the east, the dry deserts of Rajasthan in the west, the Deccan plateau of the south, and 5,000 km of coastline plus a variety of hinterlands. This mozaic of differing landscapes is inhabited by over 600 million people.

India today also presents a diverse picture of development. In the northern states of Punjab and Haryana almost every village is electrified and a system of canals provides irrigation supplemented by a network of private and public tube wells. The specter is of a populace at once alert and eager to adopt new methods and mechanization. In contrast lie millions of hectares spread across the country, dependent on rain and the vagaries of nature, with no signs of change in the agricultural scene except that village populations are forever increasing.

Ten years ago there was widespread gloom because of increasing food shortages, the high population growth rate, and the food import burden, which was crippling the country's economy. Yet the advent of high yielding wheat with its package of irrigation, chemical fertilizers, and insecticides, followed by improvements in rice and maize cultivation, has created a surplus of food in some parts of India.

The continuing spread of modern technology into rural India, where 80% of the population resides, has the potential of increasing per capita income through agricultural growth. This is especially true with cash crops, since 70% of the rural area is still untouched by these winds of change.

In the more advanced areas, double cropping is common, and sometimes three or even four crops are grown each year. Tractors are used for plowing, electric or diesel pumps for perennial irrigation, plus regular chemical fertilization, power spraying of insecticides (even aerial spraying), and harvester-combines to speedily cut and thresh the crops.

Does this replace labor, or has this augmented affluence? As an engineer who had always advocated the need for selective mechanization of Indian agriculture, despite a seeming labor surplus, and who has witnessed the transformation from the dismal days to the present hopeful times, I wish to record some observations and inferences not too apparent from the country statistics alone.

MOTIVATION FOR MECHANIZATION

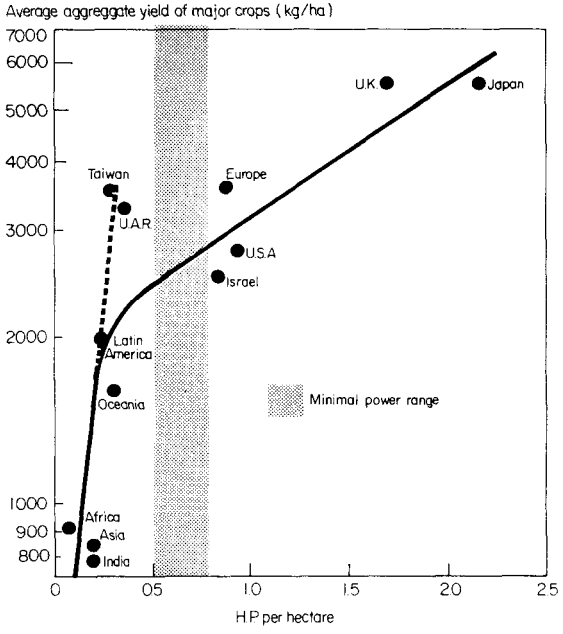
In 1970 the Indian population was 550 million, food requirements were 115 million t, and the population growth rate was 2.8%. Despite family planning schemes, the population is expected to reach 840 million by 1985 and 1 billion by the turn of the century (at which time population may be stabilized due to family planning). If a national political and economic crisis is to be avoided, provision of food for this population explosion must remain the top priority of the Indian economy in the foreseeable future. Our battle to keep hunger at bay calls for raising the historic annual growth rate of food grain production from 2% to 4%.

In 1966 – 67 successful hybrid wheat cultivation in Punjab provided the first rays of hope. Twofold and threefold increases in land productivity transformed the traditionally conservative farmers to partners in the new technology. Post – 1967 experiences of Punjab and Haryana provide an important record of the importance of science and technology.

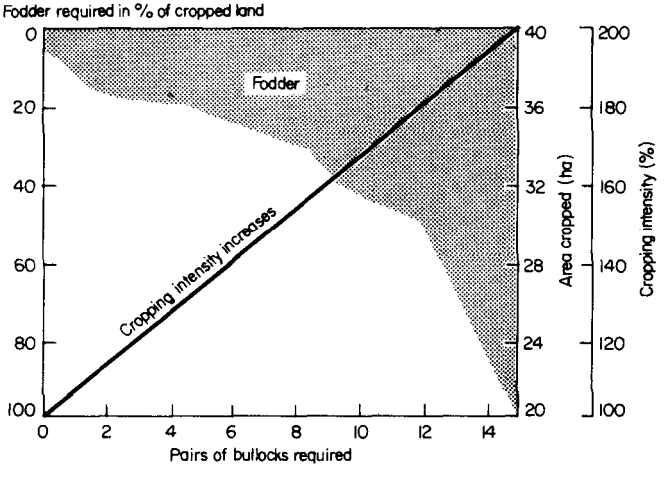
The introduction of high yielding varieties and their special needs induced further though served with a network of canal irrigation, tube wells with diesel and electric pumps increased the year – roundavailability of irrigation. This in turn increased food production in Punjab and Haryana. Use of diesel or electric pumps with tube wells is the first element of mechanization.

Once such irrigation is assured, multiple cropping occurs as a corollary. This in turn generates the need for intensive energy inputs as shown in figure 1, which relates yield in kilograms per hectare to horsepower per hectare. Punjab and Haryana confirm that there is ultimately no alternative except to introduce mechanization in all phases of agricultural production -- plowing, sowing, harvesting, threshing. Without it multiple cropping and intensive cultivation suffer due to excessive time intervals between successive crops.

Traditional bullock power has severe limitations for intensive land cultivation because it reduces the land available to grow crops. The bullock needs fodder (Fig. 2). The number of bullock required is calaculated on the basis of peak effort necessary for



1. Relationship between yields (kg/ha) and power (hp/ha) in major food crops. (Source: The World Food Problem – A Report of the President's Science Advisory Committee, Vol. III)

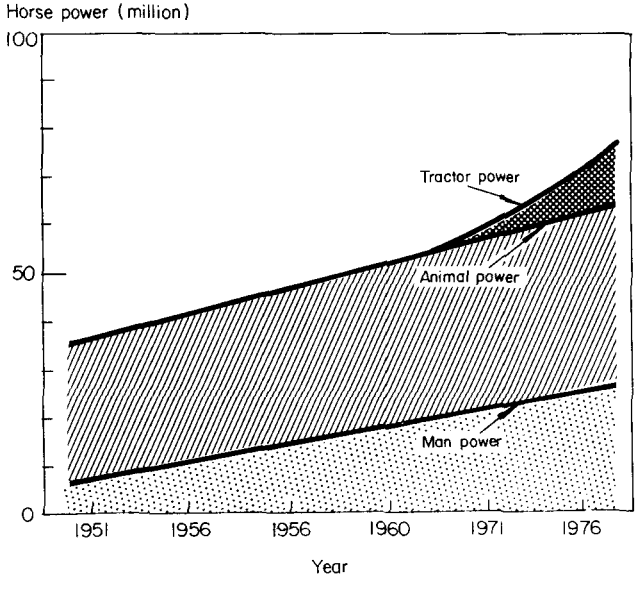


2. Bullock cultivation – cropping intensity versus fodder land. (Source: Punjab Agro-Industries Corporation. Report to World Bank)

plowing for a few days, but these bullocks have to be fed during the rest of the year when there is no work available for them. Presently there are approximately 50 million bullocks in India. To double our food production would require another 50 million bullocks. Considering their fodder requirement, they would take away the equivalent of land required for feeding 200 million humans. In India the growth rate of bullocks is 0.3%, which also limits the increase in bullock power availability for increased food requirements. Figure 3 shows how tractor power complements bullock power and fulfills power needs.

In Punjab and Haryana, bullock population since 1965 has not increased while tractor numbers grew from 12,000 to 30,000 by 1970 and to 50,000 by 1975. There has also been a clear relationship established between the increase of tube wells, the consequent increase of food production, and the needed extra energy that could only be supplied by tractors. This is the second and most compelling step fostering agricultural mechanization.

Power inputs per hectare in agriculture for different countries are shown in figure 1. Each tradtional ton of food generally requires an additional horsepower of mechanization. The most important conclusion is that hybrids along with complementary irrigation facilities are ushering in an era of farm mechanization on a truly gigantic scale in India, not limited to tractors, but a whole range of implements for improved farm productivity.



3. Farm Power supply. (Source: Agricultural Inputs Division, USAID, New Delhi)

Table 1. Minimum food grain requirements for India.

Year	Food requirements (million t)
1970	115
1975	134
1980	148
1985	175
2000	230

Table 2. Number of tube well pump sets related to food grain area and output for Punjab and Haryana.

Year	No. of tube wells/ pumping sets (mil.)	Area under food grain (mil. ha)	Total output (mil. t)
	PUNJAB		
1968 – 69	0.113	3.6	6.2
1969 – 70	0.153	3.8	6.9
1970 – 71	0.199	3.9	7.3
1971 – 72	0.346	3.9	7.9
1972 – 73	0.372	4.0	7.7
1973 – 74	0.400	4.1	7.7
1974 – 75	0.439	4.0	8.0
1975 – 76	0.450	4.3	8.8
1976 – 77	0.470	4.4	9.2
	HARYANA		
1966 – 67	0.025	3.7	2.5
1968 – 69	0.058	3.1	2.8
1969 – 70	0.084	3.8	4.0
1971 – 72	0.120	3.9	4.5
1972 – 73	0.149	3.9	4.1
1973 – 74	0.169	3.9	4.3
1974 – 75	0.191	3.8	4.5
1975 – 76	0.205	3.9	5.0
1976 – 77	0.222	4.1	5.2

Furthermore, the growing surplus of wealth in the rural population creates demands for durables and semi-durables -- fans, sewing machines, coolers, refrigerators, cycles, mopeds, scooters, motorcycles, radios, and televisions. These in turn create employment and a scenario of true rural advancement.

If agricultural mechanization is undertaken for intensive multi-cropping to increase farm productivity, it may appear labor is displaced on the individual farm. But the area taken as a whole would show that employment has been created and the whole society is elevated to a higher level of education, skills, and wage earnings, eliminating the low-paid menial labor force. An entire new scene is created, humming with activities of a wide variety but basically rooted in and dependent upon the extra wealth created by mechanized farming.

TYPE AND EXTENT OF MECHANIZATION

In developing countries, the pacesetters for mechanization are not their impoverished farmers but their government backed by World Bank or bilateral or local banks that provide financing packages as an inducement to farmers. Caution is to be sounded. Such packages buy the farmers their tractors and equipment, but if the servicing, repair, and maintenance infrastructure development are not adequate, this loan-based equipment proves a burden, leading to bankruptcy of the farmers. The adequacy of the infrastructure of repair and servicing facilities with trained personnel determines both the pace and the success of any mechanization effort. This is often neglected by development agencies and has caused much distress in Africa and Asia.

It is for this reason that IRRI-type machinery has relevance. It first introduces to the small farmers simple mechanical aids that enhance their farming productivity and educates them technically while their wealth slowly grows.

The small power tiller, thresher, bellows pump, weeder, and rice dryer are simple and much needed IRRI machines that introduce basic technologies which graduate the area into gradual sophistication. This gives the local repair and service facilities time to grow in skill and competence step by step. As opposed to massive sudden imposition of sophisticated mechanization, along with its heavy debt-servicing burdens on the farming community, the IRRI program is a slow and steady technology injection, at very low cost, complementary to the resource capability of the small farmers in developing countries.

MECHANIZATION AND LABOR DISPLACEMENT

To obtain high production per hectare through multi–cropping, increased horsepower inputs provided by mechanization are essential. Does this replace labor? Punjab and Haryana show that this is not so. Paradoxically, there is now an acute shortage of farmhands during harvesting and sowing seasons. Daily wages have consequently increased many fold.

Analysis reveals that the same land now produces four times the original crop –– four times the wealth. This increased wealth is not retained by the farmer. It buys him essential services and inputs of machinery, fertilizers, insecticides, fuels, lubricants, tractor and equipment maintenance and spare parts, without which he cannot obtain high yields. These services constitute a growing base of employment for others and call for trained and literate hands. Thus the whole scene is transformed from a stagnant state to one creating employment in the rural areas with better–paid jobs as mechanics and sales and service personnel for all types of chemicals and hardware.

As the program spreads, the areas first introduced to IRRI equipment will graduate in 5–10 years to more capital–intensive urban industry-produced mechanization, while IRRI-type equipment would shift to other virgin areas. In fact, IRRI equipment will continually grow in sophistication, because the compulsions of technological innovation are inescapable in any dynamic situation such as the developing world presents. Nevertheless, the simpler equipment developed now will be needed for newer areas of poverty–riden small farms, where mechanization takes its first steps.

ANIMAL AND MACHINE BALANCE

It becomes necessary to take a fresh look at the use of draft animals and their balance with machines because of the successful introduction of biogas plants in Indian villages. The principal drawback of bullock power was that beyond a point bullocks begin to claim productive land for fodder, competing with the demand of humans.

On the other hand, each hectare of land producing grain for human beings also produces plant wastes for animal fodder –– rice straw, wheat straw, maize straw. The quickest conversion of this agricultural waste into useful products for the farmer is via the biological route; fodder is fed to the animals and their dung is fed to the biogas plant. The farmer then has milk from his cattle, gas to meet his fuel needs, and an organic manure in the form of sludge from the biogas plant. The more the land produces, the greater the agro–waste, the higher the number of

animals that can be sustained, the more biogas available (for cooking and running diesel engines), and the increased supplement of organic manure for the farm.

In this context, especially in countries where fuel oil is expensive, economics favors owning a pair of bullocks even when the farmer has a tractor. The bullock is fed on available fodder. When the bullock is doing no other work for the farmer, it still functions as part of his biological fertilizer and fuel plant, with a high benefit-cost ratio to the farmer.

It is the experience of the Suri Research Foundation Farms and many farmers that the intense period of plowing activity, for want of time, must be covered by a tractor in multi-cropping systems. One pair of bullocks per 5-10 ha is useful for a number of activities such as inter-cultivation during the period between heavy tractor-based activities.

RESEARCH AND DEVELOPMENT

India has a large and well-funded network of agricultural research under the Indian Council of Agricultural Research. Yet, despite its many research establishments and agricultural universities, agricultural machinery development has not displayed the vigor expected.

The only major indigenous development has been the Swaraj 25 hp tractor produced by the Central Mechanical Engineering Research Institute in 1966-68. Punjab Tractors Ltd. set up to manufacture Swaraj tractors, has since introduced a 35 hp machine and is soon to introduce a 45 hp unit. Of special interest is the 15-18 hp low-cost tractor being developed by PTL, which should have a far larger demand than any tractor currently on the market because of the predominance of millions of small farm holdings.

There are sophisticated test facilities at the government's Budni Test Station, CMERI, and the Pant Nagar and Ludhiana Agricultural Universities, in addition to other institutions where R&D programs are underway. Commercially successful, industrially produced machines have yet to emerge in any large numbers from this R&D. There semms to be a lack of active backup and involvement by production engineers, which is so necessary from the very inception of a machine development program.

There is great need for an effective tractor-driven harvester, rice planter, potato planter, and a variety of other pre- or post-harvest machines that should be low-cost, sturdy, and effective

Table 3. Land – holdingpatterns in India.

Holding size (ha)	No. of holdings (mil.)	Area operated (mil. ha)	% of total area
0 - 0.4	8.67	1.7	1.3
0.44 - 2.02	22.62	23.9	17.9
2.42 - 5.05	12.60	38.6	29.0
5.45 - 10.1	4.54	30.6	22.2
10.5 - 20.2	1.77	29.1	17.3
Beyond 20.5	0.52	15.5	12.3
Total	50.8	133.4	

for the smaller quantum of work that meets the average farmer's needs.

The present tractors were not found economical on smaller holdings. The principal hurdle in the introduction of mechanization is seen in the land – holdingpattern (Table 3). There is a need for smaller machines.

The latest low-cost 15 hp Swaraj tractor, fitted with necessary hydraulics, would seem to be an effective and much awaited answer to the needs of the small farmer sector. Pre- and post-harvest equipment developed around this tractor could set the pace for a much wider and faster introduction of mechanization. It would have a direct impact on increased productivity on a massive scale. The 15 hp Swaraj may break the barrier in spreading mechanization in developing countries. Its emergence could be as significant as the advent of hybrid seeds in crop technology.

Transport needs of the farmer to and from nearby markets with a cartload of people or farm produce cost little using draft animals. Realizing the importance of animal-machine balance, some organizations, such as Dunlop India, have undertaken large R&D programs to improve bullock cart construction and operating efficiency. The extra load the new carts can carry is striking.

The Suri Research Foundation is preparing a report on the balance between machine and animal power for farmers. Data collected and experience show good benefit-cost returns where a biogas plant has been installed.

INDIGENOUS MANUFACTURE AND MECHANIZATION POLICIES

India today manufactures its agricultural equipment requirements -- tractors and implements, sprayers, threshers. Imports are no longer necessary. Harvester-combines are imported in small numbers and their manufacture is also planned. Tractors made in India range from 25 to 75 hp. The largest sales are 25 to 35 hp tractors. Heavy land development equipment like graders and levelers are also made indigenously.

To encourage mechanization, the government has directed banks to offer loans of up to 85% for farmers to purchase tractors and implements. The repayment period is 7-10 years.

An innovative measure is to provide loans to qualified engineers to set up tractor custom hiring service units in rural areas. This provides employment to engineers and technicians and introduces mechanization into farming with the necessary infrastructure. Many engineers have made a success of their ventures after carefully planning and locating their units.

In a country with small farm holdings, efficiently run custom hiring service stations could well be the answer for economic and viable introduction of mechanization. The problem has been to locate enough engineers willing to go to the 250,000 villages of India. The employment potential of such stations is self evident.

In India the pace of mechanization does not suffer from policy or fund constraints, but from the viability of small holdings for which appropriate machines are yet to be developed. Also, where irrigation is not yet assured, mechanization does not always pay. As irrigation increases, mechanization will gradually spread. Research in arid-area cultivation is beginning to show promise, but economic viability will need to be demonstrated before widespread mechanization takes place.

STATUS OF AGRICULTURAL MECHANIZATION IN SOUTHEAST AND EAST INDIA

K. N. SINGH
PROFESSOR, AGRICULTURAL ENGINEERING
G. B. PANT UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
PANTNAGAR-263145 DIST. NAINITAL, U.P.. INDIA

SUMMARY

Out of a 328.78 million ha geographical area, only 142.71 million were cultivated in India in 1973-74. The area under double cropping made up 18.7%, the irrigated area 22.8%. There has been an increase in the area, production, and yield of food grains in general and especially rice over the last 10 years. Rice is the most important crop of the country, especially the southeast and east region, in terms of area and production. The average size of operation is about 1.6 ha for most of the states of the southeast and east region.

Total draft power available on Indian farms is only 0.358 hp/ha of cultivated land. Most of the work is being done by animal and human power. It is estimated that about 40,000 tractors and 12,000 power tillers are presently in use in rice states. Some improved animal-drawn implements have also become popular. There is slow mechanization in the rice states. Power tillers have potential in this area; however, their high cost and lack of service facilities in villages hold back their use. The country is producing a good number of agricultural machines. Selective mechanization of agriculture is being promoted by the government.

INTRODUCTION

Most of the developing countries of Asia have the problem of high population and low level of land productivity compared with the developed nations. One of the main reasons for low productivity is insufficient power availability on the farms and low level of farm mechanization. This is especially true in India.

The classification of area in India for 1973-74 is given in Table 1. Out of 328.78 million ha of total geographical area only 142.71 million ha were sown. Of this only 18.7% was sown more than once and 22.8% was under irrigation.

Table 1. Classification of area in India, 1973-74.

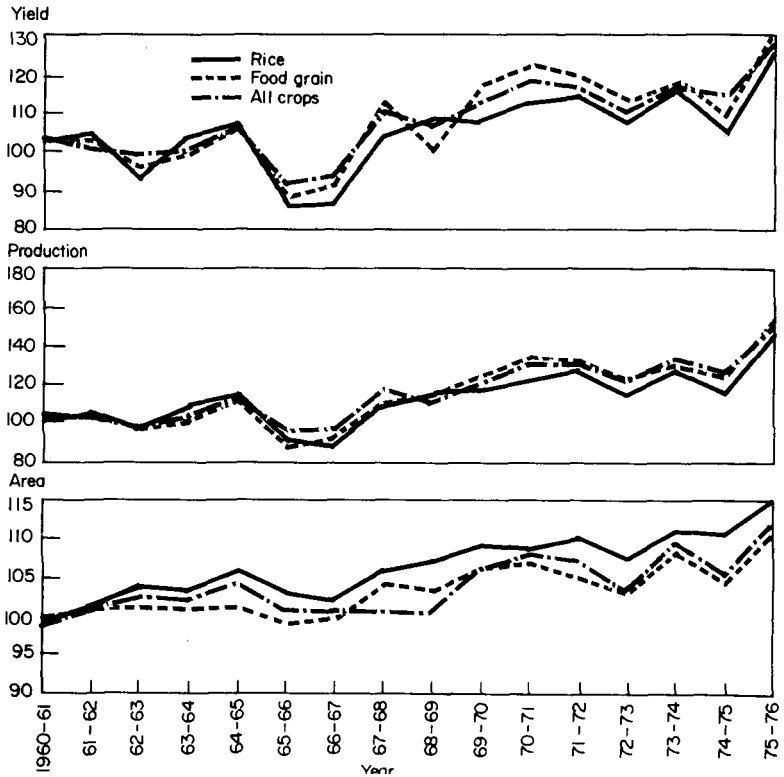
Item	Area (million ha)
Geographical area	328.78
Reporting area for land utilization	304.18
Forests	65.48
Not available for cultivation	42.71
Other uncultivated land	32.73
Fallow lands	20.45
Net area sown	142.71
Total cropped area	169.50
Area sown more than once	26.79
Net irrigated area	32.60
Gross irrigated area	40.25

Source: Times of India Directory and Yearbook, 1977. Times of India, Bombay.

The all-India index numbers of area under crops, agricultural production, and yield for rice, food grains, and all crops for the period 1960-61 to 1975-76 are plotted in Fig. 1. The index of area for all the crops has increased from 99.2 in 1960-61 to 111.2 in 1975-76. Similar increase in area may be noted for rice, food grains, and all crops. However, for all food grains and rice, the rate of increase is higher after 1966-67 compared with the period 1960-61 to 1966-67. The index of production for all crops has increased from 102.7 in 1960-61 to 148.6 in 1975-76. The production index has increased from 101.8 to 145.8 for rice during the same period.

The index of yield for rice increased from 102.0 in 1960-61 to 125.8 in 1975-76. The increase in yield is mainly due to introduction of high-yielding varieties in the latter half of the 1960s, increased irrigation facilities, and application of improved techniques in production. A number of new varieties that are suitable to different agro-climatic conditions have been developed. However, a large portion of rice area needs to be planted to the high-yielding varieties.

Total population of the country was estimated at 442.4 million in 1961. It had reached 597.9 million in 1975. There has been a growth rate of 2.19% per year on a compound rate basis. About 80% of this population depends on agriculture. There has been an increase in the national income from Rs. 13,260 crores ($1.66 billion) in 1961 to Rs. 20,080 crores ($2.51 billion) in 1975 at the 1960-61 price level. At the current price level, the national income in 1975 is estimated at Rs. 60,120 crores ($7.52 billion). Per capita income has shown a low increase from Rs. 305.6



1. All-India index numbers of area under crops and agricultural production and yield. (Source: Agricultural Situation in India, March 1977)

($38.2) in 1961 to Rs 341.4 ($42.6) in 1975 at the 1960-61 price level. The major share of increase in national income and per capita income is due to increases in agricultural production, especially after the introduction of high-yielding wheat varieties in 1965-66 and high-yielding rice varieties in 1966-67.

The total production of food grains in India in 1973-74 was estimated at 103.6 million t, out of which 44.6 million t -- 43% of total - was produced by the states of southeast and east India. Table 2 gives the density of population per thousand hectares of cultivated land for the states of this region. Density of population for these states is higher than that for the whole country.

Rice is the most important crop in India. The total area under rice in 1975-76 was 39.688 million ha, out of which 26.222 million were in the states of southeast and east India. Production of rice in these states was 34.14 million out of 49.46 million t produced in India. Table 3 gives the details of rice production in different states of this region. In some of these states there are three seasons of paddy in a year. In terms of total production,

Table 3. Final estimate of rice in India, 1975-76.

State	Area (thousand ha)				Rice Production (thousand t)			
	Autumn	Winter	Summer	Total	Autumn	Winter	Summer	Total
Andhra Pradesh	283.0	2547.0	1064.0	3894.0	450.0	4048.0	1953.0	6451.0
Assam	636.8	1565.3	38.8	2240.9	477.6	1767.3	45.5	2290.4
Sihar	598.1	4593.0	67.4	5258.5	344.8	4422.8	79.9	4847.5
Karnataka	1032.9	62.6	105.2	1200.7	1902.1	122.0	310.5	2334.6
Manipur	30.5	146.7	-	177.2	49.2	227.2	-	276.4
Meghalaya	33.5	69.0	1.8	104.3	30.0	85.6	3.7	119.3
Nalaland	36.0	30.5	-	66.5	19.8	20.1	-	39.9
Orissa	758.0	3746.0	180.1	4684.1	440.0	3834.0	257.8	4531.8
Tamil Nadu	2159.0	493.0	37.0	2689.0	4663.0	1117.0	87.0	5867.0
Tripura	129.2	135.5	35.4	300.1	136.8	172.8	57.0	366.6
West Bengal	864.6	4241.1	340.4	5446.1	785.3	5181.2	856.4	6822.9
Andaman & Nikobar Island	12.3	-	-	12.3	22.5	-	-	22.5
Arunachal Pradesh	68.4	-	-	68.4	59.9	-	-	59.9
Mizoram	16.2	33.4	-	49.6	10.0	29.0	-	39.0
Pondicherry	6.4	21.1	3.0	30.5	15.2	46.2	6.8	68.2
Total	6664.9	17684.2	1873.1	26222.2	9406.2	21073.2	3657.6	34137.0
All India	17413.3	20255.8	2018.7	39687.8	21560.6	23966.4	3930.5	49457.6

Source: Agricultural Situation in India, 1976-77.

Table 2. Density of population in southeast and east India, 1972.

State	Cultivated area in 1972 (thousand ha)	Population mid-year, 1972 (thousand persons)	Density per thousand ha of cultivated area
Andhra Pradesh	13,601	44,571	3,277
Assam	2,397	15,526	6,477
Bihar	10,123	57,649	5,695
Karnataka	11,181	30,042	2,687
Manipur	140	1,102	7,871
Meghalaya	162	1,038	6,407
Nagaland	62	526	8,484
Orissa	6,742	22,522	3,341
Tamil Nadu	7,209	42,216	5,a56
Tripura	243	1,598	6,576
West Bengal	5,712	45,560	7,976
Total	57,572	262,350	4,556
All India	151,923	562,467	3,702

Source: Report of the National Commission on Agriculture, 1976. Part I, Review and Progress. Ministry of Agriculture and Irrigation, Government of India, New Delhi.

West Bengal, Andhra Pradesh, Tamilnadu, Bihar, Orissa, and Karnataka are the leading states in the order mentioned. These are basically rice states and their problems of agricultural mechanization are more difficult than those of wheat states in the country.

CURRENT STATUS OF MECHANIZATION

The size of operational holdings is quite small -- the average in India comes to 2.63 ha. It is 2.87 ha for Andhra Pradesh, 1.46 for Assam, 1.53 for Bihar, 1.49 for Tamil Nadu, 4.11 for Karnataka, 1.98 for Orissa, and 1.56 for West Bengal. Out of an estimated 50 million rural households possessing operational holdings in India, 35% hold on the average less than 0.20 ha of land, 50% less than 1, and 70% less than 2. Besides, the holdings are scattered. No law for effecting consolidation of holdings has yet been passed in Andhra Pradesh, Tamil Nadu, and Kerala.

Table 4. Area under different size of holdings in southeast and east India, in thousand hectares.

State	Holdings in hectares			
	0-1	1-4	4 - 10	> 10
Bihar	1844.759	4099.607	3175,297	2360.192
Andhra Pradesh	698.5	4140.168	4186.138	3774.099
Orissa	769.951	3176.587	2327.732	807.445
West Bengal	1089.722.	2766.562	973.576	681.771
Tamil Nadu	1321.576	2491.898	1892.688	1003.046
Assam	509.298	1418.736	520.344	434.194
Karnataka	548.838	3426.112	3792.054	3600.821
Total	6780	21516	16865	12609

Source: Agricultural Census of India, Ministry of Agriculture and Irrigation, Department of Agriculture, 1970-71.

Table 4 gives the area under different size holdings in important states of southeast and east India. About 46.2% of the area falls within 1-4 ha and only 11.2% is covered by farms of area more than 10. Since the fields are not levelled, most of them are small for proper ponding of water for rice growing.

The total power available for crop production in India in 1975-76 is given in Table 5. Draft animals contribute 43.50% and humans 10.88%. The contribution of four-wheel tractors is only 11.55%. However, electric motors and diesel engines, which are used in pumping water and some other stationary works, together contribute 32.90% of total power. The draft power available is only 0.358 hp/ha of cultivated land in the country. This is a low level of power availability against a standard power requirement of 0.8 hp/ha of cultivated area as recommended by the President's Science Advisory Committee of U.S.A. and Task Force of Planning Commission, Government of India, on vehicles, earth-moving and construction equipment, agricultural machinery, etc.

The statewide distribution of tractors is given in Table 6. Although the number of tractors in these states has increased from 6,688 in 1961 to 26,100 in 1972, the number of tractors available in these states is only about 17.7% of the all-India figure. In 1975-76, out of a total of about 252,000 tractors in India, it is estimated that about 40,000 are located in these states. However, it is a different case for power tillers, which are more popular in the rice states. It is estimated that out of a total of about 15,000 power tillers in the country, 12,000 are in use

Table 5. Total available power for crop production in India, 1975-76.

Source	Total effective numbers (thousands)	Average hp per unit	Total available hp (millions)	% contribution
Human	81,600	0.1	8.160	11.00
Draft animals	65,540	0.5	32.770	43.00
Power tillers	13.7	7.0	.096	0.13
Tractors	252	35.0	8.820	12.00
Diesel engines	1,500	7.0	10.500	14.00
Electric motors	2,380	6.0	14.280	19.00
Power sprayers	240	1.5	0.360	0.48
Combine harvesters	469	75.0	0.035	0.46
Total available power			75.021	100.00
Total cultivated area		=	139.4 million ha	
Total power available per hectare of cultivated area		=	0.53 hp/ha	
Total cropped area in 1975–76		=	145.12 million ha	
Total power available per hectare cropped area		=	0.516 hp/ha	
Total draft power available per hectare of cultivated area		=	0.358 hp/ha	

Source: Energy in Indian Agriculture, 1976. Indian Society of Agricultural Engineers, New Delhi.

in these states. This number, although small, shows a potential for introduction of power tillers in this region.

Estimates of the availability of different agricultural implements and machinery in India in 1966 and 1972 are given in Table 7. The wooden plow still dominates the bullock–drawn implements. The increase in number of iron plows during the period 1966–72 indicates a slow progress in the adaptation of improved bullock implements on Indian farms. The progress in this field is still lower in rice states as compared with wheat states. The number of tractor–operated implements in the states of southeast and east India is about 16% of their total number, which is proportional to the relative number of tractors in these states. About 60% of the paddy threshers may be present in these states, a majority of which are the Japanese head stripping type. Wheat threshers and combine harvesters are found mostly in wheat states of the country.

Table 6. Statewise distribution of tractors in southeast and east India.

State/Union territory	1951	1956	1961	1966	1972
Andhra Pradesh	308	1626	1762	2911	6300
Assam	206	159	489	834	500
Bihar	494	1227	1520	2132	5600
Karnataka	387	807	981	2595	5700
Manipur	7	6	11	6	b/
Meghalaya	N.A.a/	N.A.	N.A.	N.A.	N.A.
Nagaland	-	N.A.	N.A.	9	N.A.
Orissa	59	95	194	667	1800
Tamil Nadu	325	822	1387	3875	5400
Tripura	3	7	13	9	-
West Bengal	325	450	330	1548	700
Total	2114	5199	6687	14596	26000
All India	8635	21005	30944	54600	147960

a/N. A. = Not available.

b/Less than 50.

Source: Directorate of Economics and Statistics. Livestock Census reports, 1972.

The distribution of engine-driven and electrically operated irrigation pumps is given in Table 8. From 1961 to 1972, the total number of pumps increased from 390,000 to 3,246,000. This increase was due to easy loan facilities and subsidies given by different state governments to the farmers for the purchase of pump sets. The relative proportion of electrically operated pumps is on an increase in the rural electrification program in the country.

From Fig. 1, it is observed that during the period 1960-61 to 1975-76, the index of area under rice registered an increase from 103.5 to 109.6. This owes to a larger double cropping area and increased availability of power as well as irrigation facilities on the farm. Increase in power availability is directly related to the extent of farm mechanization since additional power is coming through mechanical-electrical sources. The rice yield has shown an increase of 10.6% for all-India and 14.4% in the states of southeast and east India during the period 1962-65 to 1971-74 (National Commission on Agriculture, 1976). Although high-yielding varieties are the dominating factor, increased power availability contributed to increase in yield through timely operations. The

Table 7. Number of agricultural implements and machinery in India.

Item	Thousands	
	1966	1972
Plow - wooden	39,923	39,294
- iron	3,523	5,359
Blade harrow or Bakher or Guntaka		11,712)
Wetland puddler	2,724	1,689)
Earth levelers or scrapers		3,718)
Seed drills	1,135	4,047
Maize shellers	N.A.	175
Carts (animal drawn)	12,697	12,960
Persian wheels or rahats	680	638
Sugar cane crusher worked by:		
Power	45	87
Bullocks	650	678
Plant protection equipment:		
Sprayers and Dusters	211	413
Tractor operated implements:		
M.B. and disc plow		57)
Disc harrows		56)
Cultivators or scrapers		49)
Seed-cum-fertilizer drills		25)
Seed planter	N.A.	9)
Rotavator		6)
Trailer		55)
Other tractor operated implements		18)
Power driven machines and miscellaneous equipment:		
Wheat threshers		183)
Paddy threshers		14)
Threshers for other crops		10)
Maize shellers		16)
Harvester combines		)
Power chaff cutters		161)
Other power operated equipments		34)
Ghanies:		
Five kg and above	74	40
Less than 5 kg	159	76

Source: Agricultural Situation in India, June 1976, p. 141.

Table 8. Statewise growth of engine driven and electrically operated pumps, 1961-1974.

States	1961		1966		1972		1974
	Engine driven	Electrically operated	Engine driven	Electrically operated	Engine driven	Electrically operated	Electrically operated
Andhra Pradesh	33,940	17,024	46,741	37,225	117,000	145,000	261,989
Assam	76	51	362	22	500	500	694
Bihar	3,187	1,930	3,698	6,854	40,000	53,000	96,922
Karnataka	10,087	12,433	24,575	27,054	43,000	159,000	189,284
Manipur	13	N.A.[a/]	3	N.A.	500	N.A.	N.A.
Meghalaya	N.A.	N.A.	N.A.	N.A.	500	500	N.A.
Nagaland	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Orissa	1,203	129	710	189	6,000	500	2,617
Tamil Nadu	36,832	98,481	42,852	208,485	234,000	681,000	681,258
Tripura	22	N.A.	N.A.	13	500	500	40
West Bengal	3,637	2,561	4,162	629	5,000	2,000	6,535
Total	88,987	132,609	123,103	280,471	447,000	1,022,000	1,239,339
Total India	229,971	160,168	479,089	390,505	1,628,000	1,618,000	2,441,045

[a/] N.A. = Not available.

Source: Farm Machinery Directory, Indian Society of Agricultural Engineers, 1977.

Table 9. Consumption of fertilizers ($N + P_2O_5 + K_2O$).

State	Kg/ha of cropped area	
	1966-67	1973-74
Andhra Pradesh	15.8	26.4
Karnataka	7.9	17.7
Tamil Nadu	22.0	44.6
Assam	1.8	3.5
Bihar	9.0	9.1
Orissa	3.6	8.9
West Bengal	7.1	13.6
All-India average	-	17.3

Source: Report of the National Commission on Agriculture, 1976. Part I-Review & Progress.

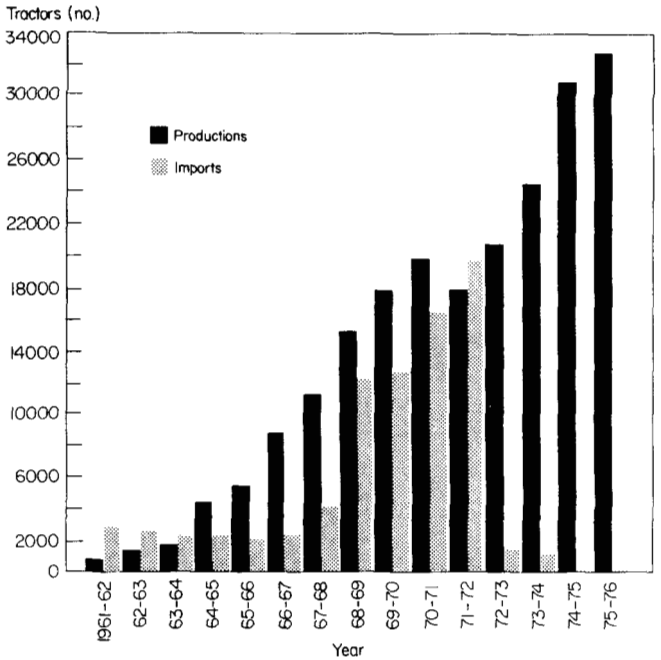
increase in fertilizer consumption in these states, shown in Table 9, is also responsible for yield increases.

Labor wages have also increased from an average of Rs. 1.75 per day ($0.22 a day) in 1960-61 to Rs. 4.50 per day ($0.56 a day) in 1975-76 in the southeast and east region of the country. In wheat regions some studies have shown that mechanization has resulted in increased labor employment and wages made possible by increased cropping intensity and diversified farm operations in the production of crops of high-yielding varieties.

LOCAL MANUFACTURE OF EQUIPMENT

The farm machinery industry has grown substantially in India during the last 10 years. There are at present more than 10 manufacturers of four-wheel tractors and 6 manufacturers of power tillers. Figure 2 gives annual production and import of four-wheel tractors in India. Presently, the tractor industry is self-sufficient with many of the models totally dependent on local components. This has resulted in the development of local ancillary industries, such as manufacturing of tires and tubes, gears, castings, batteries, dynamos, and fuel pumps.

The production of power tillers began in 1963, by M/S Krishi Engines Ltd. Other manufacturers were to follow later, in 1970-71 and onwards. Most of the power tillers have diesel engines with 5-12 hp. The total production of power tillers in 1975-76 was



2. The indigenous production and imports of tractors in India. (Source: Energy in Indian Agriculture, 1976)

2,540 against a licensed capacity of 40,000 per year. Most of the power tiller manufacturing plants are located in rice states, as demands for them is concentrated in these states.

The progress in the manufacture of pumps for irrigation has been rapid. There are a large number of pump manufacturers in the country. The large-scale manufacturers have a total installed capacity of 508,000 units per year, 95% of which are agricultural pumps. Small-scale manufacturers are also producing pumps. The industry now manufactures fractional horsepower monoblock pumps, different types of centrifugal pumps, mixed flow pumps, axial flow pumps, deep well turbine pumps, and submersible pumps of various capacities.

In India, the engine manufacturing industries began in the 1930s and have grown to include a number of big and small manufacturers of diesel and petrol engines. The diesel engine industry is capable of producing engines up to 18,000 hp. The number of production units in that organized sector rose from 6 in 1951 to 32 in 1975. Production from these units had risen to 141,000 in 1975, compared with about 20,000 in 1951. There is also substantial production of units in the small-scale sector.

About 80% of production consists of engines up to 20 hp. A large number of ancillary industries produce sufficient quantity of engine components for engine manufacturers (Zachariah et al., 1977).

A number of animal–drawn implements such as plows, harrows, puddlers, cultivators, levelers, scrapers, seed drills, ferti–seed drills, planters, olpad threshers, Persian wheel, and sugar cane crushers have been in production in the country for the last 20 years or so. Now, there are about 1,500 registered units in various states manufacturing agricultural implements. In addition, a number of artisans and small–scale workshops are also engaged in manufacture of such implements. A number of firms manufacture handtools and implements such as spade, shovel, wheel hoe, seed drill, maize sheller, and holticultural and garden tools.

Presently, there are about 500 manufacturers engaged in the production of parer–operated agricultural implements. The items of manufacture include plows, disc harrows, tillers, ferti–seed drills, levelers, puddlers, reapers, threshers, cane crushers, potato diggers, ground nut diggers, ground nut decorticators, trailers, chaff cutters, and sugar cane crushers.

A large number of rice mills exist in India. However, these are mostly huller type units. In 1964, the Government of India introduced seven modem rice mills, mostly in rice states. These rice mills performed better. Now, more modem rice mills with 250–500 kg of paddy per hour are being manufactured in the country. The number of fruit and vegetable processing industries also increased from 901 in 1961 to about 1,200 in 1975. Equipment needed by this industry such as washing tanks, cutting machines, pulpers, juice extractors, and filling machines are locally manufactured. Likewise, there are about 10 large–scale and small–scale manufacturers of seed processing equipment and ancillary items.

During the last few years India has exported tractors, threshers, implements, engines, and pumping sets to countries in Southeast Asia, Africa, and the Middle East. However, items such as self–propelled combine harvesters, tractors of 70 hp and over, and transplanters, are still imported from other countries.

POLICIES RELATING TO MECHANIZATION

Total mechanization of agriculture is not being encouraged in India because of a possible labor displacement. The concept of selective mechanization is well received and the government as well as others concerned also feel it essential.

To encourage the local manufacture of agricultural implements and machines, many of the products such as power tillers, engines, implements, and agricultural discs are put under the priority sector and receive preferential treatment in the allocation of raw materials. The government has encouraged all banks to extend credit facilities to farmers at a 10 – 14%yearly interest rate for purchase of tractors, power tillers, pump sets and other agricultural equipment. The manufacturers of this equipment also get bank loans at 10-15% interest rates.

The tax policy of the central and state governments in respect to agricultural machines and implements has been unfavorable for the last 5 or 6 years. The taxes and other governmental levies on a tractor, which ultimately become payable by the farmer consist of:

1. Import duty and ad valorem duty on imported components and raw materials from 40% to 120%.

2. Excise duty of 18% payable on ex factory cost of manufactured items/components/finished tractor.

3. Central sales tax of 4% and state sales tax of about 7% on an average.

4. Octroi and surcharge.

5. Road tax and miscellaneous taxes.

Besides the duty payable on fully built tractors, excise duty of 15 to 25% is payable by manufacturers of engine parts, tires, batteries, starter motors, and radiator hoses. Due to increased taxes on the components and on the tractors, the prices of the latter have gone up to about two and one-half times during the last 6 years. The high cost of power tillers, combine harvesters, engines, and other implements naturally slowed down their utilization on the farm.

The government is still anxious to promote selective mechanization. One Agro-Industries Corporation has been opened in each state to promote farm machinery manufacture, sales, and utilization in the state. Table 10 lists the activities of Agro-Industries Corporation in the states of southeast and east India. In addition, a number of machinery hire and service centers have been opened by either state government or private entrepreneurs to complement the efforts of the corporation. Easy loans, etc. are provided to private entrepreneurs as incentive.

The joint ownership system is rare. Usually it is individual or state ownership of machinery, Farmers owning 6 to 8 ha in rice

Table 10. Machinery owned by Agro – Industries Corporation for custom – hire work.

State	Pneumatic tractor	Crawler tractor	Power tiller	Rigs for tubewells	Well revitalizing units
Andhra Pradesh	26	168	-	57	28
Assam	20	-	9	-	-
Bihar	162	-	-	-	-
Karnataka	106	145	11	70	44
Orrisa	18	8	-	-	-
Tamil Nadu	68	-	30	-	-
West Bengal	40	-	11	-	-
Total	440	321	61	127	72
All India	1,409	367	79	128	118

Source: Agricultural Engineering Today, August 1976.

area may purchase a tractor together and maximize its use by doing the job for other farmers on a hire basis. Wherever mechanization has been introduced, it has resulted in increased labor wages. In spite of positive efforts by the government, the country still lacks a comprehensive mechanization policy that can be integrated with development goals in the agriculture sector.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

The Indian Council of Agricultural Research is the main organization of the Government of India looking after all agricultural research, including agricultural implements and machinery. It coordinates a number of plans with centers at four to seven places in the country. Ad hoc plans are also financed by I.C.A.R. Each state government has its own research organization at state level. However, a major portion of research on agricultural machines and mechanization is being conducted by different agricultural universitites in the country. Each of the major states has at least one agricultural university. The extension work on farm machines and implements is being done by state governments and agricultural universities. Council of Scientific and Industrial Research, different institutes of I.C.A.R., and manufacturers of agricultural implements and machines also either have their own research wings or finance research on farm machines and mechanization.

A research program usually concentrates on the development of equipment suitable to Indian farming conditions. Many times

adaptive research is done instead of starting design and development afresh. Here the objective is to improve upon the performance of indigenous implements or develop a new implement that can either increase labor productivity or completely mechanize the operation where a labor or power shortage hinders completing the work on time.

FUTURE DIRECTIONS

The present policy of encouraging selective mechanization is expected to continue. All the research and extension activities by different organizations will continue on the existing lines. The government encouragement for higher production by industries may be more due to the possibility of higher export by these industries and increasing mechanization in the country. Mechanization of agriculture in rice states may not progress rapidly due to slow introduction of power tillers and the relatively less effectiveness of four-wheel tractors under wetland paddy conditions. The progress of mechanization will very much be affected by the policy of the government regarding taxes and excise on machines and price of agricultural produce in relation to the price of inputs.

However, to cope with the demand of food for a growing population, it is necessary to fully exploit the untapped potential of agricultural production through increased average yield per unit area and bring more area under double cropping. To achieve this goal, it will be necessary to use more pump units for irrigation and use more tractors and power tillers along with improved equipment for providing additional draft power for timely operations. It means that mechanization is bound to progress steadily in this country.

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STATUS OF AGRICULTURAL MECHANIZATION IN NEPAL

B. K. SHRESTHA
AGRICULTURAL ENGINEER, DEPARTMENT OF AGRICUCTURE
MINISTRY OF FOOD, AGRICULTURE, & IRRIGATION
JAGADAMBA BHAWAN, PULCHOWK, LALITPUR. NEPAL

SUMMARY

Though agriculture is the main occupation in Nepal, most farm operations are still carried out manually or by animal power with indigenous tools and implements. Productivity of land and labor is low. Chemical fertilizers, improved seeds, disease- and pest-control chemicals, and improved implements and machines are just beginning to be introduced.

The scientific agricultural development program was launched about 2 decades ago. Nepalese farmers are quickly adopting new methods and practices to increase production. Power machines are used by farmers with bigger land holdings in the plains region and valleys, but only for a few farm operations. The bulk of arable land lies in hills and is unsuitable for machine operations.

INTRODUCTION

Nepal is mountainous with a total area of 14.1 million ha - 2.3 million cultivated (16%). From north to south, it can roughly be divided into three main geographical regions - the Himalayan belt, the mountainous region, and the plain (tarai).

Stretching along the southern border, the tarai consists of a long strip of plains. It has a subtropical climate and, being a part of the Gangetic plains, forms the major portion of the agricultural area of the country. This region has 36.4% of the country's population of nearly 12.9 million, one-sixth of the total area, 70% of the total cultivated area, and produces 60% of the gross agricultural output. Nearly two-thirds of the population live in the central hills and Himalayan regions, which occupy about 30% of the total cultivated area and produce 40% of the gross agricultural output.

Ninety-four percent of the total population is engaged in agriculture, which contributes about 66% of the total national income. Agricultural commodities make up over 60% of the country's total exports.

His Majesty's Government has accorded top priority to the development of agriculture in each 5-year plan.

Generally, all crops are grown under natural rainfall. Yields are low and uncertain. Total failures occur. Before initiation of the first 5-year plan in 1956, only 14,000 ha of land had irrigation facilities. Table 1 shows the improvement in irrigation facilities during the last 2 decades. By the end of the fourth plan period, about 8% of the total cultivated land in Nepal was under irrigation.

The present pattern of land utilization is shown in Table 2. Per capita availability of land is only 0.18 ha and average farm size is about 1.23 ha. This population density as compared to the surface arable land is considered high. Since agricultural land is limited, the agricultural development program has to place greater emphasis on increasing land and labor productivity by intensive and modern methods to feed the population, which is growing by 2.07% yearly.

Table 3 shows that 83% of the farmers with 28.5% of the total cultivated land have less than 3 ha each. Any development program has to take into account this major portion of the population.

Table 1. Development of irrigation facilities through 5-year plans.

Five-year plan		Irrigated area/ developed, ha
Before first plan		14,700
First plan	1956 - 1961	17,200
Second plan	1961 - 1964	26,500
Third plan	1964 - 1969	59,090
Fourth plan	1969 - 1974	72,510
Target for fifth plan	1974 - 1979	123.000
Total		312,000

Source: Shreshtha, B.P. 1974. An introduction to Nepalese economy.

Table 2. Statistics on land use in Nepal.

Land type	Area (000 ha)	Percent
Total geographic area	14,106	100
Forest area	4,475	32
Area under perpetual snow	2,112	15
Area under rivers, canals, roads etc.	1,077	8
Area unreclaimable	2,566	18
Area reclaimable	1,550	11
Area under cultivation	2,326	16

Source: Economic Analysis and Planning Division, HMG.

Table 3. Distribution of land holdings in Nepal.

Size of holding, ha	Household, %	Area, %
Less than 1	63.5	10.5
1–3	19.5	18.0
3–5	17.1	12.0
5 – 10	5.8	21.0
10 – 15	2.1	11.0
15 – 20	0.9	7.0
20 – 30	0.5	5.5
30 and above	0.6	15.0
Total	100	100

Source: Zaman, M. A. 1973. Evaluation of land reform in Nepal.

Food crops occupy 97% of the total cultivated area and cash crops only 3%. Rice is the main crop grown on about 85% of the total cultivated land, and improved varieties of paddy cover about 222,600 ha, which is close to the wheat acreage. The main crop in the hills is maize. In the tarai and valleys, wheat or pulses are grown after paddy. A double paddy crop is grown in the irrigated area. The cropping intensity of paddy is 115%. Average yields of paddy are 2.1 t/ha, maize 1.8, and wheat 1.0.

CURRENT STATUS OF MECHANIZATION

Agricultural operations from land preparation to grain storage rely primarily on animal and man power. Animal power is used for land preparation and threshing and other operations are done manually. Hence, labor productivity is low.

The rate of growth of agricultural mechanization in Nepal is rather slow. No machinery is used in the hill and mountain regions. In areas where double cropping of paddy and wheat prevails, the time factor is critical to prepare the land for the next crop on one hand and to thresh the preceeding crop in time on the other. Four-wheel tractors and power tillers are used mainly for land preparation in the tarai and valleys.

While intercropping, power spraying, harvesting, and threshing equipment are badly needed to complete operations on time, they are neither used nor popular among farmers. High initial cost, shortage of spare parts, lack of repair and maintenance facilities, and a low level of technical know-how are a partial explanation. Even farmers who have tractors own only limited equipment, such as a cultivator, disc harrow, and trailer.

During the crop season, tractors are used to haul both agricultural and nonagricultural goods. In fact, tractor hauling of nonagricultural goods has been widely used in small villages and towns where roads become impassable to large trucks.

Though accurate data are not available, Table 4 gives more information on the incremental change in use of farm machines over time. It is noteworthy that the increase of farm machined is slow

Table 4. Farm machinery data for Nepal.

Machine	Year							
	65/66	66/67	67/68	68/69	69/70	70/74	74/75	Total
4-wheel tractor	111	57	73	195	358	1,061	195	2,050
Power tiller	-	-	-	-	-	100	300	400
Irrigation Pump sets	-	10	40	100	1,130		2,032	3,500

Source: Agricultural Development Bank of Nepal.
Note : Country paper on Agricultural Mechanization - Nepal, by S. N. Regmi, reports there were 585,000 draft animals in 1966.

even though the Agricultural Development Bank of Nepal provides loans to farmers to purchase them. It also imports tractors and irrigation pump sets and distributes them to the farmers.

Tractors are imported mainly from India and England, power tillers from Japan, and pump sets from India and Japan. There is no immediate plan to manufacture such equipment locally.

No reliable data are available detailing changes in farm production and farm income as a result of mechanizing farm operations. But it can be safely assumed that production has increased to some extent due to timely land preparation and sowing. Land preparation with animal power takes about 96 hr/ha and costs $20; power tiller, 20 hr and costs $45; and with a four-wheel tractor (35 hp), 8 hr and costs $70. The number of tractors is small in relation to the total cultivated land, so labor displacement is negligible.

LOCAL MANUFACTURE OF EQUIPMENT

Small hand tools and wooden plows are locally made by village blacksmiths. Some private companies manufacture other implements such as 1 ton trailers and cultivators. Data on such implements and tools are not available

The Agricultural Tools Factory in Birgunj is the only major manufacturer of agricultural implements. There are some factories and workshops willing to produce farm machines of acceptable quantity if they receive firm orders. Table 5 shows the number

Table 5. Production of agricultural implements by Agricultural Tools Factory.

Machine or tool	Year							
	70/61	71/72	72/73	73/74	74/75	75/76	76/77	Total
Tractor – cultivator	-	-	-	-	34	156	24	214
Tractor disc – harrow	-	-	-	3	13	8	16	40
Trailer, 3t	-	21	42	79	65	86	36	329
Trailer, 5t	-	-	12	2	6	5	61	86
Trailer, 1t	-	-	-	-	-	-	74	74
Power thresher	-	-	-	-	-	9	-	9
Pedal thresher	246	226	332	195	112	94	66	1271
Animal plow	5610	3372	2797	2392	5208	1106	955	21440
Sickle	-	-	-	-	-	2205	2244	4449
Hand tools – spade, rake etc.	8082	7802	6788	10042	18180	13702	6186	70062

Source: Agricultural Tools Factory, Birgunj.

and types of implements manufactured and sold by the Agricultural Tools Factory.

All raw metals for implements are imported, mainly from India. Locally manufactured power-dram implements are working satisfactorily and fulfilling the present demand.

POLICIES RELATING TO MECHANIZATION

The introduction of agricultural inputs such as chemical fertilizer, improved seeds, and farm machines is quite new to Nepalese farmers. Under the present agricultural practice, land preparation, sowing, harvesting and thershing are the main operations which face labor shortages and need to be performed within a limited time interval. These operations need to be mechanized to increase production.

Emphasis has been given to modernizing agricultural practices. The Agricultural Development Bank of Nepal provides loans at 14% interest per year. The import tax on farm equipment has been reduced to 1% of CIF or FOB price of imported equipment. No special incentives have been provided for the purchase of fuel and lubricants for agricultural purposes.

There are many constraints to modernizing farm operations. Poor irrigation facilities, small and fragmented land holdings, low yields, dependence of a majority of the population on agriculture and the resultant low wage rate, expensive imported machines, high cost of fuel and lubricants, nonavailability of spare parts and repair shops, and the lack of technical know-how are the main handicaps in the mechanization of agriculture in Nepal.

Some help is provided to the farmers in the form of loans, farm machines, and other inputs by the Agricultural Development Bank and the Agricultural Input Corporation. District Agricultural Development offices provide information and technical guidance to encourage and broaden the knowledge of farmers in the use of modern farm equipment. The Agricultural Engineering Research Division trains farmers in the proper use of farm equipment and also arranges field demonstrations of suitable equipment.

Agricultural research stations and farm situated at different agroclimatic conditions have a number of tractors and other equipment; most of the field operations are mechanized. These stations and farm serve as pilot projects for farm mechanization. They have been a source to encourage farmers of neighboring villages and districts to mechanize.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Considering the Nepalese farmers' socio-economic condition, size of land holding, and geographic features, animal and human force are the main power for agriculture. Mechanical power is increasing gradually. About 585,000 animals are available for farm work. Therefore, to utilize the available animal and human resources more efficiently and effectively, the priority on research and development work has been given mainly to animal-drawn implements and hand tools.

Extension work on suitable implements and tools is carried out in different districts to familiarize farmers with the uses of improved implements. People are being trained to efficiently operate tractors and associated implements. This type of research, development, and extension work has been carried out by the Agricultural Engineering Research Division, under the Department of Agriculture on a priority basis in the tarai region.

Animal and human power have to be fully utilized to employ a maximum number of people in agriculture. Investment in agricultural machinery is long term and the return is slow in comparison with chemical fertilizers and improved seeds.

For the time being, the government has formulated a policy to use its limited financial resources only on small and short-term projects. Many people will directly benefit through an increase in productivity of land and labor. Animal and human power will remain the main power in agriculture for a few more years; research and development work on animal-drawn implements and hand tools will be continued. Research on suitable methods of mechanization will also be carried out at different governmental farms and stations.

FUTURE DIRECTIONS

Animal and human power will be the main source of energy for small farmers for many years. But 38.5% of the land is suitable to mechanized farming for which about 20,000 four-wheel tractors, besides power tillers for small farms, will be needed. Hence, the farm mechanization program should be approached from this angle.

During the last few years, prices of farm machinery and petroleum products have almost tripled. Bank interest rates of 14% for farm machinery are the same as for chemical fertilizers and improved seeds and are relatively unattractive because the return from farm machinery takes longer. Before implementing

any mechanization program, these problems should be analyzed and solved.

Farm mechanization will follow only after the adoption of intensive cultivation practices, which are still to be spread throughout the country. With land the limiting factor, production has first to increase through intensive cultivation and other improved agronomic practices. A definite policy to promote a farm mechanization program suitable to Nepalese conditions has yet to be designed and implemented. At present, mechanized farming on a cooperative basis seems logical; its feasibility has to be studied.

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STATUS OF AGRICULTURAL MECHANIZATION IN BURMA

U HLA TIN
ASSISTANT DIRECTOR, AGRICULTURAL MECHANIZATION DEPARTMENT
MINISTRY OF AGRICULTURE AND FORESTS
SOCIALIST REPUBLIC OF THE UNION OF BURMA
NO. 459, PROME ROAD, RANGOON, BURMA

SUMMARY

Agriculture accounts for 60% of Burma's GNP, 57% of export earnings, and 65% of the employment. Rice is Burma's major crop and is grown on about 60% of the total sown area.

The use of tractors began in 1945. In 1962 four-wheel tractors were introduced on a mass scale to help solve the shortage of draft animals in the postwar period, to extend double cropping practices, and to expand the industrial crop area. About 7,900 tractors and 350 power tillers are operating in Burma's agricultural fields. In addition about 93,200 ha are sown to second crops using pumps to supplement water supplies.

Tractors and other agricultural machinery, except some implements, are locally assembled. Indigenous agricultural machinery manufacture by small private firms is unorganized and unsystematic.

According to the country's goals, development of mechanization in Burma involves: 1) establishing large-scale state and cooperative farms and complete mechanization of them, 2) extension of tractor custom hire services to farmers, 3) introducing power tillers for rice cultivation, 4) extension of pump irrigation, 5) increasing local assembly and production of agricultural and machine parts.

INTRODUCTION

General

The Socialist Republic of the Union of Burma has a land area of some 66.9 million ha. It has four distinct climatic and topographic regions: 1) Western and Northern Hills, 2) Shan

Plateau, 3) Central Region, and 4) Arakan and Tenasserim Coastal Regions. The Central Region is the most densely settled and comprises a fertile lower wet zone, a central dry zone, and a northern wet zone. Administratively, Burma is divided into seven states and seven divisions, each state and division is subdivided into townships.

About 27% of the country -- 18 million has -- is considered arable, but only 8 million are under cultivation. Another 1.96 million has are fallow while the remaining 8.04 million are classified as cultivable waste land, most of which is unsuitable for rice, the staple crop. Forests cover about 32 million has of which some 9.4 million is reserved and producing many species of valuable timber, particularly teak.

Agriculture

The agricultural crop sector accounts for nearly 60% of the GNP, about 57% of the total exports, and 65% of the population's employment. According to the 1973 census, Burma's population is 31.5 million, of which 70% is directly or indirectly dependent on agriculture for its livelihood. Farm labor constitutes 65% of the country's labor force -- 8.1 million out of 12.4 million.

There are about 4.3 million farm holdings with an average size of 2 ha spread over 70,000 villages. Tenancy and absentee ownership have been abolished since 1963 and all land is owned by the state. Farmers have a usufruct on land right (right to occupy and cultivate land); usufruct can be inherited by members of the family who participate in cultivation.

Rice is Burma's major crop; it is grown on about 60% of the total sown area. In 1975-76, the total sown area of rice was 4.9 million has, 17% of which is under irrigation. About 70% of the area under paddy is in Lower Burma, mainly in the Irrawaddy Delta. Mostly local varieties are grown and only about 16% of the total rice area is sown to modern varieties (MY) due to inadequate water control. But the NV paddy area has increased during the present decade from 360,000 has in 1970-71 to a little over 800,000 in 1975-76.

Besides rice, Burma grows many other crops. The more important are maize, millet, pulses, oil seeds (groundnut and sesamum), wheat, cotton, jute, sugar cane, onion, garlic, chillies, tobacco, and vegetables. Cotton cultivation as well as jute and sugarcane, being the industrial crops, are becoming popular and the government has launched a special drive to increase the acreage.

Irrigation

With 960,000 ha or 12% of the net sown area presently under some form of irrigation, the ratio of irrigated to cultivated land is low. Lack of water control is a major constraint to the widespread adoption of MVs and to the achievement of higher yields with local varieties of all crops. Irrigation development, therefore, has high priority in Burma's strategy for developing the agricultural sector.

Only about 3% or 140,000 ha are currently rice double-cropped due to lack of storage facilities for dry season irrigation. Irrigation water comes mostly from the Irrawaddy River and its tributaries and is used primarily to supplement monsoon rainfall during the wet season for paddy, mostly in the Central Dry Zone, and to a much smaller extent to irrigate other crops in the dry season. About 348,000 ha are irrigated by wells, ponds, pumps, and other sources, mainly small stream diversions. In addition, there are about 2300 kms of embankments, mainly in the Delta, to reduce the effects of floods from the Irrawaddy River and its tributaries. These embankments presently protect nearly 800,000 ha of cultivated land.

Though irrigation has been considered necessary for progressive and successful agriculture, its development has been rather slow. Before World War 11, Burma had about 650,000 ha (or 9% of the cultivated area) under irrigation. By 1974, this had been expanded to 1 million or 10% of the cultivated area. Nearly 50% of the irrigation facilities are under the management of the Irrigation Department.

CURRENT STATUS OF MECHANIZATION

Founding of Mechanization Department

Agricultural mechanization, mainly the use of four-wheel 46 – 50hp agricultural tractors, was started in 1953. The Mechanization Project Department was formed as a branch of the Agricultural and Rural Development Corporation in 1962. Its purpose was to help solve the problem of the shortage of draft-animal power and especially to expand double cropping practices. In October 1972, to better define its role in promoting agriculture, it was reorganized as a separate Department.

The main functions of the Agricultural Mechanization Department are:

1. Extend tractor custom hire services to farmers for land preparation. Priority is given to those farmers cultivating for double cropping and to industrial crops.

2. Sell tractors, power tillers, water pumps, and other agricultural implements to village cooperatives and groups of farmers.

3. Take responsibility for the maintenance and repair of development-owned tractors and machinery and cooperative-owned ones as well.

4. Train tractor operators, tractor mechanics, and other technical cadres required for mechanization.

5. Try to introduce various farm implements, other than for tillage, through proper and systematic research.

6. Prepare and improve the long-abandoned fallow and newly reclaimed lands for normal cultivation practices.

Type of agricultural machinery employed

The Agricultural Mechanization Department (AMD) has established 88 Agricultural Tractor Stations (ATS) throughout the country except in Chin Hills and Tannasserim Coastal Regions. These stations, with their 4,000 tractors, have prepared 280,000 ha annually for multi-cropping.

Besides tillage, the following farm machines are being evaluated and put into use when found suitable:

1. Seeders for corn, pulses, etc.,
2. Planters and ratooners for sugarcane,
3. Inter-row cultivators,
4. Tool bar with different attachments,
5. Peanut lifter windrower,
6. Paddy harvesters, and
7. Sprayers.

According to the tasks undertaken by A.M.D., 3,335 four-wheel 50 hp tractors with plows and harrows, 350 power tillers, 26,000 water pumps, 500 paddy threshers, and 195 rice hullers had been sold to farmer cooperatives and farmer groups up to the end of 1975 – 76.In addition there are about 400 individually owned tractors. Therefore, it can be said that all together about 7,900 four-wheel tractors and nearly 350 power tillers are operating in Burma's agricultural fields.

Other than four-wheel medium-sized tractors, power tillers have also been introduced, especially in rice cultivation, and found to function reasonably well in some rice areas. Trials using combine harvesters are under way.

Training of mechanization extension cadres

All agricultural machinery is locally assembled in Burma and A.M.D. takes responsibility for distribution as well as education on proper use of these machines. In the past decade, 15,000 tractor operators, 3,000 driver-mechanics, 1,500 mechanics and 500 other technical trademen were trained by A.M.D. Training Centers. In addition, information on proper utilization of tractors and implements are disseminated to village cooperative executive members and farmers through occasional meetings in the village.

Repair facilities

Maintenance and repair of tractors and agricultural machinery are the responsibility of A.M.D. repair workshops. The repair division of the A.M.D., therefore, provides repair and maintenance facilities at its tractor stations, two Base Workshops, and five Medium Workshops. The effectiveness of repair work is, however, low due to inadequate spare parts and workshop equipment. Improvement of existing workshop facilities and extension of new repair shops, as well as fulfillment of required spare parts are, therefore, badly needed.

LOCAL MANUFACTURE OF EQUIPMENT

Source of agricultural machinery

All tractors, power tillers, water pumps, and other agricultural machinery now operating in Burma's agricultural crop sector are assembled locally by the Heavy Industry Corporation. Fifty hp four-wheel tractors are purchased from Czechoslovakia, and power tillers and water pumps from Japan. Implements (plows and harrows) for tractors are imported from various countries.

The Heavy Industry Corporation of Burma plans to increase assembly and production, not only of tractors, power tillers, and water pumps, but also other machinery and implements such as sugarcane planters, sugarcane ratooners, and peanut digger windrowers, during Burma's Third Four-Year Period. At the same

time the content ratio of locally made machine parts in machinery will also be increased. The main difficulty in the domestic production of machine parts for machinery is in the raw materials shortage, especially steel. Technology and investment problems also need to be considered.

Indigenous farm machinery production

In the production of indigenous farm machinery, there are two government engineering plants, both in Rangoon. These plants are experimenting with the production of such implements as animal-driven rotary blade-harrows, inter-row cultivators, and paddy threshers. Rice transplanters are also being evaluated.

Many family-sized machine shops all over the country are engaged in the manufacture of agricultural implements. These small manufacturers, however, do not have the qualified engineers nor sufficient capital to produce spare parts and farm machinery of good quality. Lack of an effective quality control system and unavailability of precision manufacturing and inspection tools severely constrains their ability to produce things of superior quality.

POLICIES RELATING TO MECHANIZATION

Burma is basically a country of small farms. The number below 2 ha per family comprises 63% of the total number of farm holdings. Furthermore, the average size of farm plots ranges from 0.01 ha to 0.05 ha. Such small farm size makes it nearly impossible for most farmers to have their own machines or to work independently with four-wheel tractors.

In accordance with the guidelines of the government for the development of agro-industries, sugar cane, cotton, and jute are three main industrial crops which need tractors in their cultivation. Sugar cane requires deep tillage and hence the land has to be plowed four to five times with intermittent harrowing using animal power. A pair of bullocks requires about 2 months to bring 1 ha of land from primary plowing to planting of sets. With tractors, the total time required is a matter of days. In December and January the soil is in the best condition for cultivation. Hence, with such a short period for land preparation, to achieve self-sufficiency in sugar, further expansion in sugar cane requires mechanization.

Expansion of cotton production also needs the help of tractors. Expansion is mostly in the dry zone of Upper Burma. The heavy

clay soils in this area have a limited supply of irrigation water, and to take advantage of available water for sowing, tillage has to be performed on dry, hard soil before irrigation. Since land preparation has to be done during January, the period of tillage is short. To complete the work in time, to plow the hard dry clay, and to meet the planned expansion, mechanization is necessary.

Premonsoon jute is sown in March, generally with the aid of pump irrigation. The soil has to be prepared during February and March, the hottest and driest of the year. Animal power is scarce and the soil is difficult to work with animal. Farmers also have to keep their animals well-fed and ready for the wet tillage of rice in the coming monsoon. Mechanization, therefore, is required to expand jute production.

Within the framework of the Four-Year Economic Plan, Burma is expanding oil-producing crops, such as peanut, sesamum, and sunflower, to achieve self-sufficiency. Peanut is sown as the second crop after rice in lower Burma. In November, while rice is still in the threshing stage, land preparation for peanut sowing has to begin before the soil dries up. Generally, farmers and animals are still fully engaged in harvesting and threshing, winnowing, and transporting paddy. Tractor services, therefore, are required to permit cultivation of this second crop.

Need for power tillers

In rice mechanization, soil preparation during the rainy season is not possible with four-wheel tractors in Burma due to their weight and the poor traction conditions of the clay soils. But power tillers are successful on most of the wet rice fields. Accessibility to individual plots on each farm is much better than with four-wheel tractors. Whenever there is a hardpan layer of about 125 mm - 150 mm depth, the tiller is found to be excellent in the preparation of wet soil. In soil where no hardpan layer exists, the puddling can be done before the lower soil layer gets too soft for use of the tiller.

The river banks and islets which are under flood during the annual monsoon or once in 5-10 years retain very fertile silt deposits after the flood. A shortage of animal power as well as lack of accessibility to four-wheel tractors in those areas are the main problems. Transport and accessibility of tillers in those areas are quite easy and at the same time the light, friable silt soil suits the tillers. The crops grown are mainly peanut, tobacco, pulses, and chillies.

Prospects for large-scale mechanized farms

Burma plans to establish cooperative farms and state farms -- large-scale agricultural enterprises -- through the cooperation of farmers and land reclamation. The target area of these farms, to be established by cooperative and, sectors, will amount to some 60,000 ha in the Third Four-Year Plan period from 1978-79 to 1981-82. These units will provide a favorable climate for mechanization. The effective use of four-wheel tractors can be expected on such large farm areas.

General policy on mechanization

The development of mechanization in Burma is expected to result in the following:

1. Mechanization of rice cultivation in the private sector thorough use of power tillers.

2. Extension of tractor custom hire service to farmers who cultivate industrial crops such as sugar cane, cotton, and jute through agricultural tractor stations and cooperative-owned stations.

3. Complete mechanization of cooperative farms and state farms.

The general policy of the Government of Burma is to help farmers through provision of adequate facilities to increase farmer income through double cropping, The government also aims to promote land and labor productivity on large-scale state-owned and cooperative farms through full mechanization.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Research work, not only on farm machinery, but also on methods and patterns of cultivation, can only be improved and strengthened through recruitment of qualified research workers and installation of research facilities in government agencies, universities, and institutes currently engaged in agriculture and agricultural machinery research. Large groups of technicians or research workers need to be sent abroad or to local universities for advanced study or short course training. To train engineers to conduct research, the establishments for agricultural mechanization research are planned.

FUTURE DIRECTIONS

The Government of the Socialist Republic of the Union of Burma has a number of programs and plans to promote agricultural mechanization during the Third Four-Year Plan. The general plan is:

1. Accomplish complete mechanization of selected crops, such as sugar cane, peanut, corn, and jute cultivation on state and large cooperative farms that will be developed during Third Four-Year Plan period.

2. Extend tractor custom hire service to farmers who cultivate industrial crops of sugar cane, cotton, and jute. This will be done through state-owned tractor stations and by distributing more tractors and agricultural machinery to village cooperatives and farmer groups by a suitable credit system.

3. Introduce more power tillers for rice cultivation.

4. Use more pump irrigation to expand double cropping and for intensive cultivation.

5. Increase assembly and production of farm machinery so as to meet farmer demand.

The main objective of the mechanization program during the Third Four-Year Plan is to fulfill the requirement of the agro-industry of the country, expand double cropping to improve per capita income of the farmers, and interest farmers in cooperative farming by showing the advantages of the use of machines on large-scale farms.

STATUS OF AGRICULTURAL MECHANIZATION IN INDONESIA

IR. R. DADANG TARMANA
AGRICULTURAL ENGINEER
DIRECTORATE OF FOOD CROPS PRODUCTION
DEPARTMENT OF AGRICULTURE
PASAR MINGGU, JAKARTA, INDONESIA

SUMMARY

Mechanization in Indonesia is considered a supporting agent to the increase of food crop production. The number of cattle is decreasing and it is only a matter of time until agricultural mechanization will take place. There is concern among some that agricultural mechanization could create undesirable labor displacement, hence, the concept of selective mechanization is felt to be most suitable for the Indonesian situation. A Testing Committee has been established to control imported agricultural machines and promote those that are locally made.

The potential is available in Indonesia to manufacture simple agricultural tools and equipment and, if the demand for this type of equipment is confirmed, local manufacturers could shift their production to agricultural machines.

INDONESIAN AGRICULTURE

Total land area of the Republic of Indonesia is 190.5 million hectares -- about 30% is estimated to be potentially suitable for agricultural development (Table 1).

The climate is seasonal; between June and September is an east monsoon, and December through March is a wet monsoon. The general mean temperature is 33°C (maximum) and 21°C (minimum). Humidity is between 60% to 100%.

Irrigated area recorded is 4.0 million hectares, and 2.6 million of it is located in Java. Some can be used for multiple cropping.

The 1963 Agricultural Census showed 12.26 million farms with a total of 12.88 million hectares. Ten years later there were 14.4 million farms with 14.17 million hectares.

Farm sizes are not uniform in Indonesia. In heavily populated areas they range from 0.1 to 3 ha, while in less densely populated areas from 0.5 to 10 ha or more (Table 2).

Table 1. Land area and population potential.

Region	Total area (ha)	Area with agricultural potential	Area presently cultivated	Total population
		(000,000)		
Java, Madura, Bali,	13.774	8.0	8.4	55.1
Sumatera	47.36	19.3	5.6	20.8
Kalimantan	53.95	17.1	1.6	5.15
Sulawesi	18.9	7.0	1.2	8.53
Nusa Tenggara & Maluku	8.80	7.9	0.7	3.59
Total	142.784	59.3	17.5	93.17

Source: Statistical Yearbook of Indonesia, 1975.

The greatest population density exists in Java and Bali, where roughly 70% of the economically active population lives (Table 3).

Some parts of Sumatra, South Sulawesi and Kalimantan are not yet developed for agriculture as compared with Java, where nearly all the land is devoted to agriculture. Conservative estimates indicate there are 15 - 20 million hectares available with good potential for agricultural development in Sumatra, Kalimantan, and South Sulawesi.

Due to land fragmentation, land holdings are becoming smaller, especially in Java. To overcome this situation the government is carrying out a transmigration project. Previously, this practice often failed because development at the farm level as well as establishment of the infrastructure was mostly left to the farmers. At present, however, the situation is being improved. Transmigrants receive land in a "ready for use" condition -- the land has been cleared, temporary houses are built, and simple tools are available for land preparation. Agricultural machinery is currently being introduced to help farmers in food production. Transmigrants are normally given

Table 2. Area of farms in Indonesia by status of holder and size of holding, 1973.

Size of holding (ha)	Status of holder[a]			
	Individual	Joint enterprise	Corporation	Total
	(000)	(000)		(000)
0.10	22.5	1.0	6	23.5
0.10-0.20	237.2	8.1	73	245.3
0.20-0.30	395.3	14.4	84	409.8
0.30-0.40	424.4	15.4	113	439.9
0.40-0.50	403.8	14.6	122	418.6
0.50-0.60	549.1	19.2	180	568.5
0.60-0.75	597.3	22.2	134	619.6
0.75-1.00	893.8	32.9	272	927.0
1.00-2.00	2697.4	113.6	991	2812.0
2.00-3.00	1483.4	73.2	1043	1557.6
3.00-4.00	816.9	41.4		858.3
4.00-5.00	514.9	29.3	204	544.5
5.00-7.50	714.8	49.1	600	764.6
7.50-10.00	333.8	22.5		356.3
10.00-15.00	403.8	28.9	1782	434.5
15.00 +	629.6	49.6	9866	689.1
Total	11118.2	535.5	15470	11669.2

[a] Crop producing units excluding estates.

Source: Agricultural Census, 1973.

5 ha of land; 2 ha to be used for food crop production and the rest for perennial crops. Transmigration will open a new era in the nation's life, and these areas can become rapidly developing economic regions if well organized and implemented.

Agricultural development is stressed in the second Five-Year Development Program, as it was in the first, as a means to national economic development. Agricultural food crop development is directed toward:

Table 3. Economically active population by province and field of work.

Province	Agriculture	Manufacturing
Aceh	481,054	21,590
North Sumatera	1,691.677	72,949
West Sumatera	626,353	40,873
Riau	366,091	27,179
Jambi	276,865	6,961
South Sumatera	849,640	42,591
Bengkulu	160,446	1,693
Lampung	740,693	11,804
DKI Jaya	49,346	117,060
West Java	3,880,970	442,092
Central Java	5,094,653	818,296
DI. Jogyakarta	574,310	163,425
East Java	6,503,136	541,396
Bali	488,716	42,350
West Nusatenggara	485,212	63,345
East Nusatenggara	803,549	54,626
West Kalimantan	722,864	13,039
East Kalimantan	133,057	6,333
Central Kalimantan	166,687	4,924
South Kalimantan	410,652	23,286
North Sulawesi	338,112	24,132
Central Sulawesi	243,762	20,664
South Sulawesi	936,117	104,309
South East Sulawesi	203,313	7,714
Maluku	234,757	7,000
Irian Jaya	11,445	2,321
Total	26,473,477	2,681,952

Source: Population Census, 1971.

- production,
- equity of income distribution among the people and regions,
- availability of work for everyone,
- savings in foreign exchange, and
- preservation of nature

INDONESIAN AGRICULTURAL MECHANIZATION

Mechanical power available in Indonesia is 0.001 hp/ha. Cultivation of rice is still done with simple tools. Rice is threshed by foot or beating and winnowed by wind, resulting in high but avoidable losses.

In the effort to change from subsistence farming to a technical system, an attempt is being made to disturb the socioeconomic and agroclimatic condition as little as possible and avoid unnecessary labor displacement. Cultivation in small rice fields can be done by small imported power tillers, but these power tillers are, in many cases, too expensive for the farmers. Simpler and cheaper machines can be fabricated locally with only a few imported parts (Table 4).

Industries manufacturing agricultural machinery have not expanded sufficiently owing to limiting factors such as inadequate credit, insufficient technological development, shortage of trained manpower, and limited demand of domestic markets. There is enough potential to manufacture simple tools, animal-drawn equipment, compressed air sprayers, threshers, and some tractor parts (Tables 5 and 6).

Mechanization in Indonesia is mainly used to support the increase of food crops production. Any mechanization directed toward the food crops program will be encouraged by the government provided it won't give a negative effect -- as on labor displacement. This is the reason the government prefers to use the term selective mechanization. It refers to appropriate choice of machines and sensitivity to sociological and ecological effects.

The nature of agriculture and its biological process with its unstable climatic condition, sudden outbreaks of pest infestation require timeliness, speed, and accuracy of operation to ensure maximum yield. Since this is especially true with the introduction of high-yielding, fertilizer-responsive and early maturing varieties, a certain level of mechanization and mechanical power is deemed necessary.

Utilizing the irrigation pump, a piece of land which is usually idle during the dry season now can be converted into

arable land. Early land preparation advances planting time and in combination with early maturing, high-yielding varieties can increase crop intensity. By using sprayers, at least 5% of the crops can be saved from losses due to pests and diseases. Similarly, a rice mill can help increase the quantity as well as the quality of the product processed.

Table 4. Price list of agricultural tractors marketed in Indonesia, 1977.

No.	Trademark, type and origin	Size	Items	Price (Rp) Unit	Total
1.	MUSUHAMA, Single axle, (IRRI), Indonesia	5.0 hp gasoline	tractor[a/]	450,000	
			plow	40,000	
			leveller	25,000	
			trailer	200,000	
					715,000
2.	KUBOTA, K75 GA 70 engine, single axle, Japan	5.6 PS diesel	tractor[b/]	1,100,000	
			leveller	30,000	
			plow	75,000	
			steel wheel	70,000	
			trailer	275,000	
			depth skid	18,000	
					1,568,000
3.	SHIBAURA, SKl8l single axle, Japan	5.5 PS diesel	tractor[c/]	665,000	
			rotary hoe	195,000	
			steel wheel	37,000	
			plow	70,000	
					904,000
4.	SHIBAURA, SU1300-0 double axle, four wheel drive Japan	13 PS diesel	tractor[c/]	1,425,000	
			rotary hoe	350,000	
			float wheel	95,000	
			plow	215,000	
			leveller	90,000	
					2,175,000

[a/] Equipped with puddling wheels.

[b/] Implemented by one set of rotary tiller.

[c/] Standard tractor without tiller, but equipped with pneumatic tires.

Table 5. Production of manufacturing industries by industrial group and kind of production, 1972.

Industry group	Unit	Production	
		Quantity	Value (Rp. 1000)
Rice milling	(Number of establishments 7,976)		
Production:			
Rice	ton	814,649	51,993,849
Rice bran	ton	52,104	383,808
Broken rice	ton	12,399	262,617
Straw		3,171	12,087
Total		882,323	52,652,361
Cleaning and polishing of rice	(Number of establishments 1,031)		
Production:			
Rice	kg	79,104,686	3,768,710
Rice bran	kg	5,471,235	43,287
Total		84,575,921	3,811,997
Manufacturer of agricultural and hand tools equipment	(Number of establishments 170)		
Production:			
Agricultural machines		2,498	233,880
Rice milling machines		352	14,216
All kind of spade		18,860	7,709
Axe and the like		13,570	4,934
Plows and similar products		407,000	54,569
Shovels, hoe		167,000	76,819
Sickles, chopping knife		1,138,000	224,438
Total		1,747,280	616,565

Source: Statistical Yearbook of Indonesia, 1975.

Table 6. List of manufacturers and their products related to IRRI.

No.	Manufacturers	Address	Product
1.	P.T. Pioneer Joint Venture	Jl.Ir. H. Juanda 41 Jakarta	Assembling plant for diesel engine 4 – 18HP, power tillers, rice mills and wheel tractors.
2.	P.T. Kertalaksana Private enterprise	Jl. Jen. Ludirman 508 Bandung	Rice mill, hollow brick, foundry.
3.	P.T. Purna Sadhana	Jl. Asia Afrika 150 Bandung	Sprayer, pump, rice processing hollow brick, foundry tea and rubber factory equipment.
4.	P.T. Purosani	Jl. Ketandan Wetan 41 Yogyakarta Jl. Sudiarto 26, Tegal	Hand hoe, spade.
5.	P.T. Dwika	Jl. Sudiarto 26 Tegal	Pump and other equipment for sugar factory.
6.	P.T. Kubota Indonesia	Jl. Setia Budi 279 Semarang	Assembling plant for diesel engine, wheel tractor and power tiller.
7.	C.V. Karya, Hidup Sentausa	Jl.. Magelang 144 Yogyakarta	Rice processing equipment Bolt and nut, pump foundry.
8.	P.T. Buma Sakti	Jl. Suryani Bandung	Troley for tea, trailer, rice mill, foundry.
9.	P.T. Kemajuan	Jl. Irian Jaya 3 – 3A Molang	Rice processing equipment.

No.	Manufacturers	Address	Product
10.	IK4BI Amy Enterprise	J1. Gatot Subrato Bandung	Rubber processing equipment.
11.	P.T. BBI German Sponsored	J1. K. H. Mansyur 229, Surabaya	Irrigation pump, sugar cane factory equipment, diesel engine assembling.
12.	M.I.D.C. Government/Belgian sponsored	J1. Sanghuriang 12 Bandung	Components of spare parts, foundry, welding training.
13.	Pt. Mesindo Agung Engineering Private	J1. Ancol III/12 Jakarta J1. Raya Kajen 248, Talang, Tegal	Irrigation portable pump.
14.	Musuhama Agricultural Engineering Development (Ex. P.T. Kacho) Private	J1. Raya Kajen 248, Talang Tegal	Power tiller IRRI batch dryer, weeder, chemical applicator, thresher (pedal & portable).
15.	C.V. Suratman (Private)	J1. Pamedan Kepotihan Solo	Pump, weeder, bridge construction, concrete mixture.
16.	C.V. Haji Kalla Private	J1. Ujung Pandang Sulawesi, Selatan	Power tiller, IRRI Kubota tractor dealer.
17.	P.T. Rutan Ltd. Coy Private	J1. Hompretan Surabaya	Rice processing equipment.
18.	P.T. Unimas Motor Private	J1. Pulogadung Jakarta	Power tiller IRRI B & S sole agent.
19.	Bingkil Muntjul Private	J1. Semarang Surabaya	Weeder, power tiller, IRRI

Testing committee

There is a new government policy that requires all agricultural machinery which are going to be utilized, particularly by the government, to pass through a Testing Committee. The committee will verify specifications, evaluate performance, and include an adaptive test. Imported machines and those locally made will undergo the committee's scrutiny.

The Ministry of Agriculture established the Testing Committee in 1976. Its members come from departments that deal closely with mechanization in general and agricultural machinery in particular. Committee membership comes from the Department of Industry, Metal Industry Development Center, Research & Development of Metal Machinery, Department of Trade, Directorate of Import, Department of Manpower, Transmigration Cooperation, Institute of Agriculture, Institute of Technology, Institute of Sciences, and Sub Directorate of Mechanization of the Directorate of Food Crops Production Development.

The objectives of the committee, besides carrying out testing and evaluation, are also to set up control activities over the distribution of similar machines that have already passed the test, and to formulate a draft policy on procurement of agricultural machinery and equipment. This draft is going to be submitted to be used by the Minister of Agriculture. The procurement of the machines will include designing, modification, rebuilding, assembling, and manufacturing.

Transmigration area

In Five-Year Development Programs I & II, the government stressed that through the development of each regional unit, the income of the transmigrants should increase. It is expected that transmigration will result in regional development and provide a source of work for those in higher density population areas.

To help the transmigrants produce good crops, the government subsidizes the project in the form of fertilizer, pesticides, seeds, cattle, and agricultural machinery and equipment such as hand hoe, fork, handsprayer, knapsack power sprayer, irrigation pump, rice processing equipment, corn sheller, tractor (Table 7).

A recent survey on the cropping pattern in the transmigration area indicated that land preparation and planting are done in September to October and harvesting in January to March. Multiple

Table 7. Price list of production facility for Fiscal Year 1977 – 78 (government subsidized).

Items	Price (Rp.) with wrapper	Price (Rp.) without wrapper
I. Fertilizers (per kg)		
1. Urea	70.00	
2. TSP	70.00	
3. DAP	90.00	
4. HPK 15 – 15 – 15	70.00	
II. Insecticide (per kg or 1)		
1. Diazinon/Basudin 60 EC	900.00	1230.00
2. Surecide 25 EC	900.00	1230.00
3. Phospel 300 EC	900.00	1230.00
4. Sumithion 50 EC	900.00	1230.00
5. Nogos 50 EC	900.00	1230.00
6. Thiodan 35 EC	900.00	1230.00
7. Folition 50 EC	900.00	1230.00
8. Aldrin 40 WP	900.00	1230.00
9. Furadan 8 G	175.00	1230.00
10. Basudin 10 G	200.00	1230.00
III. Fungicide		
1. Antracol	900.00	
2. Daconil	900.00	
3. Dithane M-45	900.00	
IV. Rodenticide (nonsubsidized)		
1. Racumin	1500.00	
2. Zinkphosphade	2500.00	
3. Diphacin 110	1500.00	
4. Tenorin	2300.00	

Source: Badan Pengedali Bimas, 1977.

cropping is widely practiced with paddy as the primary crop and secondary crops of cassava, corn and groundnut. The yield of upland rice is between 0.7 - 0.9 t/ha, cassava 9 t, corn 1 t, and groundnut 500 kg.

In conjunction with the survey and field analysis, the Department of Transmigration purchased power tillers, pedal threshers, batch type dryers, pregerminated multihopper row seeders, and push weeders. All of them are locally made; some are of IRRI design. The National

Table 8. Time and cost comparison of land preparation by animal and tractor per ha in Sulawesi, Bali and Sumatera.

Propinsi	1 pair of cattle 1.0 - 1.2 hp		Power tiller gasoline 5-6 hp		Power tiller diesel 7-8 hp		Mini tractor diesel 12-13 hp		Remark
	hr/ha	Rp/ha	hr/ha	Rp/ha	hr/ha	Rp/ha	hr/ha	Rp/ha	
Sulawesi Selatan (1974)	128	24.600	35	15.366	22-24	15.080	18-20	25.839	Kabupaten Pinrang Sidrap
Sulawesi Selatan (1976)	128	30.848	35	23.870	22-24	23.452	18-20	27.027	Kabupaten: Barru, Enrekang dan Tana Toraja
Bali (1976)	85	23.300	-	-	20	13.170	-	-	Kabupaten: Bandung Tabanan, Gianyar
Sumatera Utara	92.5	35.190	-	-	24	17.964	17.9	19.796	Kabupaten: Dairi, Serdang, Karo, Simalungun dan Tapanuli Utala

Sumber data: Sub Direktorat Mekanisasi Pertanian Pasar Minggu.

Bureau of Development Planning Body (BAPPENAS) emphasizes that as much as possible the agricultural machinery and equipment should be made and fabricated locally.

Field analysis provided the following capacity and performance data.

- Power tiller (IRRI type): 10-16 h/ha plowing and 8 h/ha harrowing with 70% efficiency (Table 8).
- Pregerminated seeder with seeding rate 30-50 kg/ha: 7-10 h/ha with 60% efficiency (Table 9).
- Fertilizer applicator: 12-18 hours per ha with 65-73% efficiency.
- Push weeder: 150-250 h/ha with 57-65% efficiency (Table 10).
- Pedal thresher: produces 40-60 kg of paddy per hour.

Table 9. Planting cost per hectare using traditional method, and seeding equipment.

Location of observation	Method of planting	
	Transplanting[a] (Rp/ha)	Seeder[b] (Rp/ha)
1. Way Abung (S. Sumatera)	1,017.00	533.16
2. Luwu (South Sulawesi)	1,071.00	642.92

[a] Using 20-day-old seedlings, transplanted in uniform check rows.

[b] Six-row pregerminated multihopper seeder, IRRI designed, locally made. Cost includes fixed and variable cost.

Source: Survey Transmigrasi-IPB. 1976.

Table 10. Weeding cost per hectare on rice field using push weeder and manual weeding.

Method of weeding	Cost per ha	
	Way Abung (Rp/ha)	Luwu (Rp/ha)
1. Hand weeding	2,333.3	3,257.5
2. Push weeder[a]	13,165.0	10,042.0

[a] Price Rp. 5,000 per unit, 5 years lifetime, 90 hours available for weeding per year.

A comparison of planting time revealed that the traditional method (transplanting of seedling) required 447 h/ha -- 218 hours for preparing the seedbed and seedling preparation and 229 hours for transplanting. The seeder did it in 7 – 10hours.

In spite of the difficulty of finding the right kind of soil condition, the fertilizer applicator showed promising results compared with the hand – sownmethod. It is more effective and more accurate.

Based on the research and survey findings, the Department of Transmigration ordered the following machines in 1977: four power tillers, ten pedal threshers, and six sprayers from local manufacturers

The research and survey resulted in some machine redesign. The power tiller sprocket and chain drive was reinforced; the plow was modified to give a better furrow slice and equipped with a knife coulter. The pedal thresher was modified by using peg teeth made from a bolt and nut in place of the inverted Vee – shaped steel wire threshing teeth.

Based on technical performance and need, the machine priority in the transmigration area is: power tiller, sprayer, thresher, weeder, fertilizer applicator, seeder, and dryer.

See Tables 11 through 14 for information concerning labor, equipment, operational costs, and credit.

Table 11. Minimum labor daily wage in Jakarta, 1977.

Level of labor		Daily minimum wage (8 – hourday)
Unskilled labor level	III	$ 1.05
	II	1.12
	I	1.20
Foreman		1.29
Skilled labor level	III	1.36
	II	1.45
	I	1.53
Head laborer		1.60

Source: Lembaran Pengumuman DKI Jaya, 1977.

Table 12. Rice production cost per hectare in West Java.

Item	Location	
	Cianjur	Bandung
1. Fertilizer	Rp. 24,000	Rp. 32,000
2. Land preparation	38,300	35,750
3. Insecticide	3,900	3,500
4. Seeds	3,750	2,000
5. Tax	40,000	16,500
6. Harvesting	30,000	1,400
7. Product handling	5,000	3,500
8. Fertilizing	1,800	3,100
9. Planting	6,300	7,500
10. Weeding	12,000	10,800
11. Crop protection	600	2,600
12. Irrigation	-	1,400
Total	165,350 ($398.43)	120,050 ($289.28)

An example of mechanization

A good example of one of the successful mechanization activities is found in South Sulawesi. In Sidenreng Rappang (about 180 km north from Ujungpandang) there are 45,000 ha of rice field and 52,000 ha of upland. Sixty percent of the rice field area is technically irrigated. Ninety-five percent of the population engages in agriculture. From the total population of 196,000 only 13% of the males are economically active and productive. This work force is supported by 4,500 pairs of cattle. Every season, only 25,000 ha of the land were prepared, so there was a relatively large area not being utilized.

In 1974, the Provincial Government set up a system of advanced credit aid from Regional Retribution Development to buy five small wheel tractors and two more were bought through the Regional Development budget. The people were given a chance to buy a tractor from tractor dealers with credit provided by the bank. The installments were spread over 8 seasons or about 4 years.

Table 13. Bimas credit package for rice field per hectate fiscal year 1977-78.

Item	Package A		Package B		Package C	
	Quantity	Value	Quantity	Value	Quantity	Value
1. Urea	200 kg	14.000	100 kg	7.000	250 kg	17.500
2. T. S. P.	50 kg	3.500	35 kg	2.450	75 kg	5.250
3. D. A. P.	-	-	-	-	-	-
4. Insecticide	2 1t	2.460[a/]	2 1t	2.460[a/]	2 1t	2.460[a/]
5. Rodenticide	100 gr	230	100 gr	230	100 gr	230
6. Seeds	-	3.750	-	-	-	3.750
7. Spraying cost	-	2.000	-	2.000	-	2.000
8. Subsidized budget for intensification	-	6.000	-	6.000	-	6.000
Total	-	31.940	-	20.140	-	37.190

[a/] Pesticide with rebottling cost Rp. 615 per 1/2 liter without rebottling Rp. 900.00 per liter.

Source: Badan Pengedali BIMAS, 1977.

Table 14. Estimate of drying cost using locally made batch type dryer.

A. Information known:

1.	Purchase price	Rp. 300,000
2.	Lifetime	3 years
3.	Capital interest	1% per month
4.	Power	3 hp gasoline
5.	Working time available	90 days
6.	Capacity	1 ton rice/hectare hr.
		or 2 ton/day

B. Fixed cost, per hour.

Depreciation $\frac{300{,}000}{3 \times 90 \times 12}$ = Rp. 92.58

Interest $\frac{1/2 \times 12 \times 300{,}000}{100 \times 90 \times 12}$ = 16.66

Maintenance $\frac{1 \times 300{,}000}{100 \times 90 \times 12}$ = 2.77

Salaries employee:

Manager	Rp. 20,OOO/mo.
Adminst.	10,000/mo.
Operator	15,000/mo.
Total	45,000/mo.
	6,000/day
1/3 charged to the dryer	2,000

cost per hour $\frac{2{,}000}{12} = \frac{}{166.67}$

Total fixed cost . Rp. 345.01

C. Variable cost, per hour.

Fuel, husk 5 kg x Rp. 2.50	= 12.50
gasoline 1 l/hr x Rp. 70	= 70.00
Oil 10% x gasoline	= 7.00
Wages Rp. 300.00/ton/6 hours	= 50.00
Grease Rp. $\frac{1{,}000}{12}$	= 83.30

Total variable cost/hr	Rp. 222.80
Total drying cost per hour	567.81
Drying cost per ton (6x)	3,406.86
Drying cost per kg	Rp. 3.40

Table 15. Potential requirement and logistic of tractor in Sulawesi (South).

No.	Area	Sawah area (Ha) Th 1975	Plan	Realization Mini Traktor	Realization Hand Traktor	%	Keterangan
1.	Pinrang	46,914.67	557	98	9	18.5)	Survey th 1974 (I)
2.	Sidrap	45,125.51	616	130	4	21.1)	X) Traktor Kubota
3.	Gowa	30,222.60	202	3	-	1.4)	: 12.5 hp
4.	Maros	21,699.14	315	4	11	3.1)	Survey 1975. (II)
5.	Pangbep	20,873.00	367	12	1	3.5)	X) Traktor Kubota
6.	Polmas	20,225.00	433	43	2	10.1)	: 12.5 hp
7.	Soppeng	21,692.86	205	57	2	28.2)	
8.	Bantaeng	5,015.00	14	-	-	-)	Survey tahun 1975/
9.	Bulukumba	22,370.76	528	1	-	0.2)	1976. (III)
10.	Sinjai	10,508.00	17	-	-	-)	
11.	Wajo	68,288.00	1,531	10	2	0.7)	Traktor Shibaura:
12.	Bone	74,166.00	1,220	21	1	1.8)	15 hp
13.	Jeneponto	13,742.64	164	1	-	0.6)	
14.	Takalar	16,123.35	233	3	-	1.2)	
15.	Luwu	45,318.00	667	9	3	1.6)	
16.	Barru	11,482.38	165	4	2	3.0)	Survey 1976 (IV)
17.	Enreng	9,000.00	121	-	-	-	X) Traktor Satoh:
18.	Tator	17,801.00	115	12	2	11.3)	: 13 hp
19.	KM. U.Pandang	3,956.38	-	15	-	-)	
	Total	504,524.30	7,470	423	39	5.9	

UJUNG PANDANG, 26 April 1977

XX) Potensi keperluan Traktor dikutip dari 4 Laporan feasibility Study dalam equ – ivalent traktor Mini dengan 12,5 – 15hp.

\- Pengadaan sampai dengan 25 April 1977 (Up to 25 April 1977)

In early 1977, there were 160 tractors in the area -- 12 are owned by the Provincial Government and 95 were bought by farmers through Small Investment Credit. The rest are privately owned by farmers who were able to buy with cash (Table 15). This number expanded rapidly in the latter part of 1977.

The result of this tractor introduction is that the area cultivated by machines was able to produce 15,000 tons of threshed paddy at the end of 1976. Through mechanization total production per season increased by 41% in 1976 compared with 1971.

INDUSTRIAL EXTENSION

The Government of Indonesia recognizes and gives support to local manufacturers by giving guidance and technical assistance. Credit is also made available. These activities are not, however, fully executed yet. For example, some provincial governments are still buying imported goods instead of using those locally made. Also, the flow of credit is not as smooth as expected.

Several people who dealt with manufacturing agricultural machinery and equipment were sent to IRRI in the Philippines to participate in a 2-week intensive course in manufacturing. This training is useful. Through learning by doing, these inexperienced laymen become convinced that they have the capability and opportunity to fabricate machines using existing machine tools.

Some of these participants succeeded in producing agricultural machines either from drawings or from a model or sample. Power tillers, grain dryers, irrigation pumps, and weeding equipment are examples of what the participants can produce (Table 16).

A joint program between agricultural extension and industrial extension has given good results through introduction and demonstration. Users can order directly from the manufacturer. The Department of Agriculture (cq. Subcontract Agreement IRRI-DITPROD, and Sub-Directorate of Mechanization of Directorate of Food Crops Production) acts as a bridge to transmit technological information between the users and manufacturers.

PROBLEMS

The largest problem manufacturers and users complained about is marketing. This is more an economic than technical aspect.

The unstable price of the raw material affects the security of the manufacturer in producing and selling machines. He does

Table 16.

Reporting Period: Up to October 1977

Country or Region: Indonesia

MANUFACTURER	NUMBER OF IRRI MACHINES PRODUCED					REMARKS
Name & Address	Power Tiller [1]	Axial Flow Thresher [2]	Portable Thresher [3]	Batch Dryer [4]	Chemical Applicator [5]	
1. Musuhama Agricultural Engineering Development J1. Rayakajen 248 Tegal, Middle Java	18 (5 hp) BS	-	-	13 (3 hp) BS	10	[1] Rp. 500,000 [4] 400,000 [5] 7,000
2. P. T. Puma Sadhana JL. Asia Afrika 158 Bandung West Java	-	12	-	1	-	[2] Rp. 750,000
3. Binglul Muncul J1. Semarang 62 Surabaya East Java	50 5 hp (Yanmar)	30 5 hp (BS)	-	-	-	[1] Rp. 700,000 700,OO
4. CV Suratman J1. Pamedan Kepatihan 6 Solo, Middle Java	-	1 (5 hp)	-	-	-	650,OO

Submitted by:

R. Dadang Tarmana-

not have any reference as to how much he should charge for a certain machine to keep a stable price and still make a profit on the next batch of the machines.

Most users have low ability to buy. Although the machines that are locally made are less expensive than imported ones, the farmers still cannot afford them. To get credit from a bank, various requirements must be met.

Fewer problems have arisen from the technical point of view. The availability of a certain material sometimes affects manufacturing. For example, the unavailability of the perforated sheet for the dryer caused a manufacturer to use steel wire mesh. Sometimes the dimension of the material is not suitable for a certain design that is received from IRRI. These kinds of problems can be overcome.

STATUS OF AGRICULTURAL MECHANIZATION IN THAILAND

CHAK CHAKKAPHAK
HEAD, WORKSHOP AND SERVICE SECTION
AGRICULTURAL ENGINEERING DIVISION
MINISTRY OF AGRICULTURE AND COOPERATIVES
BANGKOK, THAILAND

SUMMARY

Agricultural mechanization in Thai land has been rapidly expanded in the past 10 years. Gradual increases in the number of local manufacturers and the expansion of the businesses show that most of the machines in use are locally made. The simple machine, which gives minimum problems for the farmers, is replacing animal and manual power as the first step toward mechanization. Needless to say the needs of the farmers are to mechanize their farms for better cultivation and to do the job at the right time in the expanding two-crop area.

Many present policies are favorable to the introduction of high-yield crop varieties and growth of mechanization -- rice guarantee and price support programs, help in setting up cooperatives, expansion of governmental irrigation systems, land reformation, and important incentives for the development of agro-industrialization.

Many of the research results done by the Agricultural Engineering Division, Department of Agriculture, and the intelligence of the local manufacturer made it possible for farmers to own appropriate machines at reasonable prices. In addition, the cooperative project for the expansion of farm machinery between the Department of Agriculture and the International Rice Research Institute made available additional designs to Thailand manufacturers.

INTRODUCTION

Population in the farming sector accounts for roughly 80% of the total Thai population. With agriculture accounting for the main gross national product, production in this sector is a vital determinant of the performance of the economy not only for what it turns out but also for its regenerative effects passed on to other sectors as well.

The backbone farm products of the country -- rice, maize, mung bean, and soybean -- are cultivated twice yearly. The year's main crops coincide with the rainy season (June to September) and the second crops stretch from the later months of the year into the first few of the next. Jute and kenaf, sugar cane, and tapioca are harvested mainly in the last few months of the year. Besides this, climatic seasons also differ from one geographical area to the next so that some crops grow later in some areas.

A good year of rain depends on the southwesterly monsoon from the Indian Ocean, localized cyclones and their influence from the Bay of Bengal, and typhoons from the Pacific. The failure of even one or two of these to bring in its full quota of rain can cause a certain degree of drought. The irregularity of nature's water supply points to the need for effective irrigation or -- on a wider scale -- an overall water resources management plan for the country (Table 1).

Double cropping of rice, initiated some 15 years ago, has greatly increased the necessity for effective irrigation programs, as most arable areas lack water for about half of each year. The Chao Phya irrigation projects in the Central Plain, the first large-scale scheme, covers about 1 million ha. Irrigation projects are being expanded in other regions of the country (Table 2).

Rice occupies the largest area of cultivated land, provides the best employment opportunity for the majority of the people, supplies the staple food for the Kingdom, and earns the top amount of foreign exchange. Rice can be grown under different patterns of climatic environment, most types of soil, and various levels of topography if a sufficient amount of moisture is available (Table 3).

Table 1. Average rainfall in Thailand.

Region	Av. rain in rainy season, mm	Av. rain for whole Year, mm
North	700 - 1,000	800 - 1,200
Northeast	700 - 1,000	800 - 1,200
Center	1,000 - 1,000	1,200 - 2,000
South (East Coast)	1,500 - 3,000	2,000 - 4,000
South (West Coast)	2,400 - 3,000	3,500 - 4,000

Source: Irrigation Department.

Table 2. Irrigation projects completed in Thailand as of the end of fiscal year 1975 or under construction in 1976.

Description	Unit	Completed	Under construction
Water stored in dam reservoirs or tanks	Million cu.m.	27,965.86	996.09
Land under irrigation programs	rai[a/]	15,119,434.00	4,960,008.00
Land reached by canal ducts	rai	7,601,300.00	140,000.00
Land consolidation	rai	53,100.00	41,600.00
Paddy fields aided by pumps during 1975	rai	1,656,458.00	

[a/] 6.25 rai = 1 hectare
2.5 rai = 1 acre

Source: Irrigation Department.

The cultivated lands in Thailand are of three levels: high land, medium land, and lowland. As most of the medium and lowlands lie just above sea level, these are flooded to various degrees during the wet season. On these lands, the rice crop flourishes. Areas free of floods are mostly occupied by the upland crops.

People 11 years old and over, considered as economically active, constitute the labor force of the Kingdom. In 1960, 52% of the 26.4 million people were in that age group, among them 81% were either farmers or farmhands. The proportion of labor force in the agricultural sector had insignificantly decreased to 78.01% in 1975.

CURRENT STATUS OF MECHANIZATION

The expansion of agricultural mechanization in Thailand during 1965–75 has been more rapid than during any previous period. This mechanization has improved the prosperity of the farmers, as well as manufacturers, marketers, machinery repairers, and consumers of the produce.

Table 3. Area planted and paddy production by regions, 1970-75.

Year	Northern		Northeastern		Central Plain		Southern		Whole country	
	Area planted (1000 ha)	Production (1000 t)	Area planted (1000 ha)	Production (1000 t)	Area planted (1000 ha)	Production (1000 t)	Area planted (1000 ha)	Production (1000 t)	Area planted (1000 ha)	Production (1000 t)
1970-71	1663	4070	3410	4920	2173	3720	560	860	7806	13570
1971-72	1534	3557	3579	5434	2195	3895	533	858	7841	13744
1972-73	1579	2710	2040	4298	2394	4483	643	1022	6656	12413
1973-74	1916	3984	3100	4638	2582	5451	514	825	8712	14898
1974-75	1732	3872	3447	3795	2497	4829	639	890	8315	13386
1975-76	1778	4049	3754	5737	2066	3341	544	805	8149	13932

Source: 1970 - 1974 MOAC; 1975: NSO.

There are two patterns of mechanization:

1. Use of large, imported tractors mostly of 70-80 hp. These are mostly employed on contract disc plowing or similar cultivation in the large fields of upland crops and broadcast rice. These tractors are moved around the country to follow the available work. Three drivers are used to achieve a working day of around 18 hours.

2. Use of small tractors 6-20 hp. These are mostly owned by rice farmers of the 4-5 ha range. The tractors are either imported or manufactured in Thailand -- the largest selling are locally manufactured. The majority of rice farmers in the two-crop area use these tractors to prepare the land for the next crop at the appropriate time.

LOCAL MANUFACTURE OF EQUIPMENT

The government of Thailand in 1953 created the Rice Department by enlarging the Rice Section of the Department of Agriculture. This new department initiated and encouraged a number of research activities under the Engineering Division. Some successful research resulted in low-cost water pumps and small two-wheel tractors mounted with 5 hp stationary engines. Later improvement called for engines of 7-9 hp. When four-wheel tractors were out, the power was raised to 12 hp.

Improvement on these machines came about in 1965 when the results of this research were turned over to small factories for commercial production. Thus started volume production of small tractors to replace water buffalos for land preparation in the early part of the rainy season (Table 4). Expansion of the

Table 4. Rice farming: mechanization vs. cattle.

Area	Cattle	Small tractors	Large tractors	Others
		%		
Central Region	41.0	31.0	25.0	3.0
East Region	25.0	44.0	10.0	21.0
West Region	62.0	13.0	23.0	2.0
North Region	80.0	11.5	6.5	2.0
Northeast Region	91.0	0	2.0	7.0
Southern East Coast	68.6	1.6	29.4	0.4
Southern West Coast	70.5	0	11.8	17.7
Average	62.3	14.9	15.3	7.5

Source: Ben James Jr., Report G.I.T., Atlanta, Georgia, 1977.

double crop rice area stimulated the demand for small tractors on Thai farms.

These tractors are usually sold complete with wheels for use in paddy fields, as well as a plow and harrow. Also available are trailers with rubber wheels for transport and threshing.

The establishment in 1971 of a cooperative project for the development of farm machinery between the Engineering Division and the International Rice Research Institute, Los Baños, Philippines, made available additional designs to Thailand manufacturers.

The most successful machines introduced have been the power tiller and axial flow thresher. In the future it is expected that the hand weeder and portable thresher will gain popularity.

MANUFACTURE OF SMALL MACHINERY

Most of the machinery are manufactured in small workshops with an area of approximately 80 m^2 each.

Each firm normally employs 10 or more workers; the bigger ones employ up to 60. Twenty–sixof these firms produce 10,000 tractors annually (Table 5).

Machine tools used in tractor production are:

1. lathe machine,
2. electric or acetylene welder,
3. power saw,
4. metal guillotines,
5. drilling machine, and
6. air compressor (for paint spraying).

These are general for each small manufacturing firm. Bigger firms may own a hydraulic press, steel roller, and sprocket wheel cutter.

Each firm trains its own workers through experience and skills from their elders. Thus experience and skills are acquired by a long period of apprenticeship.

Materials for manufacturing are mainly mildsteel and iron castings with ball bearings, gears, and discs. Other parts are

Table 5. Price of tractors in Thailand, 1976.

Large tractors	HP	Cash (US$)	Credit (US$)	Period (month)
John Deere	97	14,950	15,210	24
	79	12,850	--	--
(rebuilt)	79	9,750	--	--
Massey Ferguson	45	8,800	11,162	30
	66	11,600	14,827	30
	75	13,000	16,565	30
Ford	45	8,250	9,840	24
	78.6	14,750	16,710	18
	94	16,250	16,900	5
M. T.	77	8,500	--	--

Small tractors	Price range
2-wheel (7 hp)	
Without engine	150 - 500
Diesel engine	600 - 700
Gasoline engine	175 - 200
4-wheel (14 hp)	
Without engine	800 - 950
Diesel engine	1,250 -1,400

Source: Ben James, Jr., Report G.I.T. Atlanta, Georgia, 1977.

from specialized producers. Only engines are imported.

Manufacturing firms generally produce:

1. two-wheel tractors,
2. four-wheel tractors,
3. water pumps,
4. disc plows,
5. corn shellers,
6. threshers,
7. small rice mills, and
8. equipment for big tractors such as 6- to 8-row disc plow, earth moving blades.

Of all the products listed above, two-wheel tractors, small four-wheel tractors, and disc plows are most popular. Since the patent laws are not strictly observed, many firms manufacture very similar products widely used in certain cultivated areas.

In 1976, at least 60 companies were manufacturing farm machinery in volume quantities in Thailand (Tables 6 and 7).

Table 6. Number of farm machines in Thailand, 1976.

Item	Units
Large tractors	13,338
Two-wheel tractors	90,001
Four-wheel tractors	16,792
Puddlers (with engine)	9,882
Sprayers	46,317
Irrigation pumps	308,179
Winnowers (rice)	42,342
Corn shellers	5,721
Rice threshers	3,955
Windmills	1,937
Rice mills	24,658

Source: Ben James Jr., Report G.I.T., Atlanta, Georgia, 1977.

Table 7. Main products manufactured by farm machinery companies, 1976.

Products	No. of companies
Power tillers and tractors	40
Pumps	25
Threshers	10
Disc plows	6
Corn shellers	8

POLICY RELATING TO MECHANIZATION AND FUTURE DIRECTIONS

Under the fourth Five-Year Social and Economic Development Plan, starting this year, many policies which are under active

implementation give priority to farm mechanization. Increasing funds are available for farmers and farm groups through commercial banks and the Bank of Agriculture and agricultural cooperatives. This should increase farmer purchasing power (Tables 8 and 9). Land reform, expanding of the irrigated area, and strengthening of farm cooperatives are among the current policy. Promotion of small industries in technical and financial aspects are also an active task of the present policy.

Since the available additional land that can be used for food growing is limited, the only way to increase the amount of food produced for domestic consumption and for export is to increase yields. Mechanization is among the major means to achieve that goal.

Table 8. Estimated demand for power tiller locally manufactured, 1977-82.

Year	Units
1977	16,237
1978	18,267
1979	20,550
1980	23,118
1981	26,007
1982	29,257

Source: Suwit Disayanaren, Industrial Service Division, Department of Industrial Promotion, 1977.

Table 9. Estimated demand for small four-wheel locally manufactured, 1977-82.

Year	Units
1977	2,918
1978	3,282
1979	3,692
1980	4,153
1981	4,682
1982	5,268

Source: Suwit Disayanaren, Industrial Service Division, Department of Industrial Promotion, 1977.

STATUS OF AGRICULTURAL MECHANIZATION IN JAPAN

YOSHISUKE KISHIDA
PRESIDENT, SHIN-NORINSHACO., LTD.
TOKYO, 101 JAPAN

INTRODUCTION

Japanese agricultura1 mechanization is peculiar in its characteristics and history. It reflects agroclimatic and cultural factors, that have contributed to making Japan the modern, industrially diversified nation it is today.

Japanese farmers enjoy a higher standard of living than people in other cities with well-developed small-and middle-scale mechanization. The present status of Japanese farming is shown in the selected statistics after the references.

Our main crop is rice, but its consumption has been decreasing every year, while government has been regulating the price of rice to help both farmers and consumers. The government reduced the rice transplanting area in 1969 for the first time. This policy has been carried out for the past years. But the inventory of rice in government storage increased, so a second policy has gone into effect to further decrease the rice transplanting area. The government estimates that the rice in storage will be over 4 million t in 1978. The government is going to establish a new policy which will subsidize farmers to change from rice to other crops. The government wants to decrease rice production by 5.1 million t starting in 1978.

The rice yield this year is estimated at about 4.75 t/ha (in brown rice), which is 104% of the average yield of previous years. The total cropping area of rice in 1977 is 2.723 million ha of which upland is 34,000 ha. The food self-sufficiency rate, which had decreased every year, has remained at the same level since 1974 FY; the rate was 74%. Agricultural production decreased 3.7% from the previous year because of the unusually bad weather. In this unfavorable condition, farmers still increased their income from both agricultural and nonagricultural sources.

Average figures of main indicators of economic performance per one farm household for 1976 are as follows.

Family labor spent in own agriculture (mh) 2,225
(by 1.37 persons)

Toyama Pref.	1,313	
Hokkaido	3,850	
Size of holdings (ha)		1.141
Kagawa	0.615	
Hokkaido	7.827	
Agricultural fixed capital ($)		6,555
Okinawa	3,168	
Hokkaido	18,543	
Agricultural gross income		8,517
Okinawa	4,402	
Hokkaido	23,526	
Agricultural expense ($)		4,072
Okinawa	1,698	
Hokkaido	13,539	
Agricultural net income ($).....		4,445
Kagoshima	2,284	
Hokkaido	11,026	
Nonagricultural net income		9,640
Hokkaido	3,657	
Tokyo	15,553	
Total net income ($)		14,085
Kagoshima	8,162	
Kanagawa	20,427	
Total net income after tax ($)		12,358
Kagoshima	7,197	
Aichi	16,479	
Governmental aid income such as "Dekasegi Income" ..		2,375
Okinawa	1,182	
Kyoto	4,592	

Disposable income	14,733
Kagoshima	9,537
Tokyo	18,570
Living expenditure	11,187
Kagoshima	7,483
Tokyo	14,506
Surplus after living expenditure	3,548
Kagoshima	2,055
Nagano	5,415

(Total bank deposits were $23,228 and the amount of borrowed money was $3,893). The disposable income in 1976 FY increased only by 7.3% over 1975 FY, while 1975 FY increased by 17.1% compared with 1974 FY.

Japanese farmers are now better of financially than city workers. Net income and living expenditure of workers' household in cities with a population of 50,000 or more in 1976 are as follows.

Net income	$12,005
Living expenditure	8,443

Investment in agricultural machinery in 1976 FY .. 687[a/]

Tokyo	$ 223
Hokkaido	2,557

Investment in agricultural machinery by size of farm

0.1 - 0.5 ha	$ 1,508
0.5 - 1.0.	547
1.0 - 1.5	916
1.5 - 2.0	1,335
3.0 & over	1,420

There were 4.89 million Japanese agricultural households on January 1, 1976. The population engaged in agriculture was 7.79

[a/] $614 in 1975 FY. The rate of increase showed big differences among prefectures (+67.5% in Okinawa, - 14.2% in South Kyushu).

million and arable land totaled 5.54 million ha.

CURRENT STATUS OF MECHANIZATION

Agricultural mechanization began with the introduction of rice processing machinery such as rice polishers, hullers, pumps, electric motors, low speed engines, threshers, and sprayers before the World War II. In 1950, soil cultivation was done by human labor and animal. In 1952, an importer introduced a simple tiller with a 2.5 hp gasoline engine. This was the start of rapid mechanization of soil cultivation.

Many farmers sold their cows and bought simple tillers that could pull trailers and cultivation equipment (i.e. "SUKI"). Industry rushed into the business to make power tillers in the 1950s. Tractor horsepower on farms:

Year	All tractors	Four – wheel
1950	73,000	
1955	489,000	
1956	778,000	
1957	1,250,000	
1960	4,159,000	57,000
1965	14,182,000	488,000
1970	22,133,000	4,533,000
1975	28,905,000	12,995,000
1976	31,980,000	17,010,000

The peak year for two – wheeltractor horsepower farms was 1972, when it totaled 18,400,000 hp.

Mechanization could release agricultural labor to industry and still steadily increase food production.

Our agricultural machinery industry has been developing cheap, suitable, and timely new machines for small farms. Labor requirements for rice production were decreased from 2,045 man – hours/hain 1950 to 797 man – hours/hain 1976. The intensity of tractor power was changed from 0.08 hp/ha in 1952 to 5.77 hp/ha in 1976.

The number engaged in agriculture decreased as a result of mechanization: 16,100,000 (persons) in 1950; 15,410,000 in 1955; 13,390,000 in 1960; 11,080,000 in 1965; 10,250,000 in 1970; 7,830,000 in 1975.

There is an interesting relationship between the number engaged in agriculture and tractor density per ha. During 1960 to 1975, the relationship shows complete linear function. In 15 years, an increase of 4.52 hp/ha released 5,560,000 agricultural laborers. This means that 370,700 agricultural workers were displaced annually by introducing about 0.30 hp/ha. In other words for every 3.9 tractor horsepower introduced, there was one less agricultural worker.

Japanese farmers have been investing in agricultural machinery every year as follows: $206 million in 1955, $448 million in 1960, $927 million in 1965, $1,520 million in 1970, and $3,281 million in 1975.

The total investment in agricultural machinery during the 20 years from 1955 to 1975 was $24 billion. This shows that 7.58 million agricultural laborers were released by the investment of $24 billion during the last 20 years. In other words, it needed about $3,119 to replace one agricultural worker by agricultural machinery from 1955 to 1975.

Most of the important operations in rice production have been recently mechanized. But other upland crop production is not yet completely mechanized. Fruit and vegetable harvesting are especially difficult, because most go to the fresh market.

Major agricultural machinery (units) on farms in January 1977:

electric motor	1,381,000	(in 1967)
engine	1,727,000	(in 1967)
two-wheel tractor	3,178,000	
tractor (riding type)	833,000	
rice transplanter	1,251,000	
power duster	1,710,000	
power sprayer	1,389,000	
binder for rice and wheat or barley	1,598,000	
power thresher	3,297,000	(in 1967)
combine harvester (heading feeding type) for rice and wheat or barley	530,000	
dryer for rice and wheat or barley	1,779,000	
rice huller	1,008,000	(in 1976)
straw and forage chopper	943,600	(in 1967)
truck for agricultural use	1,245,910	(in Jan.1976)
combine for rice or wheat ((connectional type)	520	(in Feb.1970)
tea picker	70,800	(in Oct.1975)

Number of common facilities:

rice center	1,557	(Jan. 1977)

country elevator	168 (Jan.1977)
fruits and vegerable grading house	3,007
fruits storage house	1,013
nursery plant facility for rice transplanter	2,541
agricultural products drying house	1,109

Riding type tractor by horsepower January 1, 1976:

Unit	hp
167,600	10
204,700	10-15
161,300	15-20
134,700	20-30
52,700	30

In the last 10 years greenhouse agriculture grew rapidly. This is one of the most intensive forms of agriculture in the world. Total area of greenhouses except glass houses is 218.6 million m^2 and that of the glass houses is 11.3 million m^2. Mechanization for greenhouse production is most challenging and will be rapidly advanced with automation engineering.

The rate of machinery utilization is not high in Japan, about 178 hours are used for rice production with powered machinery. Rice was planted on 2.72 million ha in 1977, of which 2.19 million ha (80.4%) was transplanted by machines. Two-row machines transplanted 82.4%, four-row machines 17.1%, and over six rows transplanted 0.5%.

Farmers are replacing old machines with larger ones. The biggest machine in 1977 is the 18-row tractor-mounted type which uses paper-pot seedlings. Many kinds of seedlings are widely used and tested for rice transplanters.

As to the rice harvesting, about 2.4 million ha was done by machinery in 1977. The rate of expenditure for rice production machinery in cost per ha in 1976 was 22.8% ($834).

PRODUCTION OF AGRICULTURAL MACHINERY

Machinery production is undertaken by several big companies that produce several kinds of machinery, mainly for rice production. In 1976, the value of the production was $2.41 billion, almost six times the 1966 figure ($390 million).

Sales by the top five manufacturers in 1976 follow. Kubota: $790 million, Yanmar: $540 million, Iseki: $410 million, Mitshubishi: $270 million, Satoh: $170 million.

Their sales account for more than 80% of the total production. These five manufacturers have their own marketing channels. They have dealers in almost every prefecture. But there are more than 1,000 small and medium–sized manufacturers who produce specialized products to meet many kinds of farmer needs. The role of those manufacturers is important for agricultural progress.

Production of Japanese agricultural machinery and tractors in 1976 was $2.41 billion (126.7% of 1975's):

	Amount (million $	%
four–wheel tractor	110	36.9
rice and wheat	550	22.8
walking type tractor	180	7.5
rice planter	170	7.3
grain dryer	160	6.6
pest control machinery and pump	102	4.2
all type of threshers	73	3.0
rice and wheat binder	100	3.1
others	183	7.6

The production value of engines was $300 million in 1976. The production value for 1977 January – June was $1.36 billion, which is 118.8% of the production value during the same period in 1976. But tractors and other major machinery were over–produced and inventories are increasing. This shows that manufacturers failed in demand forecasting.

Consumption of material and basic products for Japanese agricultural machinery in 1976:

ordinary steel	159,072 ton
special steel	23,226 ton
motors	708,403 units[a/]
engines	935,192 units
transmissions	$ 4.4 million
chain	$ 3.7 million
bearings	$ 9.6 million
hydraulic units	$ 2.8 million

Average number of employees per month in 1976 in agricultural manufacturing was 19,995. Yearly changes in production of selected machinery and value of total production are shown in Table 1. Growth of the agricultural machinery industry has always resulted from new products which could give profits to farmers, dealers,

Table 1. Change of production quantity of selected machinery and value of total agricultural machinery production.

	Farm machinery total value x 10^6 $	4-Wheel tractor	Rice transplanted	Grain reaper	Power thresher	Grain combine	Grain dryer
1966	393	15,897	-	86,632	344,955	9	219,660
1967	467	24,090	-	68,321	367,987	1,269	208,191
1968	590	36,615	-	133,192	372,263	14,758	233,376
1969	685	46,753	-	239,102	273,780	39,224	206,284
1970	685	42,611	80,601	322,421	190,121	44,934	136,963
1971	585	33,757	129,796	245,369	142,185	38,159	110,122
1972	634	51,019	140,894	164,893	108,841	51,414	79,026
1973	954	99,394	186,142	222,607	119,600	68,279	102,745
1974	1,798	168,167	345,180	244,887	152,657	117,381	125,022
1975	1,910	207,285	251,437	152,187	121,297	127,271	93,570
1976	2,410	286,639	238,887	141,561	83,341	172,351	133,397
1977 (Jan.-June)	1,355	158,637	134,448	52,003	83,902	88,216	81,768

and manufacturers. New products were developed through the close cooperation of manufacturers, dealers, and farmers.

Export of Japanese agricultural machinery in 1976 was $169 million, which showed a 50% increase over the previous year, and which is 7% of the total production of $2,410 million. Main export markets are Asia - 25.0%, Europe - 29.2%, and North America 28.7%.

Export of the four-wheel tractor increased rapidly the last few years. The exported number during the first 6 months in 1977 reached 20,619. The import value of agricultural machinery and tractors in 1976 was $99 million. The number of imported tractors in 1976 was 6,856.

Japanese tractor manufacturers recently started to produce bigger sizes, such as the 83 hp tractor developed by Shibaura and the 79 hp tractor by Kubota. The competition between imported Japanese-made tractors will become intense.

POLICIES RELATING TO MECHANIZATION

The government budget for agriculture, forestry, and fishery in 1977 FY was determined by the following considerations: 1) to stabilize food supply, 2) to secure agricultural land and workers, 3) to stabilize the price of agricultural products to secure farmers' income, 4) to improve rural environment, and 5) to modernize food marketing. The general figure is $10 billion, which means a 9.4% increase over previous fiscal year and which amounts to 9.3% of the total national budget of $110 billion.

The introduction and subsidy of agricultural machinery budget is $567 million (35.3% increase over 1976). The amount for agricultural machinery and facilities is $201 million. The main government undertakings are improvement of the agricultural structure to conserve land conditions, increase forage crop production, and develop program for efficient production of wheat, silk, and fruits. The amount for the research and training expense to improve farm mechanization techniques is $4.72 million, which is a 10.2% increase over 1976.

A subsidy of $2.73 million is appropriated in the budget to the Institute of Agricultural Machinery. In addition, there are funds to aid the introduction of farm machinery, $1.73 billion, and loan funds for improvement of agriculture, $115 million.

The government wants to promote mechanization more for other crops than rice. Governmental research stations are doing research and development in various fields, especially for mechanized harvesting of upland crops, vegetables, and fruits. Japanese engineers have to develop small and cheap machines suitable for small farms.

New targets of research and development of new machinery were recently reported by the Institute of Agricultural Machinery: 1) safety and comfort of operators, 2) automation, 3) energy and resource conservation, 4) transportation and material handling, 5) soil fertility, 6) improvement for machinery related to soil, 7) increased utilization of paddy field, 8) utilization of steeply sloping land, 9) harvesting of fruits and vegetables, 10) food marketing, especially vegetable storage, 11) environmental control for animals, 12) treatment of waste and noxious gas.

A more detailed outline for rice production follows.

1. Soil preparation

   a. tractor for very soft soil
   b. ridge making machine

2. Rice transplanting machinery

   a. body for very soft soil
   b. new seedling feeding unit
   c. new transplanting method for long seedlings
   d. position control of transplanting unit
   e. automated finding of unplanted seedling
   f. releveling method after tractor wheels
   g. new system for growing seedlings

3. Pest control

   a. research on new pipe nozzle
   b. low volume sprayer
   c. low loss sprayer

4. Weeding

   a. new mechanical weeder
   b. weed reaper for water channels or for ridges

5. Water management

   a. automated irrigation system to save water and to increase yield
   b. new system for raising water temperature

6. Fertilizing

   a. manure spreader or applicator
   b. granular or solid fertilizer applicator
   c. liquid fertilizer applicator

7. Harvesting and transportation

   a. auto–control of threshing function of combine
   b. all–weather combine
   c. combine with planting unit
   d. improvement of conventional combine

8. Drying and storage

   a. high speed dryer
   b. new bulk storage method for brown rice
   c. automation for dryer
   d. handling of grain

Manufacturers are also promoting new developments in various fields. Automation, use of micro–computers, and hydraulics are being studied in many projects.

Trends in development of selected machinery for rice:

Tractor (four–wheel: 9 – 83 hp are available. Farmers are demanding more powerful, automated, and comfortable tractors. Rotary operations with tractors are going to be automated.

Rice transplanter: 2–, 4–, 6–, 12–, 18–row machines are available. Operation speeds are 0.1 ha/hour – 0.8 ha/hour. Eighteen–row planters use paper pot seedling for cold weather areas. Farmers want to buy bigger machiners.

Direct seeder: Many kinds of direct seeding machines have been developed by several manufacturers.

Weeder: Power weeder is now widely used to control weeds and to increase yield. Farmers increased yields 10–20% by using power weeders.

Deep fertilizing machine: Farmers are showing interest in this machine to increase yields. Several manufacturers are test marketing.

Combine: Two directions (toward bigger and smaller) are indicated by new models. Length of cutter bars range from 50 cm - 150 cm; engine power ranges from 5-30 hp, weight from 350 - 2,820 kg, harvesting speed from 0.03 - 1.8 ha/h, price from $2,269 - $17,538. Iseki developed a fully automated combine last year as a prototype. Direction control, cutting height control, travel speed control, threshing drum load control, and feeding depth control are already available.

Machinery for straw and husk: Several kinds of straw collectors, harvesters or pickers have been developed. A self-propelled straw baler for soft soil is available. Many manufacturers are developing various kinds of husk burners, charcoal producing units, gas producers, husk mills, husk manure producers, drainage machiners (using rice husks), chemical husk converters (to animal feed, etc.).

Last year Sasakinoki in Aomori Prefecture developed a new chemical straw processing unit to prepare animal feed.

FUTURE DIRECTION

Japanese agriculture has several difficulties: 1) rapid decrease of young farmers, 2) small and separated fields, 3) big gap in labor productivity, 4) competition from foreign countries who want to sell their agricultural products under the big deposit of foreign currency, it is hard for many Japanese products to compete with them in price, 5) political power for the agricultural sector is decreasing because of the increase of city population and industry.

How can we solve these problems and develop agriculture further? We have to rapidly develop automation in our agriculture, which means to promote a new "brain mechanization" instead of a "muscle mechanization." Many manufacturers and institutes have already started research on automation of Japanese agriculture. I estimate that the first stage of this automation will be completed by about 1995.

Agricultural automation will be developed in various fields, such as 1) systems for controlling many scattered small fields at the same time, 2) fully automated system for greenhouses, 3) utilization of steeply sloping land, 4) food production unit for every house.

Japan has a positive social need to develop automation in agriculture through the development of new automated machinery, the energy consumption, land and labor productivity, farmers' work schedules and life styles will change greatly. I believe that creative engineers will overcome Japanese agricultural difficulties.

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SELECTED STATISTICS

Total land area, cultivated land, and area by use

	1965	1975
Total land, ha	36,978,000	37,753,000
Cultivated land, ha	6,004,000	5,572,000
Cultivated land ratio, %	16.2	15.0
Irrigated paddy field, ha	3,123,000	2,719,000
Upland rice, ha	132,000	45,000
Upland field, ha	2,614,000	2,402,000
Common field, ha	1,948,000	1,289,000
Orchard, ha	526,000	628,000
Grass land, ha	140,000	485,200
Forest and field, ha		25,011,000

Area of land planted, selected crops (ha)

	1965	1975
Total planted area	7,430,000	5,755,000
Rice	3,255,000	2,764,000
Wheat and barley	966,800	181,000
Sweet potatoes	256,900	68,700
Potatoes planted in spring	202,000	132,000
Miscellaneous cereals	83,500	25,600
Pulse	485,200	257,100
Fruits and nuts	355,900	430,400
Vegetables	691,500	631,700
Industrial crops	364,600	241,800
Mulberry	163,800	150,600
Forage and manure crops	610,800	871,900
Greenhouse area	3,259	18,760
total planted area in the greenhouse		31,536

Ratio of land utilization (%)

	1971	1975	1975 (in winter)[a/]
Total	104.5	103.3	30.3
Paddy field	94.5	98.5	8.7
Upland field	118.6	109.6	69.5

[a/] Two reasons farmers do not utilize their field during winter season are: 1) labor shortage - 36%, 2) unsteady market price - 26%.

Location of four main islands (Hokkaido, Honshu, Shikoku, Kyushu)

North latitude	30°	-	46°
East longitude	128°30'	-	146°

Average temperature (C°) and rainfall (mm) in selected cities in 1975.[a/]

	Sapporo	Tokyo	Takamatsu	Kagoshima
Last 10 days of January	-5.2°C 35mm	3.8°C 0mm	3.3°C 0mm	5.0°C 3mm

	Sapporo	Tokyo	Takamatsu	Kagoshima
First 10 days of May	8.8°C 25m	14.5°C 48m	15.4°C 8mm	16.7°C 37mm
First 10 days of August	20.6°C 12m	26.2°C 5lmm	26.7°C 7Omm	28.1°C Imm
Last 10 days of October	7.7°c 96mm	16.0°C 28mm	14.8°C 35mm	17.8°C 36mm

a/ 1976 was one of the cold and unusual weather years, which damaged rice production in northern Japan.

Farm population and population engaged in agriculture

Year	Farm population	Ratio a/ (%)	Population engaged in agriculture	Ratio b/ (%)
1950	37,811,000	45.4	16,100,000	90.6
1960	34,411,187	26.8	14,541,624	26.8
1970	26,281,780		10,251,878	16.9
1975	23,195,000	20.7	7,907,000	14.8
1976	22,895,460	20.1	7,479,550	

a/ divided by total population.

b/ divided by total population of engagement

Farm number by full-time and part-time

Year	Total	Full-time farms	Part-time farms	2nd kind
1960	6,056,630	2,078,124	3,978,506	1,042,176
1970	5,341,844	831,350	4,510,494	2,708,680
1975	4,953,100	616,400	4,336,600	3,077,900
1976	4,891,360	658,680	4,232,680	3,230,760

Farm households by area (ha) of arable land in 1975 (x 1,000)

Prefectures	-0.5	0.5 - 1	1.0 - 1.5	1.5 - 2.0	2.0 - 2.5
	1,995	1,436	349	162	162

2.5 - 3.0	3.0 -	
74	76	Total = 4,818

Hokkaido	-1.0	1.0 - 2.0	2.0 - 3.0	3.0 - 5.0
	27	11	11	25

5.0 - 10.0	10.0 - 20.2	20.2 -	
33	16	10	Total = 134

Agriculturalengagement by age, January, 1976 (x 1,000)

Age -	15-19	20-24	25-29	30-34	35-39	40-54	55-64	65 -
	54	241	318	446	671	2,844	1,392	862

Total = 7,480

(number of males is 2,975,000)

New agricultural engagement among new graduates from middle and high school

	1971	1975
Total graduates	981,674	640,216
Ratio of agricultural engagement	3.1%	2.1%

Location of concentrated farm houses (C.F.H.) 1975

Number of farm houses concentrated near DID city, town, or village: 92.9% of 18,000 C.F.H. sampled from 142,000 (hours to reach DID city, town, or village).

0.5 hours	0.5 -1	1-2	2 and above
39.4%	38.0%	20.0%	2.3%

Almost Japanese farmers are within commuting distance to work in a factory, office, or shops.

Price of farm land for farming $/ha

	Paddy field	Upland field
1965	7,842	4,739
1975	25,487	14,892

Average price of farm land used for housing is $64.4 - 290/3.3m^2. Above figures do not include Tokyo, Ohsaka, or Kanagawa, where land price is specially high.

Status of agriculture in national economy

	1970	1974	1975
Net domestic product at market price (bil.S)	272.4	433.6	490.7
Agriculture (%)	4.3	3.7	5.0
Personal consumption expenditure (bil. $)	139.6	268.6	316.6
Foods & drinks (%)	34.3	33.1	33.0
Value of imports (bil. $)	26.1	69.5	66.0
Agricultural product (%)	33.1	26.7	27.0
Self-sufficiency ratio of foods (%)	81.0	77.0	78.0
Self-sufficiency ratio of cereals (%)	48.0	40.0	43.0
National general budget (bil.S)	31.6	73.8	80.1
Agriculture	10.8	10.5	9.6

Status of rice production in agriculture in 1975

Total agricultural production (in bil. $)	34.0	100.0%
Rice (in bil. $)	13.1	38.6%
Animal meat & eggs (in bil. $)	8.6	25.3%

Indices of agricultural production (1970 = 100)

	1955	1965	1975
Total agriculture	71.9	89.0	105.6
Rice	97.2	97.7	103.5
Vegetables	58.8	84.1	103.4

	1955	1965	1975
Fruits & nuts	32.7	69.3	103.4
Pigs	15.6	62.8	120.2
Hen eggs	24.3	67.0	102.1
Cow milk	21.0	67.7	104.5
Beef cattle		102.4	84.6

Agricultural labor productivity indices (1970 = 100)

1975 145.7

This is 41.4% of nonagricultural labor productivity. But it was 28.6% of nonagricultural labor productivity in 1971.

Change of labor hours for paddy rice production and the yield

Year	1975	1970	1969[a/]	1960	1955
Labor (man-hours/ha)	814	1,179	1,179	1,709	1,918
Yield in brown rice (t/ha)	4.81	4.42	3.90	9.98	3.90

Year	1940	1925	1910	1900	1882
Labor (man-hours/ha)	-	-	-	-	-
Yield in brown rice (t/ha)	2.98	2.72	2.58	2.24	1.78

[a/] Cold weather year.

Farm household economy (national average, per one farm household)

	Fiscal year - Apr. - Mar. 1974	1976	76/75 (x 100%) (unit: $1,000)
Bank deposit	12.1	23.2	115.5
Total debt	2.7	3.9	116.2
Total gross income	17.0	21.3	110.0
Total income of farm household	13.1	16.5	108.0

	1974	1976	76/75 (x 100%)
Farm household income	11.3	14.1	107.3
Agricultural income	3.6	4.4	100.8
Gross income	6.8	8.5	106.4
Expenditures	3.3	4.1	113.3
Nonagricultural income	7.8	9.6	110.5
Gross income	8.4	10.4	110.2
Expenditures	.06	.77	106.4
Taxes & other public charges	1.4	1.7	115.2
Income after taxes	100.0	12.4	106.2
"Dekasegi" income grants & subsidies etc.	1.7	2.4	113.0
Disposable income	11.7	14.7	107.3
Living expenditure	8.8	11.2	109.7
Surplus after living expenditure	2.9	3.5	100.2
Family members	4.59	4.52	99.1
Cultivated area (ha)	1.125	1.14	100.8
Members engaged on own farm	1.41	1.37	97.2

Expenditures related to agricultural machinery per farm household

	1974	1976
Lighting, heating, and power	$108	$145
Total of small agricultural implements, agricultural motor vehicles, maintenance and repair of farm buildings, and other expenditures	357	454
Depreciation	780	993

Purchase and disposal sale value of fixed assets ($1,000)

	1974	1976
Purchase value	2.5	3.4
Buildings	1.2	1.7
Motor vehicles	.41	.51
Large agricultural implements	.48	.68
Disposal sale value	1.1	.92
Land	.85	.61

Price index (1970 = 100) of agricultural products, agricultural implements, and price, of rice

	All agricultural products	Rice	Ave. selling price of rice to govt. ($/t)
1970	100	100	523
1975	181.0	187.6	999
1976	196.0	200.4	1,053

STATUS OF AGRICULTURAL MECHANIZATION IN KOREA

SUNG KUM HAN
DIRECTOR, INSTITUTE OF AGRICULTURAL ENGINEERING & UTILIZATION
MINISTRY OF AGRICULTURE & FISHERY
SUWEON 170, KOREA

SUMMARY

Rice and barley are the main grain crops grown in Korea, so mechanization of agriculture centers mainly around these crops. Mechanization began in the early 1960s when the power tiller and power sprayer began to be supplied to the rural areas. The production system for rice and barley began to cahnge from manual and animal power to partially mechanized operations.

But transplanting, harvesting, and drying are not yet mechanized. In Korea, peak labor requirements occur in the rice transplanting and barley harvesting season (June, July) and rice harvesting and barley seeding season (Oct., Nov.). These peak labor requirements have caused farm wages to rise with a 29-38% increase between 1976 and 1977. Mechanization is urgently required to relieve the peak labor requirements and ensure timely harvesting and transplanting.

The government is promoting agricultural mechanization by increasing the supply of power tillers and tractors, constructing model mechanized pilot areas, establishing mechanized operational systems, providing low interest loans for major farm machinery, enforcing laws that concern mechanization, and promoting a system of free competition in the manufacturing sector.

INTRODUCTION

Extent of irrigation

Of the total 1.28 million ha of paddy field, .92 million are irrigated and .34 million partially irrigated or rainfed. The latter represents 28% of the total area.

Utilization of land and size of farms

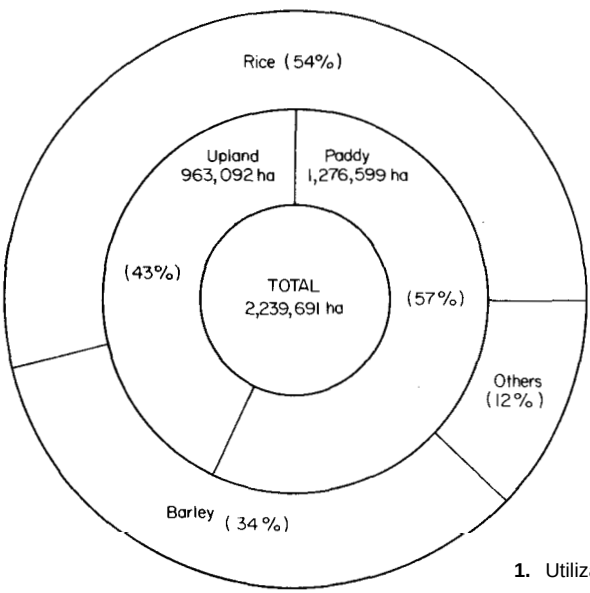
Paddy fields occupy 57% of the total 2.24 million ha of cultivated land and upland 43% (Fig. 1). Rice and barley, the principal grains in the Korean diet, are the main crops grown. Rice makes up 54% and barley and wheat 34% of the total production (Fig. 1). Land holdings per household in Korea average only 0.9 ha -- 34.8% are between 0.5 and 1.0 ha, 18.1% between 1.0 and 1.5, and only 1.5% over 3 (Figs. 2 and 3).

Percentage of farm labor and level of farm income

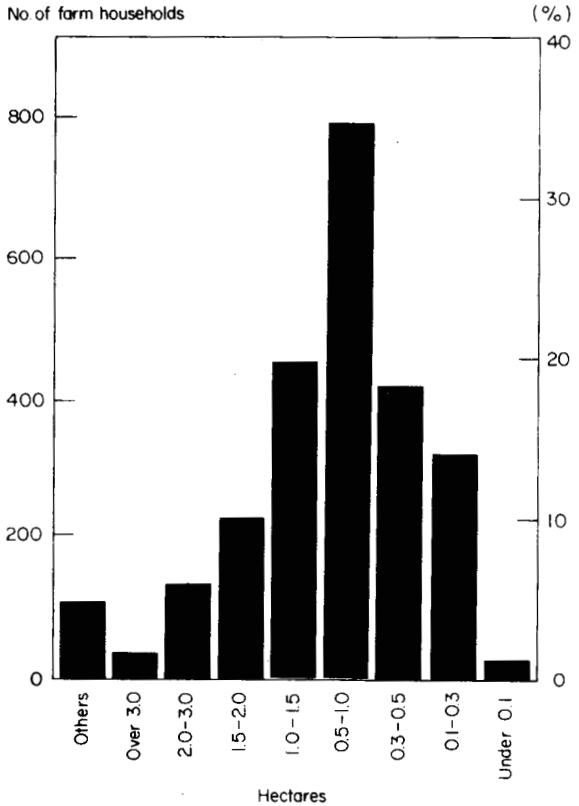
In 1976, the total labor force was 36% (12.34 million persons) of the total population. The agricultural labor force is about 42% (5.12 million persons) of the total labor force. Average farm income per household in 1976 was $2,404, an increase of 31% over the previous year. Farm household expenditure has increased by $505, or 39%, between 1975 and 1976. As a consequence, the real farm household income has increased 28.9% faster than the annual average national income of $1,899 for 1976 (Fig. 4).

Rainfall

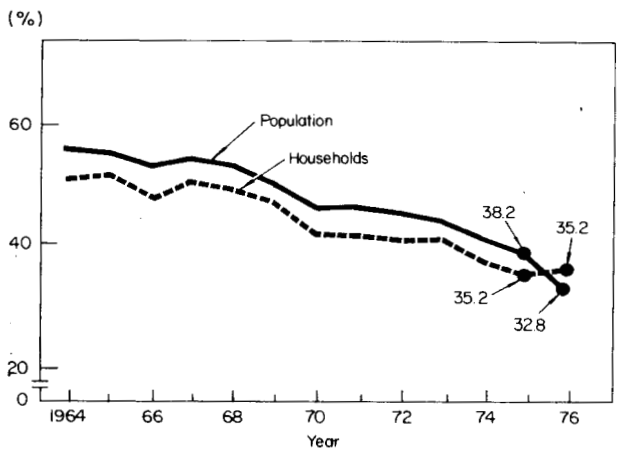
Average annual rainfall is between 1,200 and 1,500 mm in Korea. But its distribution sometimes does not fit the farming pattern (Fig. 5).



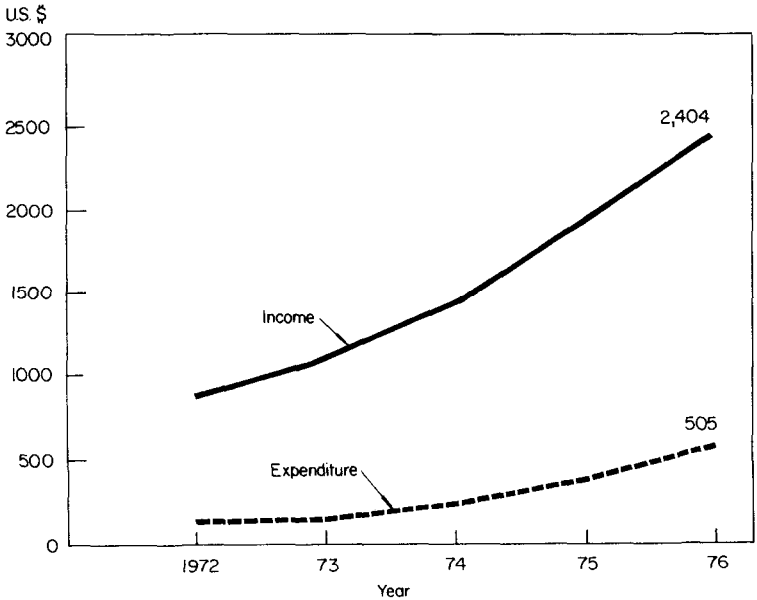
1. Utilization of cultivated land.



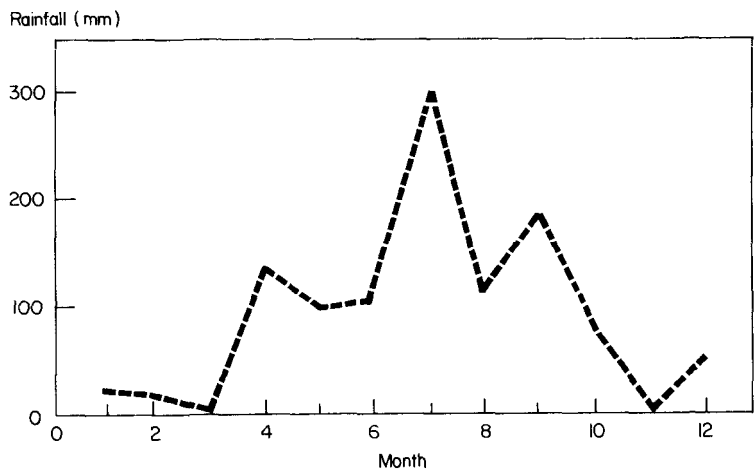
2. Farm size distribution, 1976.



3. Farm population and number of farm households, 1964–76.



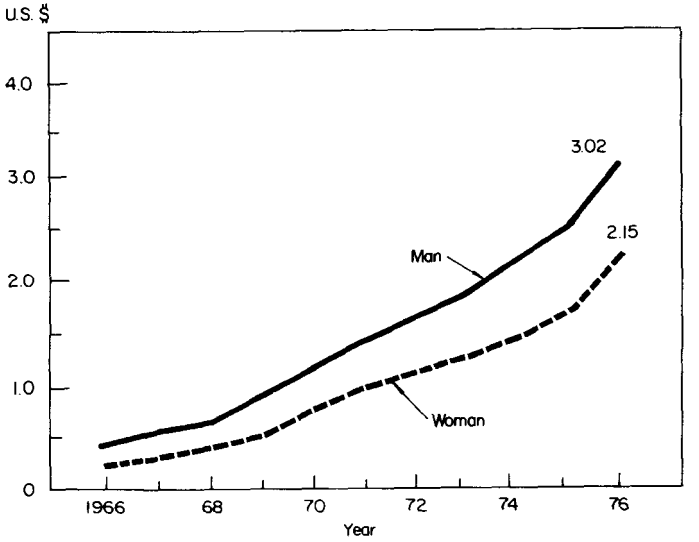
4. Changes in farm household income and expenditure.



5. Rainfall.

Distribution is as follows:

Rainy season (July - August), 46.2%;
Dry season (April - May), 12.8%;
Harvesting season (September - October, November) 18.4%
Winter (December - March), 10.2%;
Transplanting season (June), 12.2%.



6. Increase in farm daily wages, 1966–76.

Daily wages of farm labor

Daily wages of farm laborers increased by 29% to 38% between 1976 and 1977. Figure 6 shows the tendency of wages to increase and the current daily wages -- $3.02 for a man and $2.15 for a woman. This tendency will continue seasonally under typical Korean farming conditions.

CURRENT STATUS OF MECHANIZATION

Rice is the most important cereal in Korea's diet. Thus agricultural mechanization has been developed in accordance with the rice cultivation system.

Plowing and harrowing

Up to 1963, plowing and harrowing operations were performed by oxen. Since then power tillers have been supplied steadily and the system for rice production changed from animal power to partially mechanized operations. The number of power tillers supplied during the most recent 2 to 3 years increased rapidly and the number supplied by the end of 1976 totaled 122,079. Although only 790 tractors were supplied by the end of 1976, the government currently has put more emphasis on tractors. Thus it is expected

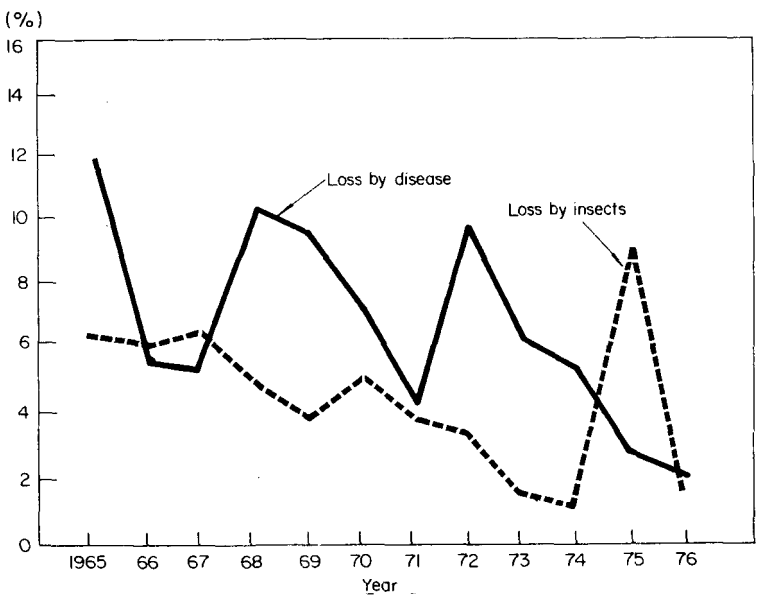
that the number of tractors will increase and the cultivation systems will be changed to suit tractor system by 1980.

Transplanting

Although mechanized transplanting has been attempted in Korea, a suitable technology has not yet become available and there is still heavy reliance on manual labor. In 1977 the Korean government supplied 50 imported rice transplanters from Japan to the joint farming areas as a demonstration. Some agricultural machinery manufacturers plan to make rice transplanters and the Institute of Agricultural Engineering & Utilization is also developing a version which is attached to a small power tiller.

Pest control

Prior to l9,60, spraying in paddy fields was carried out with a manual sprayer, but misters and dusters and power sprayers started to be produced and supplied in 1960. In 1970 the supply of these machines was standardized. By the end of 1976, 123,638 misters and dusters and 40,534 power sprayers were supplied in rural areas. Figure 7 shows the percentage of rice lost through insects and disease attacks.



7. Percentage of rice lost through insect and disease damage.

Reaping

Reaping operations have traditionally been carried out manually. Various types of reapers were developed and introduced, but few were ever supplied to the rural areas. There are 3,376 manual reapers and 173 power reapers currently in operation. According to a plan, the government is attempting to mechanize the harvesting operation and has supplied some combines and binders as models.

Threshing

In Korea, threshing developed originally from manual methods and progressed to use of power machines. Most farmers today use power-driven machines and a few use pedal threshers, but the number of farmers using the pedal threshers is now steadily decreasing. Combines which carry out reaping and threshing simultaneously will soon be widely supplied to the rural area.

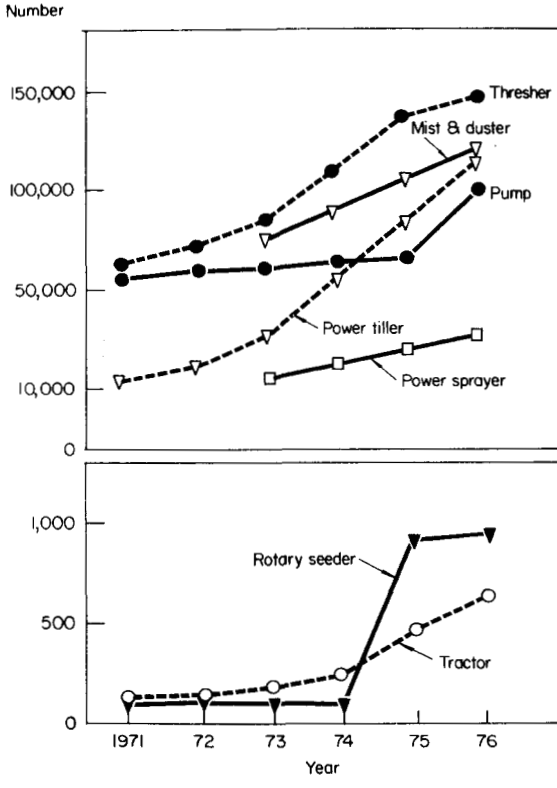
Drying

Solar drying is the most common method used because of the excellent weather conditions during the harvesting season. In rural areas, 366 batch-type dryers and 262 circulating-type dryers have been supplied to farmers and farm groups. As the number of combines supplied in the rural areas increases, so will the need for dryers.

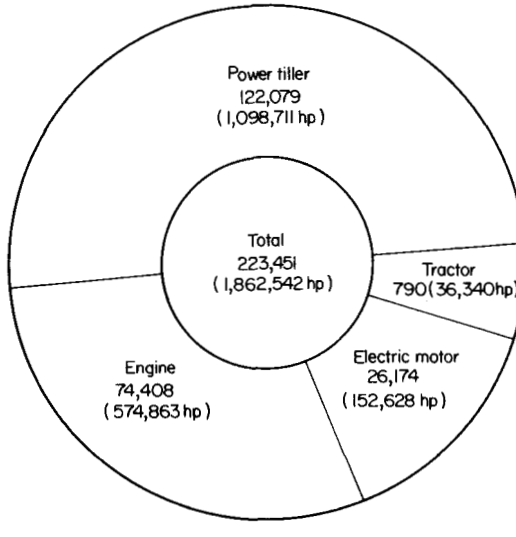
Storage

Most farmers use a straw bag or simple grain bin for storage. To improve grain quality and reduce losses and costs, I.A.E.U. is developing a solar energy system for grain drying and storage. As paddy production continues to increase, expanded storage facilities will become more important.

Agricultural machines began to be supplied in the early 1960s. Mass production of farm machinery and supply on a wide scale began in 1970. Agricultural mechanization has progressed rapidly due to a shortage of farm labor and increases in rural income (Fig. 8). A total of 1.86 million hp is available on Korean farms: engines (574,863 hp), electric motors (152,628 hp), power tillers (1,098,711 hp), and tractors (36,340 hp). This represents an average of about 0.8 hp per farm (Fig. 9). The main source of the increase in farm horsepower is from power tillers and tractors.



8. Development of rice mechanization, 1971–76.



Total farm household	Total horsepower	Horsepower per farm household
2,336,000	1,862,542 hp	0.8 hp

9. Horsepower available per farm household, 1976.

LOCAL MANUFACTURE OF EQUIPMENT

Power tillers, mist blowers and dusters, power sprayers, threshers, and tractors are the major items currently produced in Korea. All machines except the tractor are entirely domestically produced. Table 1 shows the major equipment in Korea and the manufacturers producing them.

POLICIES RELATING TO MECHANIZATION

Plans for encouraging local manufacturers

To promote agricultural mechanization, the government classifies manufacturers into two groups. The first are large companies capable of producing a range of items. Manufacturers in this class produce engines, power tillers, tractors, rice transplanters, reapers, and combines. The second group are medium- or small-sized firms which generally produce one special item. These manufacturers produce such items as dryers, pest control machines, and threshers.

Table 1. Major farm machines and other items produced in Korea[a/].

Machine	Number of manufacturers	Local content (value)
		%
Tractor	2	37
Power tiller	2	100
Power sprayer	6	100
Mist and duster	2	100
Manual sprayer	5	100
Power thresher	13	100
Pedal thresher	4	100
Seeder	2	100
Reaper	3	100
Pump	13	100
Milling machine	21	100
Dryer	2	100
Machine for animal	3	100
Engine	11	100

[a/] Manufacturers that produce more than one kind of machine are recorded for each machine category.

Table 2. Statistics on the supply of farm machinery in Korea, 1976-77.

Machine	Number (by 1976)	Number (plans for 1977)	Amount of loan, % (1977)
Power tiller	122,079	47,510	50
Power sprayer	40,534	10,030	80
Mist and duster	123,638	22,497	70
Pump	85,704	12,967	70
Power thresher	144,780	8,010	50
Seeder	1,525	2,000	100
Power cutter	4,877	200	70
Tractor	790	210	70
Dryer	628	60	
Combine	69	65	
Transplanter	32	65	

Plans for supply of farm machinery

Farmers who wish to purchase agricultural machines can obtain a government loan representing 30 and 50% of the initial investment cost, which is repayable over a period of 3-10 years (Table 2).

Training

The Office of Rural Development provides training in nechanization for farmers, Training centers are divided into three classes -- National, Provincial, and City.

The National Center trains rural guidance workers and farmers who purchase the larger farm machinery (tractors) and newly developed machines (rice transplanter, combine, binder) on operational techniques and maintenance. The National Center spreads new techniques and guides farmers. The Provincial Center trains rural youth and women in operational techniques on power tillers and small machinery. The objective of the Provincial Center is to relieve the labor shortage and to prepare the younger generation for modern agriculture. The City Center trains farmers who have purchased machines in field operational techniques. Table 3 shows the details of the training programs.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Research is carried out mainly by the Institute of Agricultural Engineering & Utilization of the Office of Rural Development. The

Table 3. Training centers and trainee details.

Classification	Training center	No. training centers	Trainee	Term	No. trainees (1976)	No. trainees (1977)
National Center	Office of Rural Development	1	Rural guidance Officer and farmers	2-24 (wk)	530	143
Provincial Center	Provincial Office of Rural Development	9	Rural youths and women	1-6 (wk)	2,490	2,778
City Center	Rural Guidance office	141	Farmers	1-3 (da)	73,728	90,000
Total		151			76,748	92,921

objectives and aims are to develop farm machinery and adapt machines to suit Korean conditions.

Government policy is to recommend to farmers those newly developed machines and new techniques which show good performance. Newly developed operational techniques are introduced through special training courses.

Some machines developed in I.A.E.U. and currently being supplied include:

Rice transplanter: The price is kept low since the transpanter is an attachment for a small power tiller. The existing model is a four-row rice unit, so the efficiency is high.

Rotary power seeder: Plowing and seeding are carried out at the same time, and the efficiency is high. By using the existing power tiller after changing the rotary blades the cost is kept low. It is possible to work in semiwet land (moisture content 90%).

Small power tiller: Low priced and simple in construction, the tiller is lightweight and suitable for operation by a woman or older person. It is useful for spraying, transport, pumping water, and many other aspects of farming.

Axial flow thresher: Suitable for both barley and rice threshing, this machine gives high threshing performance (650 kg/hr for rice and 450 for barley). The straw is returned to the field.

Rice hull furnace: This machine has sufficient heat output for drying and is economical, using rice hulls as fuel.

FUTURE DIRECTION

The fourth 5-year agricultural mechanization program has been established. The plan calls for supplying farm machinery, encouraging manufacturers, and provision of service and maintenance, as well as a research program for mechanization. The basic objectives of agricultural mechanization are to increase land and labor productivity and improve agricultural mechanization techniques.

The principal features of future plans are:

1. Increase the supply of farm machinery.
2. Install pumping stations for efficient use of river water.

3. Improve low productivity land and supply of tractors.
4. Relieve peak labor requirements through mechanization of transplanting and harvesting.
5. Utilize land efficiently through the supply of newly developed farm machinery.
6. Provide low-interest loans for major farm machinery and subsidies for newly developed machines.
7. Promote development of farm machines suited to Korean conditions by establishement of an Institute of Farm Mechanization.

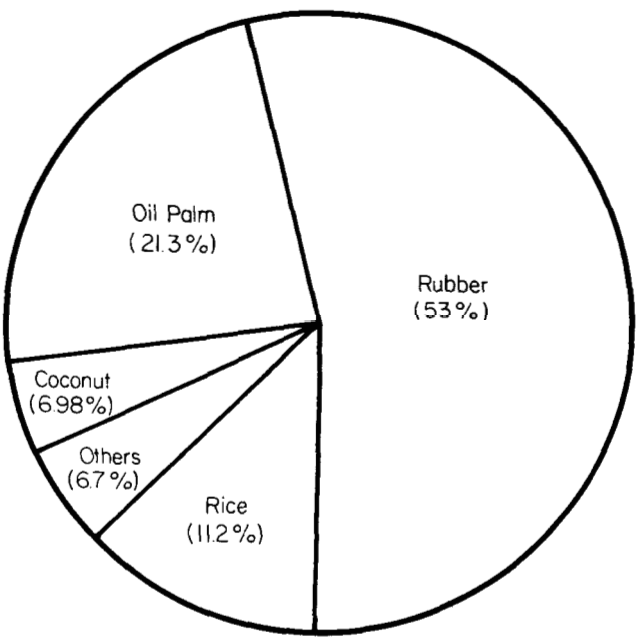
STATUS OF AGRICULTURAL MECHANIZATION IN MALAYSIA

AYOB BIN SUKRA
HEAD, AGRICULTURAL ENGINEERING,
WATER MANAGEMENT, & CENTRAL WORKSHOP BRANCH
MALAYSIAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE
LOCKED BAG 202, UPM POST, SERDANG, SELANGOR, MALAYSIA

INTRODUCTION

The agricultural sector holds a prominent position in the Malaysian economy. In 1975 it provided employment for 49.3% of the country's total work force, contributed 45.5% of the foreign exchange earnings, and 29.8% of the gross domestic product (Govt. Malaysia, 1976).

About 10% of the 33.3 million ha total land area in Malaysia is under cultivation. In peninsular Malaysia the cultivated land represents 22% of the 13.1 million ha total land area. Figure 1 shows the proportion of land under various crops. Tree



1. Percentage of cultivated area under various crops in peninsular Malaysia.

crops make up 82.6% of the agricultural land. Rice is the major cereal crop (11.17%). In peninsular Malaysia, the lowland rice area constitutes about 97% of the total paddy land of 382,194 ha of which 76.3% is irrigated. Double cropping is practiced on 56% of the total paddy area.

About 20% of the population in peninsular Malaysia is engaged in rice farming (Selvadurai, 1971) with an average per farmer income of M$110 per month. This is comparable to the wages received by semiskilled workers in the manufacturing sector -- M$3.50 - M$4.50 per day (Fed. Industrial Dev. Authority, 1977a).

CURRENT STATUS OF MECHANIZATION

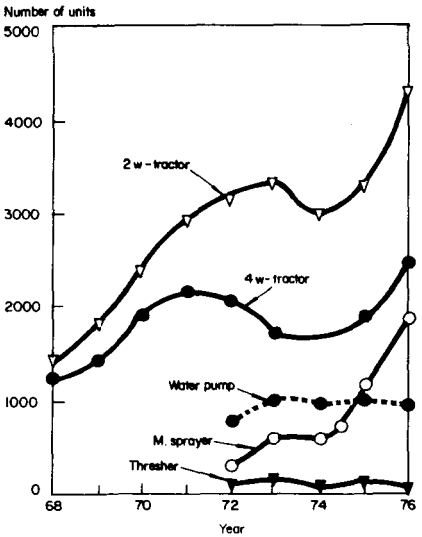
Agricultural operations currently mechanized

In the tree crop plantations, four-wheel tractors are employed for transportation, handling, and general farm maintenance. Besides this, mechanization is mostly employed in the cultivation of lowland rice, especially for land preparation. For paddy land preparation both four wheeled and two wheeled tractors are being used, and most common implement is the rotary tiller. The moldboard plow is seldom used in mechanized paddy land preparation. Generally paddy land cultivation is done under wet field conditions.

In the main rice growing regions, 60 to 90% of the farmers cultivate their land mechanically, either using machines owned and operated by themselves or by custom hiring from cooperatives, government departments, or contractors. Plowing with buffalos is still employed in the smaller rainfed paddy growing areas.

The type of tractors used varies with the area depending on the soil and water control conditions. Two wheeled tractors are mainly of the imported Japanese type with 10-15 hp diesel water-cooled engines. Most four wheeled tractors are in the range of 25-35, 50-60, and 70-80 hp, depending on the soil condition. In one major paddy growing area, it has been observed that 25-30 hp tractor are becoming more popular than 50-60 and 70-80 hp as a result of deepening of the soil hardpan and the high frequency of tractorsl "bogging down."

Rice harvesting combines of both Japanese and American/ European types have been used with varying success. The American/ European types are mostly operated by contractors and used mainly in the Muda irrigation scheme area. Japanese-type rice combines, especially developed for local soft soil field conditions, have recently been introduced. However, rice harvesting is still predominantly performed manually, using the sickle and tub thresher.



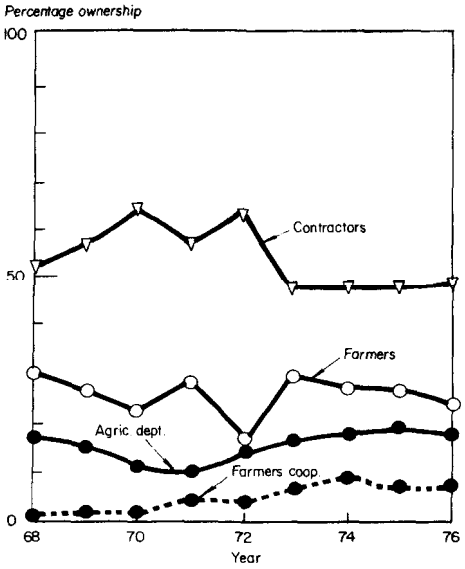
2. Machinery population growth in peninsular Malaysia. (Source: Dept. of Agriculture. P. Malaysia 1968–76. Annual Reports Extension Branch. Dept. of Agriculture, Kuala Lumpur)

Introduction of the Japanese-type mechanical rice transplanter has met with limited success. This could be due to deep water conditions and poor leveling practices in most paddy areas and the difficulty in raising seedlings for the transplanter under these situations.

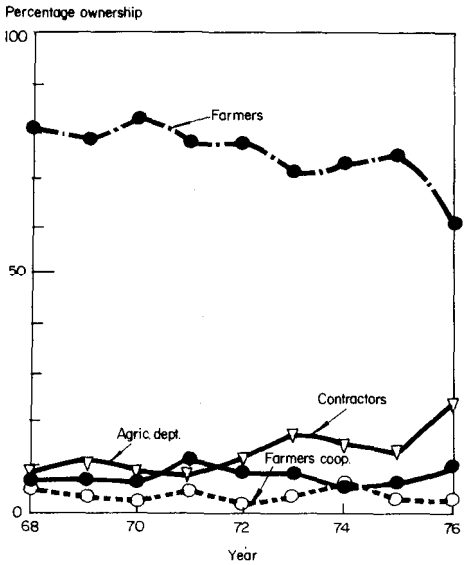
Figure 2 shows the changes during the last 5-10 years in the population of five classes of farm machinery (other than those used in the estate or plantation industry) in peninsular Malaysia. Generally the machinery population had been increasing over the period. Exceptions to this are the motorized threshers and water pumps, which have remained at a fairly constant level. Growth in the machinery population, especially tractors and motorized sprayers, has been influenced by the increase in the paddy area under double cropping. The "no growth" in the number of motorized threshers seems to indicate its poor acceptance by farmers.

Agricultural machinery ownership pattern

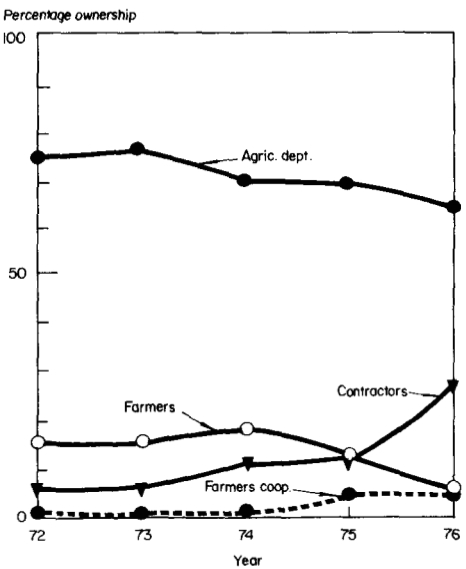
There are four types of agricultural machinery ownership in the country (excluding those in the estate industry) -- 1) individual farmer owned, 2) contractor owned, 3) farmer cooperative owned, and 4) farm machinery owned by governmental agencies. Changes in the proportion of machinery ownership under each type over the last 5-10 years are shown in Figures 3-7.



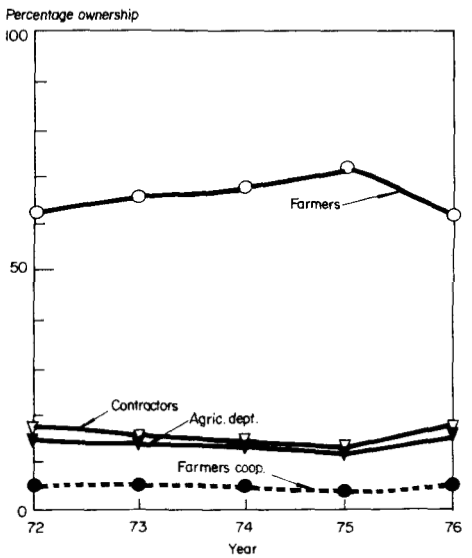
3. Ownership pattern of two-wheel tractor in peninsular Malaysia. (Source: See Fig. 2)



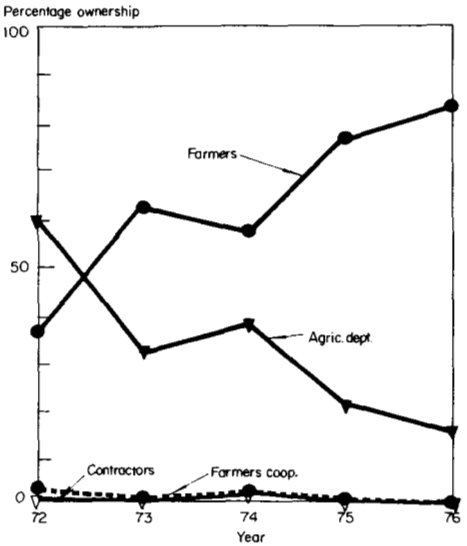
4. Ownership pattern of two-wheel tractor in peninsular Malaysia. (Source: See Fig. 2)



5. Ownership pattern of threshers in peninsular Malaysia. (Source: See Fig. 2)



6. Ownership pattern of water pumps in peninsular Malaysia. (Source: See Fig. 2)



7. Ownership pattern of manual sprayer in peninsular Malaysia. (Source: See Fig. 2)

Generally, the highest share of the machinery ownership is either by individual farmer or by contractor. The share for collective ownership by farmer cooperatives is small.

Current mechanization problem areas

The current short-term problem areas in which the introduction or development of suitable machinery would be desirable are listed in this section. The list has been prepared in an approximate order of importance in terms of the national agricultural development program. Mechanization is needed because of the increasing tendency toward labor shortages, especially at peak labor demand periods; labor migration of agricultural labor. Mechanization would also be required to expand the acreage for selected crops under the country's Crop Diversification program.

Mechanization Needs by Problem Areas

Crop/location	Mechanization problem area
Rice (lowland irrigated)	1. Transplanting (deep water and poor land leveling practice) 2. Harvesting (soft soil, insufficient drainage of fields and heavy rainfall at harvest--off-season, poor access to plots)

	3. In-field transportation of paddy grains at harvest 4. Drying and post-harvest losses
Tobacco	1. Land preparation, tillage and weeding 2. Curing--furnace utilizing cheap fuel source
Tapioca (cassava)	1. Harvesting 2. Chip making and drying 3. Pellet making
Crops grown on peat soil	1. Prime mover/transportation 2. Destumping, ditch maintenance
Livestock rearing	1. Forage harvesting and handling 2. Waste disposal and treatment
Cocoa	1. Drying and processing

LOCAL MANUFACTURE OF EQUIPMENT

Statistics on the local agricultural machinery manufacturing industry are not readily available. There are only a few firms actively involved in the assembly or manufacture of farm machinery. Local assembly activity (with a small percentage of local content) is mainly limited to four wheeled and two wheeled tractors.

To date there has been no organized study on the various aspects of local farm machinery manufacturing. No reference is available on the proportion of farm machinery that is produced within the country. Generally, however, the proportion of domestic production is small, as the major part of the country's requirement is met through importation.

MECHANIZATION-RELATED POLICIES

A general policy exists in the country encouraging mechanization cost reduction and adoption where labor shortage and timeliness present a significant obstacle to the efforts of increasing food production. Such guidelines relate to the overall government objectives of agricultural diversification, import substitution, and raising the farmer's income. The general policy covers machinery utilization aspects -- credit facilities for farmers

and encouraging joint ownership through farmer's association. Credit facilities are available for dealers to help make farm machinery readily available to farmers.

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

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

Thus, even though there is currently no single comprehensive mechanization policy, general policies exist that would directly or indirectly cover some important aspects of mechanization. In the long term, it would be desirable to formulate a comprehensive national policy on agricultural mechanization encompassing and linking the various aspects such as research and development, evaluation and testing, extension to manufacturers and farmers, manufacturing and distribution, servicing, credit facilities, and education. The role and extent of the local farm machinery manufacturing sector also needs to be defined.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

In Malaysia the functions of research, development, and evaluation of farm machinery and mechanization are carried out by governmental institutions separate from those undertaking the functions of extension to farmers and manufacturers. There has been little organized "manufacturing extension" in agricultural machinery. The main emphasis has been on the extension to farmers and on local assembly of suitable imported machines rather than on total indigenous manufacture.

At the Malaysian Agricultural Research and Development Institute, the program on research, development, and evaluation of farm machinery is conducted as part of its overall agricultural research and development program. The overall program covers

research in production and post-production of all crops (except rubber) and livestock. The agricultural mechanization program of the Institute is still in its formative stage and to date has been involved mainly in farm machinery evaluation, field experiments on aspects of mechanization, and in development of rice harvesting and tapioca lifting machinery. The program will be intensified soon with the completion of research facilities currently under construction.

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STATUS OF AGRICULTURAL MECHANIZATION IN COLOMBIA

ROLF KAESER
MECHANICAL ENGINEER, SENA-ASTIN
ASISTENCIA TECNICA A LA INDUSTRIA
APARTADO AEREO 8053, CALI, COLOMBIA, S.A.

SUMMARY

Farm mechanization progress in Colombia is slow. There is almost 100% mechanization of the flat valleys owned by a few rich people while the poorer small farmers on the hillsides are unable to purchase modern equipment. The local agricultural machinery industry is only oriented toward the heavy equipment needed for large-scale farming.

Only one government-owned research organization has attempted to develop low cost equipment. It has been unsuccessful because the implementation phase of industrial production and promotion does not exist.

Government policies to bolster national production are not encouraging and procedures to obtain credit or tax relief are too complicated for the small farmer or the small manufacturer.

The Technical Assistance Group, ASTIN, which holds an IRRI subcontract, has constructed various IRRI-designed machinery adapted to Colombian needs. Early results are showing up through intensive promotion work and the employment of a full-time Colombian agricultural mechanical engineer, supported with IRRI funds.

INTRODUCTION

Colombia has about 25 million people with a labor force of 5.8 million. The agricultural labor force has about 1.9 million laborers. Total cultivated area in Colombia is about 4 million ha, the rice area 372,450 ha with about 69% irrigated. Average pay for a farm worker is about US$ 1.80 per day.

Colombia's topography consists of five main regions: 1) Atlantic and Pacific coast, 2) hot lowland up to 1,000 m elevation, 3) cool highland 2,500 m, 4) Amazonian plains 550 m, and 5) Cordillera hillsides 500 to 3,000 m.

The main crops are sugarcane, cotton, rice, and bananas on the flat lowland; grains and potatoes on the flat highland; and coffee on the hillsides (Tables 1 and 2). Net income per hectare for the small farmer who owns property or rents land is shown in Table 3.

In lowlands, almost every hectare suitable for sugarcane is currently rented to the sugarcane factories. The income per hectare is higher from renting the land than growing crops. Rice income is low. Edible crops are subject to much pilferage at harvest time, so the cost for protection has to be deducted from the income.

CURRENT STATUS OF MECHANIZATION

The three main valleys -- Tolima, Cundinamarca, and Valle -- represent about 50% of the Colombian agricultural area. They are almost 100% mechanized with 47 ha per tractor at the Valle, 100 at Tolima, and 108 at Cundinamarca. In the whole agricultural area there is an estimated use of 226 ha per tractor (Table 4). Growth of the mechanized area is about 2.4% per year. Growth of cultivated land is about 1.7% per year, so the actual growth rate of mechanization is only 0.7% per year (Fig. 1).

About 39% of the Colombian population lives in rural areas, however, where marketing and use of the implements made by Colombian industries has been limited to medium- and large-sized farms on flat

Table 1. Cultivated area and production of principal crops for 1976.

Crop	Cultivated area (000 ha)	Production (000)	Annual production increase (%) 1970 - 76
Cotton	285.6	415	2.73
Rice	365.6	1,541	15.65
Sugarcane	85.3	983	6.65
Maize	647.5	780	2.11
Potato	125.0	1,584	5.30
Yucca	240.0	1,540	5.00
Coffee	1,095.5	644	4.61
Banana	16.2	621	13.33

Source: OPSA - Agricultural Ministry: National Coffee Growers.
a. Coffee Growers Census 1970.

Table 2. Changes of average productivity in 11 crops (kg/ha).[a]

	1950	1955	1960	1965	1970	1975[b]	% Increase 1950 - 75
Cotton (fiber)	230	290	440	440	480	504	119
Rice	1,800	1,700	1,980	1,840	2,729	4,333	141
Sesame	750	620	620	690	700	500	33
Banana	9,350	10,770	11,140	11,250	17,000	35,300	277
Sugarcane	33,700	46,400	52,300	58,600	77,700	95,140	183
Barley	1,150	1,210	1,880	1,550	1,704	1,611	40
Corn	750	900	990	990	1,150	1,439	99
Potato	6,200	6,900	7,500	7,660	8,900	10,000	61
Sorghum[c]			710	1,630	2,140	2,500	252
Soybean[c]			1,460	1,670	1,783	2,000	35
Wheat	700	810	890	1,000	1,180	1,292	84

Source: Atkinson (for 1950 – 60); DANE (Departmento Administrativo Nacional de Estadistica) (for 1960 – 70); and "Agricultural Programs," OPSA.

[a] A11 these crops consume two or more agricultural elements in large quantities.

[b] The biggest yield in agricultural history occured in 1974. In 1975 there was low production in some products, probably because of the reduced consumption through high prices.

[c] Soybean and sorghum production started in 1959. Percent increase is for 1960 – 75.

Table 3. Net income from various crops.

Crop	Income/ha harvested	
	Owned land, US$	Rented land, US$
Cotton	516	180
Rice	123	70
Sugarcane	1,888	834
Beans	381	298
Maize	195	112
Banana	931	
Sorghum	123	40
Soybeans	187	104

Table 4. Tractors and total horsepower available.

Year	Tractors imported[a/]	Total units	HP
1950	1,590	6,350	254,000
1960	2,428	16,953	755,000
1970	3,094	22,507	1,240,000
1974	2,381	22,718	1,363,000

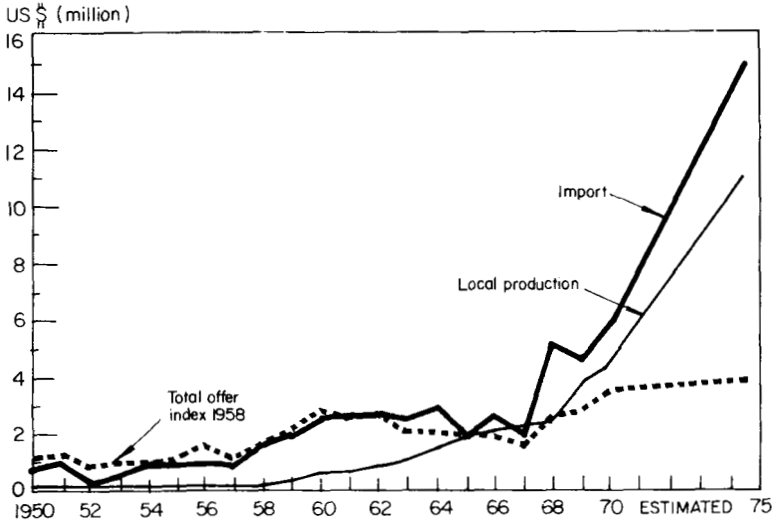
[a/] The main suppliers are England, The United States and Germany.

or gently sloping land. The rural population lives for the most part on the hillsides. The hot and cool flat valleys are owned by a few rich people.

LOCAL MANUFACTURE OF EQUIPMENT[a/]

In Colombia the process of agricultural mechanization began during the first few years after World War II, when machinery was imported on a large scale. Often this machinery was found unsuitable for Colombian conditions. In some cases it also created serious social problems, for example, cotton picking machines each displaced about 600 man-days.

[a/] partly taken from Technology and Employment in Industry, ILO Study.



1. Estimated amount of gross investment in agricultural machinery and implements, 1950–75.

The present Colombian agricultural equipment and implement industry is composed of various private enterprises. The industry produces tractor-drawn implements such as cultivators, plows, rakes, weed cutters, trailers, seeders, and spreaders. About 30% of this equipment is being built by three factories, mostly copied from imported machinery and seldom under licensed conditions.

POLICIES RELATING TO MECHANIZATION

The Colombian development plan does not favor heavy mechanization. It recommends first better use of soils, seeds, and fertilizers. It also recommends that modern technology be introduced step by step. The Agricultural Bank offers special credit lines. But the small-scale farmer is afraid of the whole process of obtaining credit, so only the big farmers take advantage of the government offers. Special import and export exchange rates have been established for agricultural products and equipment, but here too the small farmer is only buying and selling locally. Price control through government authorities is weak and has little effect.

Andenpact agreement

The Andenpact Agreement was devised to bolster national production. All countries on the Pacific side of South America agreed on a distribution of the manufacturing and exportation

rights. Colombia has the following assignments: combines, threshers, cultivators, seeders, and sprayers.

There is some tax relief for national production (up to 5 years on new products), but even here the procedures are too difficult for the small-scale manufacturers to take advantage of the tax relief.

Wage levels

The official wage minimum for metal workers is US$ 1.70, but because of the high unemployment rate many laborers accept work €or lower pay under bad working conditions.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

The only Colombian institution that tried to develop simple, low-cost agricultural implements for mini-farms is ICA -- the Institute of Agriculture and Animal Husbandry. Other institutions and the universities carry out research, but the results languish in the archives.

Since 1969 attempts have been made to design a small two-wheel tractor, agricultural grader, and animal-drawn plows. The prototype with a 10 hp engine has shown good results, but because of the lack of communication between manufacturers of agricultural equipment and institutions devoted to research, only some animal-drawn implements have been produced commercially. The main reasons for this failure are not lack of satisfactory designs, but lack of publicity of the ICA development work, and lack of a promotional campaign among farmers and manufacturers.

ASTIN-IRRI subcontract

In mid 1976 the Technical Assistance Program for a small-scale metalwork industry at Cali was started. It was looking for low investment products to be produced locally.

A subcontract agreement with IRRI was signed in February 1977, and the prototype production was started immediately. The first client had great interest in the batch dryer, but he needed a heat exchanger because he is in the coffee drying business. Colombia is a coffee-producing country and has, therefore, a good market for dryers. The IRRI arrangement was changed and the new version is working well.

The first units of the power tiller and axial flow thresher, also the portable type, have been produced and our promotion work has included the Spanish version of the information sheets and participation in agricultural exhibitions.

Raw material used for agricultural machinery production is mostly national in origin, except for engines and bearings.

FUTURE DIRECTIONS

Though there are no new government programs, the National Apprenticeship Organization has shown an interest in the IRRI program. It wants to introduce this low-cost agricultural equipment in the various agricultural training centers to promote the IRRI designs among students and local farmers.

STATUS OF AGRICULTURAL MECHANIZATION IN SRI LANKA

S. KATHIRKAMATHAMBY
SUPERINTENDING ENGINEER (R&D)
DEPARTMENT OF AGRICULTURE
PERADENIYA, SRI LANKA

Scarcity of foreign exchange as well as of minerals and other resources is an important constraint to industrial development in Sri Lanka. The country's economy is predominantly agriculture. Paddy is the main crop, grown mostly on holdings of less than I ha. Little effort had been made in the past to help farmers develop an appropriate level of mechanization. The Engineering Research and Development Division of the Department of Agriculture, Sri Lanka, has work under way with equipment that could be manufactured at the rural level with local materials.

INTRODUCTION

General

Sri Lanka is predominantly an agricultural country. Its economy rests mainly on the earnings received from three major crops -- tea, rubber, and coconut. Sale of various spices such as cinnamon and cloves add to foreign exchange earnings. Half the labor force of the country is involved in agricultural production activities. About 85% of the agricultural output is crop production. The balance comes from livestock, forestry, and fisheries.

Crop production has two categories -- export-oriented crops and crops for domestic consumption like rice, grain, legumes, and vegetables.

Climate

The two seasons in Sri Lanka are known as maha and yala. Maha begins in November with the northeast monsoon and ends in March; yala starts in May with the soutwest monsoon and ends in September.

Climatically Sri Lanka falls into dry, intermediate, and

wet zones. The dry zone composes about 40% of the total area and is mainly in the northern and eastern part of the island. The wet zone makes up about 20% of the total area and occupies the southwest quarter of the island. The wet zone received rainfall during both monsoons, while the dry zone is dry during the southwest monsoon.

The dry zone is the main agriculturally developed area. In the past, hundreds of tanks were used for irrigation; some are still in use. Most of the old tanks were abandoned, but action is being taken to restore most of them.

Rice production

With the rehabilitation of ancient tanks and implementation of various irrigation projects, Sri Lanka has shown a marked increase in rice production. In 1969-70 rice production was 602,000 t, while in 1974-75 production had increased to 1.2 million t.

High yielding varieties of rice have helped significantly in achieving this increase. Total area under rice production is estimated at 570,000 ha, and the yearly total area under paddy production (maha and yala) is 910,000 ha per year.

Rice importation has been reduced. With an increase in population (growth rate 2.4%), however, total food needs are met by importing wheat and by growing more subsidiary crops.

Subsidiary food crops

With a total ban on importation of subsidiary food crops, farmers have taken a keen interest in growing them, as they have a ready market. Moreover, the government has made crop loans available through banks for this purpose.

CURRENT STATUS OF MECHANIZATION

With the rapid increase in population and lack of foreign exchange for importation of cereals, the government's main aim is to achieve self sufficiency in food. To achieve this objective, agricultural mechanization has been given priority. The following section gives a brief description of agricultural machinery developed and in use.

Hand operated tillage equipment. Primary tillage, secondary tillage, and seedbed preparation are performed with an implement called a mamoty (hoe). Three shapes are available –– square, rectangular, and triangular. The Sri Lanka State Trading Corporation manufactures most of the mammoties. Some are manufactured by local mechanics.

Animal–drawn equipment. The country plow is still the most popular primary tillage tool for wet paddy farmers. To a certain extent the model C type moldboard plow is also used with buffalos. A moldboard plow is used for upland crops too. For secondary tillage the Burmese harrow with four or six spikes along with a leveling board is being used.

Power tillers 5–7 hp. The Sri Lanka State Trading Tractor Corporation is the only organization importing tractors into the country. It is estimated that 8,000 power tillers had been imported up to 1976. Most of these are of Japanese origin.

Four–wheel tractor and equipment. All four–wheel tractor–drawn implements are imported. Only the nine–point tine cultivator and the trailer are manufactured locally.

Hand operated seeders (lowland). For sowing lowland the John Pulle seeder is being used. This seeder is in production and being sold through government sources. The IRRI multi–hopper seeder is also being manufactured and introduced to the farmer.

Hand operated seeders (upland). Single–row and two–row seeders of the pull and push types were developed and are being produced locally. These seeders can handle a wide range of seeds from mustard to ground nut. A two–wheel tractor–drawn upland seeder (three–row) is also being produced locally. Trials are being conducted on animal–drawn, multi–row seeders.

Inter–cultivation and weeding equipment. Hand operated cultivators are available for upland crops, as are single row types consisting of three to seven interchangeable tines with duckfoot sweeps held in a socket by a screw. These are being manufactured by local blacksmiths.

The push – pullhoe, consisting of a thin blade held by an oscillating frame used with a rocking motion, has proved to be an efficient weeder for upland crops.

For wetland paddy, the Japanese rotary hand weeders are quite suitable. These are being manufactured at Implements Project Factory in Welisara.

Irrigation equipment. Engine – operatedwater pumps are produced locally by several manufacturers.

Crop protection equipment. Hand operated sprayers and dusters are being manufactured and are freely available locally.

Harvesting equipment. Harvesting is still in the traditional stage and is done by hand. The sickle is the most popular single harvest implement and is made locally.

Threshing equipment. Threshing in Sri Lanka is done either by use of animals or by driving a tractor over paddy stalks that are spread on the threshing floor. In some small holding threshing is done by manual trading. All these methods can result in complete shedding of grain. Threshing with animals or a tractor can result in checking and dehusking, both undesirable. There is no control on grain damage or stones and animal dung that get mixed with the grain. To overcome these problems, power threshers are being introduced.

The Japanese pedal – operatedthreshing machine is a simple labor – savingdevice but its capacity is low and it is difficult to maintain a constant drum speed.

Imported mechanical power threshers were tested and most were found unsuitable to local conditions, especially in threshing long – stemand wet paddy. Some of these machines are being modified.

The IRRI axial flow thresher, manufactured locally at the Implements Project Factory in Welisara, was tested at our facility and at various locations of the country. The results indicated that performance is satisfactory and the machine is suitable for use in Sri Lanka. More of these machines are being produced for extension work.

The IRRI mini thresher, manufactured and tested at Welisara and other parts of the country, was also found suitable. Farmers seem to like this machine since most have small holdings and the

cost appears to be within their reach. Local manufacturers have shown a keen interest in this machine and are already manufacturing it.

LOCAL MANUFACTURE OF EQUIPMENT

Great importance is attached to the development of agricultural machinery and farm equipment in Sri Lanka. Considerable progress has been made in recent years in the production of agricultural equipment by various light engineering enterprises and by the Department of Agriculture.

Hand tools

There is a big demand for the imported mamoty due to increased wear resistance compared with the locally manufactured models. However, the present production of this item has proved to be satisfactory.

Animal-drawn plow

Animal-drawn plows are also in great demand by farmers. Plows are manufactured at the village level. At the moment the department is trying to introduce the single animal-drawn plow due to scarcity of draft animal power.

Pest control equipment

A wide range of hand- and power-operated sprayers are being manufactured locally. The engines for power-operated sprayers are, however, still being imported.

Irrigation pumps

Since there is a big demand for water pumps, especially in the dry zone, there are various establishments in Sri Lanka that are producing them. The main problem these manufacturers face is the importation of suitable engines.

Threshers

A manufacturer had turned out about 500 threshers to work on Landmaster two-wheel tractors. But farmers appear to be

discontent with the quality. The manufacturer has since abandoned this project. However, the Department of Agriculture with the help of IRRI has turned out the axial flow thresher and mini thresher. Tests have shown that these two models are quite suitable and could be manufactured with locally available materials. Some of the local manufacturers have started production.

Two–wheel tractors

Most of the local manufacturers of two-wheel tractors have abandoned this project since they cannot compete with the improved and more versatile Japanese tractors. Negotiations are taking place to set up an assembly line in Sri Lanka to produce Japanese tractors using imported components.

POLICIES RELATING TO MECHANIZATION

In most Western countries, advances in farm mechanization have been made where a strong demand for labor in other industries has drawn workers from the land. In Southeast Asia, the reasons for advances in farm mechanization seem to be different. The desire to be self sufficient in food production seems predominant.

As far as Sri Lanka is concerned, increasing food production is one of the most urgent needs. To achieve this end, two efforts are being made. The first is to increase production on existing land, and the second is to bring more land under production. There are three areas in which investments have been made with this objective in mind. They are fertilizers, agrochemicals and applicators, and tractors and allied agricultural machinery.

Farmers in Sri Lanka are aware of the value of using fertilizers and agrochemicals to increase yields. Both the private and public sector have adequately met the demand. With agricultural machinery, there is an unsatisfied demand in the principal rice-growing areas, particularly where there is a shortage of labor during peak periods of the cultivation season. There is also a scarcity of draft animals.

To meet these needs and yet keep pace with increased production goals both in the developed areas and areas that have yet to be reclaimed, mechanization seems to be the only answer. It, therefore, follows that greater attention must be paid to agricultural mechanization than in the past.

Establishment of machinery designs testing unit

A research memorandum prepared in 1964 and approved by the Cabinet recommended the establishement of a machinery testing and design unit. Such a unit was established in March 1968 at Maha-Illuppallama. From 1944 on, a large number of different types and models of tractors, implements, and other agricultural machinery had been imported into the country with no knowledge of their suitability for local agricultural conditions. In addition best use was not being made of the foreign exchange payments on the import of such equipment.

It was, therefore, decided that the Agricultural Machinery Designs and Testing Unit be reestablished and given the sole responsibility to test and report on the suitability of imported and local agricultural machinery. Further it has also designed and developed new and improved machinery to suit local agricultural conditions.

Establishment of engineering research and development division

In 1974, the Implements Project, Welisara, and the Machinery Designs and Testing Unit were brought under one division called the Engineering Research and Development Division. The main function of the Division are 1) machinery design and development, 2) machinery testing and evaluation, 3) field trials and experiments, 4) machinery extension evaluation, and 5) machinery production.

Establishment of farm mechanization committee

A Farm Mechanization Committee was formed in 1975 with the director of agriculture as the chairman. It is composed of officials from other departments and institutions who are directly involved in farm mechanization. This committee meets twice yearly and discusses mechanization problems and also recommends the type of machinery to be locally manufactured.

RESEARCH DEVELOPMENT, EVALUATION, AND EXTENSION

The Engineering Research and Development Division of the Department of Agriculture is the only organization in the field of investigation, development, evaluation, and extension of agricultural machinery. It also has the responsibility to test and evaluate all imported agricultural machinery. This division also has an agricultural implements factory to manufacture prototypes

of machines designed and developed for the extension program.

Agricultural production in Sri Lanka is now involved in three major developments. The first is the Mahaveli – Ganga Development Project which is a major irrigation scheme designed to provide irrigation to 360,000 ha for double cropping of wetland rice. The second is land for diversified cropping made available under the present land reform act in Sri Lanka. The third is use of agricultural land, previously under utilized, to establish intensified small farms under the auspices of the proposed 480 Agricultural Productive Committees.

Due to varying ecological conditions and different agricultural climatic zones, cultural practices in crop production differ considerably. It has been found impossible to fit machines produced outside the country to these requirements, In fact the most difficult problem is the variation found in the same catchment area. Agricultural equipment, designed for one set of conditions may not work as efficiently in other areas within the same catchment. Therefore, it has become necessary to develop a machine to fit varying conditions of soils and crops and of a size to meet a range of cropping patterns. Intensive work in farm machinery research and extension has to be carried out and the country provided with the type of equipment that will meet the exact demand of each farming pattern.

Available animal power cannot be harnessed to fulfill even a fraction of the demand imposed by the farming schemes that are being developed. This situation is further agrravated by the fact that 500,000 educated, unemployed or underemployed youths must find employment in farming. It is most unlikely that these educated youths will be attracted to a system of nonmechanized farming.

FUTURE DIRECTIONS

The Farm Mechanization Committee has identified seeding and threshing of paddy as the major problems envisaged by the average cultivator.

Hence it was decided to give special attention to the development of equipment for these purposes. Aid has been sought from foreign agencies for qualified personnel to work with our local engineers to help design and evaluate suitable machines.

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STATUS OF AGRICULTURAL MECHANIZATION IN TAIWAN

TIEN–SONG PENG
SENIOR SPECIALIST, PLANT INDUSTRY DIVISION
JOINT COMMISSION ON RURAL RECONSTRUCTION
37, NANHAI ROAD, TAIPEI, TAIWAN, R.O.C.

SUMMARY

Between 1970 and 1974, a 4–year program was carried out to expedite farm mechanization in Taiwan. One of its important aims was to improve the quality of locally manufactured farm machines and to lower their cost. Meanwhile, it provided more long–term, low–interest loans in addition to subsidies.

In 1975, another 4–year program was mapped out by the government to speed up the extension of grain dryers and thereby reduce losses of fresh–harvested rice during the rainy season. Under the program, about 18,000 small– and medium–sized dryers and 45 drying plants are to be extended.

Power tillers, which still take the leading role in Taiwan's farm mechanization program, totalled 55,748 units in 1976; for every 15.6 farm households or every 16.5 ha of cultivated land, there was a power tiller. The annual increase in the number of power tillers was about 7,000 units during the past 2 years.

Besides power tillers, some farmers have recently adopted tractors.

At present, the demand for other machines such as rice transplanters and combines is on the increase but is still rather limited. This could be attributed mainly to the small farm size. Therefore, positive measures should be taken to expand the size of private farms, improve farmers' organizations, and encourage joint and cooperative farming to fulfill the farm mechanization objective.

INTRODUCTION

In the past 20 years, considerable efforts have been made to promote mechanized farming in Taiwan. In the first 10 years,

the pace was slow. In 1965 or so, after three successive 4-year economic development plans were completed, Taiwan's agriculture began a new phase which marked an end of slack labor in the face of rapid industrialization. This change has hastened the tempo of farm mechanization.

Land and soil

Of the total 919,680 ha of cultivated lands, 528,205 ha are paddy fields. The rice crop is usually grown on the alluvial soils either on the plains or along the river valleys. Paddy soils of slate and sandstone origin are rich in plant nutrients, while those of saline alluvium are generally inferior in soil fertility.

Water resources

It is estimated that a total of 8.8 billion cu m of rain water falls on Taiwan annually. Of this amount, about 21% has been harnessed for irrigation and generating power. Well-developed reservoirs and canal systems are now under the administration of 16 irrigation associations, mostly in the southern part of the island. Almost all the cropped acreage of rice - 786,343 ha - is irrigated.

Small farms

The land holding per household in Taiwan averages about only 1 ha. A widespread feature of land holdings is that a farm does not necessarily consist of a single plot, but has a number of plots averaging about 0.1 - 0.2 ha.

Multiple cropping systems

In Taiwan, many crops are raised in rotation with rice. In the rice growing areas, wheat, tobacco, soybeans, flax, sweet potatoes, peanuts, corn, sorghum, and jute are also grown. Therefore, farmers need multipurpose machines to work not only in paddy fields but also in operations for raising other crops. However, due to the increasing farm labor cost, the intensity of multiple cropping has decreased in recent years - from an index of 179 in 1957 to 185 in 1965 and 175 in 1976.

Mechanized land preparation

Before the end of 1976, 55,748 power tillers were used. On the basis of 919,000 ha cultivated land and 870,000 farm households, there was approximately a power tiller for every 15.6 farm households and every 16.5 ha of land. With the number of power tillers increasing, draft cattle have decreased since 1966 at about 20,000 head annually.

While power tillers remain the backbone of mechanized farming, small four-wheel Japanese-made tractors of 25 hp or so are also used by local farmers, and larger tractors of 70 hp have been introduced into Taiwan.

The input power of tractor and power tiller per hectare in Taiwan has increased rapidly in the past years. At present, an estimated 0.67 hp/ha is available. It is estimated that more than one-half of all tillage operations are mechanized.

Mechanical transplanting

In 1966, the government imported two Japanese rice transplanters - a motor-driven and a hand-pushed unit - for field tests. Preliminary results from the experiments conducted in 1967 were encouraging, as the transplanter can save two-thirds of the labor required for the seedling nursery, and it is four times faster than hand transplanting. To the present, about 8,000 transplanters have been adopted by rice farmers.

Water pumping

The water pump was introduced from Japan about 50 years ago. At present, small centrifugal pumps driven by 3-5 hp kerosene or diesel engines usually can be employed, as they can be easily moved from one place to another. Today, all of the pumps for individual farm irrigation are locally manufactured.

Pest control

Some 20 years ago, most sprayers and dusters were imported from Japan. In fact, chemical spraying for control of rice insects and diseases was not widely practiced until Parathion and Endrin came into use for controlling rice borers in 1955. Since then more than a dozen private factories have been established

to manufacture both sprayers and dusters, including some power sprayers.

Since 1967, the government and farmers associations have practiced aerial spraying of pesticides on paddy fields and banana plantations. Spraying has been carried out by mounting sprayers and dusters on helicopters. Pest control in Taiwan has been completely mechanized.

Mechanical harvesting

About 128,000 manual rice threshers are still being used in rural Taiwan. The figure is less than that of a few years ago, indicating that more farmers have adopted the highly efficient power-driven threshers. Improved power threshers equipped with cleaning devices have been developed and extended to local rice farmers, too. Meantime, about 1,000 power-driven reapers and 2,000 small rice combines have been introduced.

Mechanical drying

A drying bin with a motor blower and a burner for mechanical drying of rice was developed for extension by the Provincial Department of Agriculture & Forestry (PDAF) experiment stations in 1966. The bin-type dryer is portable, weighing about 270 kg. Under average conditions at harvest time, the grain dryer can reduce the moisture content of the grain from 23 to 13% and turn out about 1,500 kg of dry rice every 12 hours. The fuel for the dryer burner is kerosene or light diesel, while its 1/2-hp blower uses an electric motor. Circulation-type batch dryers have also been widely adopted during the past 2 years.

LOCAL MANUFACTURE OF EQUIPMENT

Power tiller

In 1956, the Joint Commission on Rural Reconstruction (JCRR) imported 13 small Merry Tillers for testing and demonstration at various agricultural stations. During the demonstrations, local farmers showed an interest in the machines. The demand became so strong later that local machine factories began to produce the machine by copying the imported models. Up to 1958, a total of 22 small factories had begun producing power tillers. However, small factories, whose products were of doubtful quality and some of whom built only a few units, soon found themselves in financial straits.

Table 1. Number of major agricultural machines in Taiwan.

	1965	1970	1972	1974	1976
Power tiller	12,213	28,292	35,222	42,123	55,748
Tractor	425	539	620	892	1,718
Rice transplanter	-	280	658	1,914	6,108
Power sprayer	4,489	17,820	25,309	45,399	37,489
Water pump	32,107	52,794	65,755	119,905	123,645
Rice thresher	205,784	186,398	196,637	135,158	128,232
Grain dryer	150	198	361	1,008	9,269
Rice combine	-	20	154	1,127	2,811

In 1961, two groups of Taiwan industrialists, in cooperation with Japanese agricultural machinery companies, set up two factories to produce power tillers with some parts imported. From that time on, the import of power tillers, except spare parts, stopped. Up to the present, about 55,000 power tillers have been adopted by local farmers (Table 1).

Transplanter and seeder

Among the 8,000 units of rice transplanters in use, half are locally produced. Currently, five farm machinery manufacturers are producing the machine. Most manufacture two-row machines, while one company makes four-row ones. The machines, with the exception of the small gasoline engines, are entirely manufactured locally. Besides transplanting, about 15,000 ha of paddy fields were directly seeded with some 3,200 locally developed seeders in 1976. They are manually pulled and simple in construction. A six-row seeder costs only US$34.

Several kinds of planters for dryland crops have been imported or locally developed for demonstration purposes. Among them is a local-made peanut planter that is equipped with a belt-type seed metering device and has shown promising results in field tests.

Water pump

After World War II, local manufacturers turned out about 2,000 pumps annually to meet local requirements. At present, an estimated 123,000 units, including deep-well pumps, are owned by farmers for irrigation purposes (Table 1). Now more than a dozen local manufacturers are producing water pumps for local use and export.

Sprayer

In 1976, about 215,000 sprayers, 15,000 hand dusters, and some 37,000 power-driven sprayers and dusters were owned by local farmers (Table 1). All the hand sprayers and dusters were locally made. Some power-driven units have been imported.

Harvesting machine

In 1970, a number of small Japanese-made rice combines consisting of a reaper and an ordinary automatic power thresher were introduced for testing. So far some 2,000 small combines have been imported and there are three local manufacturers ready for production of two- or three-row machines. There are, however, still some shortcomings with these machines.

Grain dryer

Up to the present about 7,700 flatbed-type dryers have been extended to local farmers for adoption. Meanwhile, some 1,600 units of circulation-type dryers of locally made ones were also adopted by farmers as shown in Table 1. About a dozen local farm machine shops are producing these dryers. Several farmers' association and some concerned agencies have also constructed bigger dryers for commercial purposes.

POLICIES RELATING TO MECHANIZATION

Improvement of the environment for farm mechanization

Land consolidation. Under the government program of land consolidation in recent years, about 300,000 ha of small paddy fields have been consolidated.

Joint organization for mechanized farming. As the number of part-time farmers has increased, government agencies have encouraged farmers to organize themselves for joint operations to facilitate efficient use of modem techniques and machinery.

Development of contract work. Since 1970, the Provincial Food Bureau (PFB) has been Subsidizing township farmers' associations for the organization of mechanized farming service teams. The teams do contract work for farmers in the respective

townships with the use of power tillers. Up to the present, 310 such teams have been organized.

Setting up nursery centers. A supply of healthy seedlings is essential to the extension of mechanized rice transplanting. The government is now subsidizing those who set up cooperative nursery centers able to supply enough seedlings for about 100 ha. So far, 230 centers have been developed.

Providing farm machinery purchase loans and subsidies

The PFB, the Bank of Taiwan, the Provincial Cooperative Bank, and the Farmers Bank of China have all established agricultural machinery purchasing loan programs over the past decade. All loan agencies have lowered interest rates on machinery loans over the years. The present interest rate is 8.5% per year.

On the other hand, a subsidy of NT$5,000 (US$131) was granted each farmer who bought a power tiller during the period of 1970-71. Under the Program for Accelerating Rural and Agricultural Development announced by the government in September 1972, a farmer or farmers' organization is to be subsidized at 10-20% for purchase of such items as tractors, combines, rice transplanters, power sprayers, and dryers. And at present, machines eligible for this kind of subsidy must be locally made.

Training of farmers and technicians

In the first 5 years of power tiller extension, or 15 years ago, 940 government officials and extension workers attended classes lasting from 1 week to 1 month, depending on the nature of the training. As a measure to extend new machines, thousands of agricultural workers and farmers were trained during 1971-76.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Strengthening research

To expedite the extension of mechanized farming in Taiwan, research and development of farm machinery has been actively promoted. Emphasis is on modification and improvement of existing machines and the design of new ones to suit farming conditions in Taiwan. This has been the approach since 1957.

Evaluation of farm machinery

To ensure that farm machines purchased by individual farmers are of good quality, the government thoroughly inspects and tests in the field before it is put on the market. All new models are tested in a 20-ha field to check performance and durability. Only farmers who buy machines that have satisfactorily passed these inspections may apply for low-interest loans and subsidies.

Rural repair service

In 1966, as a new attempt to expedite the agricultural mechanization program in Taiwan, a network of Agricultural Mechanization Promotion Centers (AMPC) was established at principal townships by the government and farmers' associations concerned. One of their main functions is to maintain and repair farm machines owned by individual farmers. So far, 43 AMPCs have been established.

FUTURE DIRECTIONS

The program for promotion of mechanized farming, initiated by JCRR in 1954 to increase land productivity and save farm labor, has been progressing steadily. Plans have been made to accelerate extension of various kinds of farm machines to offset the labor shortage that is being increasingly felt in areas close to industrial towns.

However, a number of new problems such as wage increases, decline of farm land price, and a decrease in the cropping index, together with such old problems as small farm size and low purchasing power of the farmers, have greatly hindered farm mechanization as well as agricultural modernization in Taiwan. To cope with these problems and to raise farm income, farm mechanization has been given first priority among the various development measured programmed under the nation's new agricultural policy. Measures to be taken are:

1. Consolidate an additional 100,000 ha of paddy fields to facilitate farm mechanization.

2. Provide sufficient loans and subsidies for farmers to purchase additional farm machines.

3. Set up an Agricultural Mechanization Research and Development Center to strengthen research work.

4. Intensify farmers' training through strengthening of Agricultural Vocational Training Centers.

5. Promote the growth of the local farm machinery industry by, helping it produce more and better machines and provide good after-sale service.

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STATUS OF AGRICULTURAL MECHANIZATION IN EGYPT

AHMED BAHGAT
CONSULTANT, AGRICULTURAL MECHANIZATION
FORD FOUNDATION
P. O. BOX 2344, CAIRO. EGYPT

SUMMARY

Egypt has an intensive and productive agriculture that is endowed with a favorable climate, fertile soils, and adequate irrigation water. Modern mechanization has been largely ignored for such social-political reasons as small holdings, surplus labor, land reform, and inefficient government-supported mechanization services. Since 1973 there has been an awakening to improve farming operations through various levels of mechanization but to date no definite policy has been established.

INTRODUCTION

Agriculture in Egypt is almost exclusively confined to the narrow irrigated Nile River Valley and the similarly fan-shaped irrigated delta. This small area (2.33 million ha) supports an agricultural economy that employs nearly 60% of the population and provides 88% of the foreign exchange earnings for a nation of 38 million people.

Cropping intensity is high (1.92) and yields, because of fertile soils, adequate irrigation water, and moderate climate, are equally high. The principal crops are cotton (700,000 ha), wheat (562,000 ha), rice (473,000 ha), maize (636,000 ha), sorghum (206,000 ha), fruits and vegetables (215,000 ha), and berseem clover (1,155,000 ha). The clover is forage for some 9 million head of livestock. Nearly 95% of the farm holdings are less than 2 ha. There are nearly 3 million farmers plus another 1 million landless farm laborers.

Scientific and institutional support in agriculture is high. Eleven faculties of agriculture provide 4,500 agricultural graduates each year. There are also 11 poorly equipped and supported major experiment stations staffed with over 3,000 graduate scientists. Over 4,000 government cooperative outlets supply inputs, procure farm production, and attempt to supply agricultural services. There is an extensive rural credit bank that makes low interest, short- and medium-term loans. It has had a consistently bad repayment record.

The irrigation system annually supplies 19,000 m^3 of water for each hectare throughout the year. Largely as a result of poor irrigation, over 526,000 ha are either tile drained or will have to be by 1980, and more than 1,260,000 ha are served with open drains that either return to the Nile or are pumped to the sea.

The agricultural sector has essentially financed the development of an industrial sector in Egypt. Farm gate prices for rice, cotton, wheat, and maize were all well under world market prices. The government procures 66% of all paddy production at $63/t. The urban consumer can purchase milled rice at $84/t retail. On the other hand the government supplies to the agricultural sector free irrigation water, charges low or no land taxes, and heavily subsidizes fertilizers and insecticides. Average 1974 agricultural sector annual wage was $91; annual industrial wage was $416. The usual daily wage in rural areas would average $ .70 to $1.00.

CURRENT STATUS OF MECHANIZATION

Egypt has a 5000-yearhistory of agricultural cultivation. Yet many of the tools developed in those ancient times still predominate. The ox-drawnwooden plow, the sickle, the flail, and threshing under animal hooves can be found on nearly every farm. Modern farm mechanization has essentially by-passed Egyptian agriculture. Some of the reasons are:

1. Egypt has had a history of surplus labor in the form of slaves, serfs, and tenant farmers. This has resulted in a labor intensive agriculture that was not conducive to modernization but rather sought full employment of the ignorant and the poor.

2. Land holdings have remained small and laws and tradition have prevented the accumulation of large holdings that would support modern mechanization.

3. The agricultural sector has concentrated most on the labor-intensivecrops of cotton, rice, fruits, and vegetables. Until recently these crops have not had a competitive mechanized technology.

4. There is a cultural barrier-the educated and wealthy do no manual labor nor operate farm machinery. Hence, those who do the manual operations in agriculture have

neither the education nor finances to reduce their labor burden.

5. In recent years, the government's experiment in socialism stressed industrial expansion, cooperative farming, land reform, and a central planned agriculture directed toward the smallest farmers and the landless laborer. This discouraged those who had capital to invest in farm machinery, and the few tractors that were imported were earmarked for cooperatives.

Thus, the environment, population, and political situation have combined to restrict the degree of agricultural mechanization. There are only 25,000 tractors in Egypt, of which an estimated 18,000 are operational. Of those rated operational, perhaps 1,000–2,000 are used in the industrial and service sector. Over 4,000 are owned by the public sector and assigned to the cooperatives where management, labor, and lack of spare parts combine to reduce utilization to about one–half the normal operating efficiency.

Implements available for tractors have been extremely limited. The tine tiller or chisel plow and four–wheel trailer are the most common implements. The only exceptions are some 6,000 tractor–powered, belt–driven, throw–in-threshers and about the same number of belt–driven, low–lift pumps. There are essentially no planting, land levelling, cultivating, or harvesting implements.

Primary tillage, or the initial plowing for each crop, appears to be the highest priority of mechanization. Most of the other operations are done with draft animals or by hand.

Total agricultural power has been calculated as 26% from humans, 21% from animals, and 53% from tractors, engines, and electric motors. This is based upon a horsepower rating of a man at 0.006, an animal ranging from 0.3 for a buffalo to 0.6 for a mule or horse, and tractors rated at the drawbar, would average 35 hp each in Egypt.

Even though 53% of the total power used in agriculture comes from mechanical sources, a farmer presently supplies more than 260 days of hand labor and 35 days of animal power for each day of tractor use in Egypt.

Ten years ago land preparation was 55% mechanized, pumping 50% and threshing 20%. In addition, a majority of the plant protection spraying done by the public sector was mechanized, ranging from powered backpack sprayers to contract aerial spraying using foreign planes and pilots.

The degree of mechanization was assumed to have remained essentially constant until 1975 – 76. Then a large increase in tractor imports and a stimulation of the private manufacturers of agricultural implements reflected government policy to encourage mechanization. The government reduced the import duty and the quotas on tractor imports, ceased the sequestration of those private firms capable of locally producing machinery and implements, and stabilized land tenure-land reform so that landowners would begin to invest in mechanized farming.

LOCAL MANUFACTURE OF EQUIPMENT

Perhaps one of the greatest constraints to mechanization in Egypt is the lack of local fabricators. Concurrent with land reform in the 1952 Revolution, there was a program to sequester and nationalize the more successful and larger workshops. The emphasis of many of these workshops shifted from servicing the rural sector to providing equipment for national defense.

Traditional sources of farm machinery (USA and West Europe) were replaced by Romanian, Russian, Yugoslav, and, later, East German equipment that was obsolete, uneconomical, and, largely, one-time barter arrangements. With the shortage of spare parts, the public sector-owned tractor became inoperative pending importation of parts, But with the pressing need of the private equipment owners, a series of small machine shops and workshops began to make spare parts and provide repairs. These operations were small, primitive, and dispersed. Their products were not standardized and frequently very expensive.

In 1962, a public sector automotive manufacturing company (NASCO) began to assemble a 50 hp Yugoslav tractor. NASCO fabricated about 20% of the parts. Between 1962 and 1967 some 5,000 of these were assembled and sold locally. In 1967 the horsepower was increased to 56, the chassis lengthened, larger tires used, and another 3,500 were made before assembly stopped in 1970.

In 1970, arrangements were made to assemble in Egypt a 65 hp Romanian tractor which was of better quality. Some 6,000 have been assembled to date. To meet the demand for more tractors, a new contract was signed with Yugoslavia in 1975 to once again assemble another 1,500 of the 56 hp model that was discontinued in 1970.

Restrictions on importing tractors were relaxed in 1974, and in the past 3 years a frigtening range of tractor sizes and

Table 1. Sector distribution and size of tractors in Egypt-1974.

Engine hp	Private sector & cooperatives	Public sector	Total
35	4,434	997	5,431
36-50	10,507	1,352	11,859
51-70	4,845	4,108	8,953
71-100	146	186	332
Total	19,9322[a]	6,643[b]	26,575[c]

[a] Of this number about 4,000 are in cooperatives.

[b] Of this number about 4,000 are in land reclamation.

[c] An estimated 60% of total tractors are operable at any one time. Thus there are 155 ha cultivated and 293 ha cropped land for each operable tractor.

models have been imported by the private and public sector (see Table 1). An attempt to standardize tractor imports has not been too successful, but negotiations are under way to import using US loan funds, 2,400 Model 265, Massey-Fergusons, to sell to farmers through local credit sources.

One aspect of nontractor power which has received emphasis is plant protection services. A 1975 survey showed there were 1,000-30 hp sprayers, 13,000-6 hp sprayers, and 4,000-3 hp back .pack sprayers in addition to the 120,000 manually operated back pack sprayers. How many of these are operating is not known, but certainly the 6 hp petrol engines (mostly Wisconsin and Briggs and Stratton) are in great demand and a central facility for the repair and rebuilding of these engines is needed.

Low lift pumping of irrigation water is increasing. There were 54,000 small engine and electric portable pumps, 2,000 stationary h electric and diesel-powered pumps, and 6,000 tractor-powered pumps reported in 1974. During the past 10 years swll worksh ps have been able to copy centrifugal pumps in the 250 to 400 m^9Ihr capacity and are using locally manufactured electric motors or primitive diesel engines for power.

Locally manufactured electric motors are 3 phase, 220 V, 50 cycle with horsepower ratings from 3 to 12. Locally manufactured diesels are copies from a 30-year-old Deutz design and are slow-speed, water-cooled, and with horizontal cylinders in,the older

models. The horsepower range is from 6 to 16. The engine and pump are classified as portable because they are mounted on 25 cm steel wheels, but in reality are very difficult to move over fields or bunds. About 6,000 portable pump sets are sold each year, of which 70% of the pumps and 10-15% of the engines are manufactured locally.

There has been complete acceptance of a sheet metal, low-lift version of the Persian wheel for lifting irrigation water 1 to 2 m with animal power. Shafts and yokes are made from wood and, in some cases, the gears are also primitive intermeshing wooden pegs.

The capacity for local manufacturing of agricultural machinery has been difficult to measure because a majority of the facilities are diverse and small and owners are not anxious to become obvious because of sequestration and, more lately, taxation. The workshops frequently do nonagricultural and vehicle repair as well as manufacture agricultural machinery. The sales and service of agricultural machinery as well as stocking of spare parts is almost nonexistent. Most machinery is manufactured on individual order and frequently financed by a partial downpayment.

The Ministry of Agriculture has a few agricultural workshops for fabricating farm machinery, and each has some degree of specialization. One such workshop in Cairo manufactures spray pumps, another spray tanks, and a third assembles cotton sprayers. A fairly large facility outside of Alexandria manufactures threshers, pumps, chisel plows, trailers, and land levelers and has the production capacities and prices listed in Table 2. Such production capacity is estimated to be 10-15% of the country's capacity and prices would be more or less representative.

Persian wheels or "saqias" cost $253 to $332, depending on size and it would cost up to $1,059 to provide an electric motor-powered saqia. Small (6 hp) diesel-powered centrifugal pumps with a capacity of 100-120 cu m/h cost $1,020.

Cost calculations show that an animal-powered saqia costs $ .24 per horsepower-hour, diesel pumps $ .008, and an electric pump $ .02. This demonstrates the relatively high operational costs of animals to lift water with the efficiency of the saqia (40%) and the conversion of animal feed into power.

Diesel oil is presently subsidized at 75% of actual cost and the electrification network is expanding into rural areas and is expected to be completed in 1990. Thus, the long-run forecast would be for electric powered axial flow, low-lift pumping and the shorter term solution would be diesel pump sets, particularly if the local capacity to manufacture these units or some components could be increased.

Table 2. Production capacity and unit cost of selected implements from Behera Company.

Item	Description	Monthly capacity (units)	Unit cost US$
Thresher	360 – 450kg/h - belt drive (tractor or elec. motor)	50	658
Chisel plow	mounted 7-9 shanks, 20 cm depth	100	259
Chisel plow	trailed 9-11 shanks, 20 cm depth	100	994
Subsoiler	trailed - single shank w/mole, 65 cm depth	20	588
Ditcher	trailed - 200 cm width, 45 cm depth	20	490
Blade/leveler (small)	trailed - 2 m widths	40	595
Blade/leveler (large)	trailed - 4 m widths	30	1,050
Trailers	4-wheel, 2 x 4 m box 4 t capacity	25	1,540

POLICIES RELATING TO MECHANIZATION

The government farm mechanization policy within the framework of the current 5-year plan calls for:

1. acquiring the necessary number of tractors to replace man and animal power in the operations of land cultivation during the next 10 years at the rate of 3,500 tractors per year;

2. replacing primitive irrigation and drainage tools with mobile or stationary machines (elimination of saquias) and initiate use of rural electricity in at least two governorates;

3. provision of main workshops in five governorates for the maintenance and repair of farm machinery;

4. completion of training centers to provide a sufficient number of trained people to meet the operation, maintenance and repair needs for farm machinery; and

5. undertaking experimental and research work necessary for mechanizing cotton and sugar cane cultivation,

and mechanizing the harvest and threshing of grains, particularly rice.

The Farm Machinery Department of the Under-Secretaries of Engineering Offices, Ministry of Agriculture, is responsible for farm mechanization in Egypt. At the national level there are three units: 1) Investigation and Testing (staff of six engineers), 2) Service Planning and Maintenance (staff of four engineers), and 3) Supplies and Spares (staff of four engineers).

The department also has 56 engineers in the field with the primary responsibility of seeing that plant protection sprayers are operating or to serve as a relay in processing requests for the purchase and delivery of farm machinery. There is no staff or unit directly concerned with the on-farm use of machinery or to select, schedule, and establish rates for contract hiring of machinery. Standardization of equipment, based upon local testing and evaluation, has not been effected because tractor purchases have been largely barter arrangements and bilateral aid, reflecting political opportunities rather than rational decisions.

Mechanization during the 1950-70 period involved many private companies and foreign governments promoting mechanization and equipment sales without service, training, spare parts, or supervision. The large FMC sprinkler irrigation project, the Yugoslav tube well project, the Russian Mechanized Model Farms can all be judged failures because the residual equipment is inoperative, the lands developed are largely abandoned or only marginally productive, the trained staff has scattered, and several millions of dollars have been squandered.

There has been a justifiable reticence on the part of the Government of Egypt to enter into any additional large-scale mechanized development schemes that do not have a long-term management commitment and a sizable investment from the foreign country or company. Many investment schemes are pending that relate to the sale of advanced technologies ranging from drip irrigation to food processing and including several loans and grants to establish tractor rental services, tractor repair facilities, tractor training courses, electrification of on-farm pumping, tractor assembly plants, and direct donation of assembled tractors. Some of these have been politically difficult to refuse or delay.

There is a justifiable concern about displacing labor in the highly labor-intensive agriculture that exists in Egypt. There is an equal or even stronger concern that farm labor costs are increasing at a rate above normal inflation, reflecting actual labor shortages at specific seasons. There is some concern that

the limited tractor power is being controlled by a few and that those who controlled the land before land reform are now controlling agricultural power and credit.

Formation of over 4,000 service cooperatives that have at least one tractor for hire was a governmental attempt to break the monopoly of custom tractor operators. In reality, however, the operation of the cooperative tractors has been less than economical or efficient. The operator is a government employee who has a salary whether the tractor operates or not. Scheduling the tractor involves considerable transit time to and from the work site. The lack of spare parts and machines results in considerable down time. Opportunities for corruption, influence, and incompetence in a public sector tractor operation dealing with illiterate farmers are great.

The recent relaxation of custom duties on tractors and agricultural equipment has made it considerably easier to import tractors and parts back into Egypt for those who have foreign exchange resources abroad. Additional foreign exchange has been allocated by the Government of Egypt through the Ministry of Agriculture for the purchase of imported tractors and equipment. When the quota arrives a farmer can apply for a tractor by depositing 50% of the cost and paying the balance over one crop year. The quota is distributed by a lottery.

The domestic production of assembled tractors is distributed through potential buyers making a deposit and waiting on a list for the allocation. There are three ways to secure tractors:

1) individually purchase from abroad with foreign exchange,
2) subscribe a lottery of a quota of imported tractors, or
3) wait for a domestically assembled model.

RESEARCH, DEVELOPMENT, EVALUATION, AND EXTENSION

Presently, mechanization research is effectively nonexistent. Cairo and Alexandria University have essentially no funds for research, so their programs are largely limited to graduate student library-type projects.

Ford Foundation in conjunction with nine universities and the Ministry of Agriculture has undertaken a year-long survey of 900 farms in nine provinces. Part of this survey measures the labor, animal power, machinery inputs, costs, and benefits. For the first time a survey will assess farm production as a measure of energy utilization and identify labor and machinery requirements. Ford Foundation has also sponsored a program for developing small,

locally fabricated, multipurpose machinery designed to work with a 10 hp diesel engine. This concept has attracted joint participation by IDRC, Catholic Relief, and a local public sector workshop, Behera Company.

FUTURE DIRECTIONS

Considerable emphasis is being given to farm mechanization. The policy is to first assess the need, level, and social and economic costs of mechanization development with both imported and locally assembled tractors. There is also the option or concurrent alternative of developing smaller, locally fabricated farm machinery using a single power source for many farm operations.

Plans call for the formation of an agricultural mechanization institute with five components: 1) research and development, 2) testing and evaluation, 3) workshops, 4) training, and 5) extension. A blue ribbon committee has been designated by the Minister of Agriculture as the Supreme Council for Agricultural Mechanization. It consists of several chairmen of boards of public sector corporations involved in agricultural machinery fabrication, sales, service, and importing. Also on the Council are the Undersecretary of Engineering Affairs, Ministry of Agriculture, and Heads of Agriculture Engineering Departments of Cairo and Alexandria Universities.

A field testing station and workshop at Maryout, designed and operated by the German Democratic Republic, has been taken over by the Ministry of Agriculture as a field testing station and a farm machinery training facility. A laboratory in Sabaheya, specially designed for testing farm machinery by FAO, will be taken back from the Navy and become the research and development component as well as the engine and tractor laboratory testing facility. Located next to this facility are the Behera Company Workshops that have their own machine shops, foundry, sheet metal shops, and assembly lines. Also located nearby is a rice processing research and training center which will soon be directly involved in rice harvesting, drying, storage, handling, milling, and parboiling.

Seventeen mechanical and agricultural engineers are assigned to the test facility. It is hoped that some of these or others can be brought into research and training.

Ford Foundation has agreed to one more year of support in the development of 10 hp appropriate mechanization. The International Development Research Centre of Canada is processing a 2-year grant to provide intensive testing of this scale of

machinery. The United State Agency for International Development has agreed to a $1.1 million project over a 5-year period to develop a rice mechanization program in Egypt and is in the process of providing up to $40 million in assistance for agricultural mechanization.

The World Bank has written a feasibility report for a $23.4 million loan for establishing two mechanized pilot projects in Egypt. The Federal Republic of Germany has just granted 3 million D.M. for agricultural mechanization in Egypt. Deutz-GMbH has donated forty 10 hp diesel engines to support the Ford Foundation "Ten Horsepower Agricultural Mechanization Program." The Catholic Relief Program has secured a grant from Canadian Aid (CIDA) and is securing US PL-480 surplus currency (204) funds for the purchase of intermediate 10 hp machinery[a/] for secondary training schools and to provide loans for secondary school graduates to purchase the individual components of the 10 hp machinery.

[a/] 10 hp machinery presently consists of multicrop threshers, combination planter-drill, traction unit with trailer, 600-liter sprayer, and a low lift axial flow pump. Future plans call for improved models of the above plus rice transplanters, two-wheel tractors, village type rice and flour mills, and farm electrical generating units.

STATUS OF AGRICULTURAL MECHANIZATION IN PAKISTAN

M. TOAHA QURESHI
DIRECTOR OF RESEARCH (AE)
AGRICULTURAL RESEARCH COUNCILOF PAKISTAN

SUMMARY

During the past 20 years of planned development, significant structural changes have been brought about in the Pakistan economy. Agriculture remains the largest sector of the economy in terms of employment andincome.

Agriculture contributes 36.4% of the total Gross Domestic Product (GDP), provides employment for 75% of the rural population, and accounts for 75% of foreign exchange earnings. The agricultural sector, while supplying raw material for the bulk of domestic industry, also consumes 80% of its finished goods. Within the agricultural sector, cropping activities contributes 69% of the GDP, the livestock sector around 28%, and fisheries and forestry subsectors, 3%.

Agriculture in Pakistan has generally been land and labor oriented. It is passing through a transition from subsistence to commercial farming. It resulted from a combination of farming technologies: adoption of improved cultural practices, adjustments of economic crop rotations, better irrigation facilities, increased cropping intensities with the installation of tube wells, use of fertilizers, improved and high yielding varieties, plant protection measures, and use of tractors and improved implements.

Thus, gradual transformation of agriculture from subsistence to commercial has begun by accommodating technological changes in production.

Per capita food production has increased but at a slower rate than population growth. The rapidly increasing population creates a task for the nation to increase food and fiber production. This can only be achieved by extensive adoptation of technological innovations coupled with the use of farm machines in the production of crops. Future progress in agriculture

depends more on raising per acre productivity than on expansion of area under cultivation because of limited land and water resources.

TYPES OF FARMING AND MAJOR CROPS

A good climate and a network of irrigation canals make Pakistan well suited to greatly expanded agricultural production. Crops are grown throughout the year. Mixed farming predominates. Major crops in terms of cropped area are wheat, cotton, rice, gram, sorghum and millets, sugar cane, oilseeds, and fodder crops. Various tropical and temperate fruits are grown over extensive areas.

Both wheat and rice are staple food crops consumed in the country. Wheat is grown during rabi (winter) and cotton in kharif (summer). Sugar cane competes with other crops in both rabi and kharif. On an average, 18.2 million ha are cropped annually in Pakistan, out of which 7.9 million ha are sown in kharif and 1.0 million ha cultivated in rabi. Nearly 80% of the cropped acreage -- 14.0 million ha -- receive irrigation water and about 3.5 million ha are cultivated in rainfed and riverine areas.

HECTARAGE AND PRODUCTION OF CROPS

Agricultural production during 1969-70 surpassed all previous records and can be favorably compared with that of 1959-60 when "the green revolution" took place in the country. The area as well as production of major crops has increased immensely.

An increase in production by 141% for rice, 84% for cotton, 147% for sugar cane, and 187% for wheat has been recorded during 1969-70 over the base period 1959-60. The increase in acreage under these crops was 35% for rice, 31% for cotton, 56% for sugar cane, and 28% for wheat. The increase in production during 1974-75 has been 132% for rice, 111% for cotton, 100% for sugar cane, and 96% for wheat over the production of these crops during 1959-60. The area devoted to these crops during 1974-75 also increased by 33% for rice, 53% for cotton, 69% for sugar cane, and 19% for wheat as compared with 1959-60. The indices for area and production of rice, cotton, sugar cane, and wheat crops calculated by assuming 1959-60 as base period are indicated in Table 1.

Cropping intensities

More than one crop per year can be grown in nearly all agricultural regions of Pakistan when sufficient rainfall or

Table 1. Indices of changes in area and production of major crops grown in Pakistan during 1959-60 to 1972-73 (Base period: 1959-60 = 100).

Crop Year	Rice		Cotton		Sugar cane		Wheat	
	Area	Production	Area	Production	Area	Production	Area	Production
1959-60	100	100	100	100	100	100	100	100
1960-61	89	104	96	103	98	110	95	98
1961-62	101	113	104	111	112	135	101	103
1962-63	99	110	102	126	134	173	103	107
1963-64	107	120	110	144	120	151	103	106
1964-65	113	135	109	136	127	175	109	117
1965-66	116	132	116	142	151	209	107	100
1966-67	117	137	119	158	164	206	110	111
1967-68	118	151	128	177	127	175	123	164
1968-69	129	204	130	181	136	206	126	169
1969-70	135	241	130	184	156	247	128	187
1970-71	125	221	129	186	160	217	123	166
1971-72	122	222	146	243	152	202	121	176
1972-73	123	234	150	241	134	187	122	190
1973-74	127	287	137	219	162	224	125	195
1974-75	133	232	153	211	169	200	119	196

Source: Government of Pakistan, Year Book of Agricultural Statistics.

Table 2. Area cropped, cropping intensity, and extent of machine use on farms in Pakistan

Farm holdings in ha	Total area cropped kharif & rabi (%)	Average cropping intensity	% using tube wells & low lift pumps	% using tractors
All holdings	84	111	28	18
Under 20	94	114	27	17
Under 0.4	113	152	16	17
0.4 to 2	105	132	21	17
2 to 5	103	121	26	14
5 to 10	93	111	33	18
10 to 20	80	103	41	26
20 to 60	63	97	45	38
Over 60	37	88	38	44

Source: Pakistan Basic Economic Report, September 24, 1976.

irrigation water is available. Overall cropping intensity in Pakistan is 111%; it is highest (139%) on small farms. It progressively declines with increased farm size and is only 88% on farms larger than 60 ha. Irrigation water is considered essential to increase the area under crops, although certain studies reveal that with proper and efficient use of present water resources, the area under crops can be increased with the help of added draft power. It is very much true in an area of high rainfall and in areas where subsoil water is suitable for irrigation purposes. In these areas if sufficient draft power is available, the cropping intensity can be increased. On farms where sufficient draft power is available, the cropping intensity has gone up to 200% as compared to only 100.2% intensity on the farms with insufficient draft power. Table 2 shows the cropping intensity and extent of machine use on farms.

Land use

Only 24% of the total geographical area of Pakistan is cultivated; 3% is in forest, pastures, and range; and 14% is

classified as culturable waste land. There are many reasons for the noncultivation of such lands, the most critical being lack of water. Improved utilization of water supplied would enable the existing cultivated area to be more intensively cropped. The situation is rapidly changing due to the application of fertilizers and utilization of ground water resources. Future increases in cropped acreage are expected to be achieved largely as a result of increased water supply and cropping intensities in areas already served by canals.

The availability of irrigation water from both surface and ground sources was 11.9 million ha meters during 1974-75. The area sown during the same year under irrigated conditions was 13.0 million ha, out of which 6.16 million ha were cropped in kharif season and 6.85 million ha were sown in rabi season. The rainfed area under cultivation was 3.45 million ha during 1974-75. Out of this, 1.14 million ha were cultivated in the kharif season and 2.31 million ha were cropped in the rabi season. The overall area cropped during 1974-75 showed an increase of 3% over 1969-79.

Size of land holdings

The average cultivated area per agricultural worker is so small that most are operating below the subsistence level. This situation leaves farmers without resources or incentives to adopt measures to improve crop yields. In comparison with world standards, the structure of land holdings in Pakistan is considered small. About 68% of farmers possessing 30% of the farm area hold less than 5.06 ha each. Eighty-nine percent of the holdings are less than 10.13 ha and 97% are less than 20.25 ha. Holdings of less than 20.26 ha each constitute 76% of the farm area. The average farm size in Pakistan is 5.27 ha. Farms below 3.04 ha constitute 12% of the total farm area and 45% of the farms are between 3.04 and 10.13 ha. Table 3 indicates numbers and area of farms classified according to operational farm size in Pakistan.

Land tenure

The system of land tenure delineates the legal and customary relationship between land, the cultivator, and parties involved and interested in land. Land tenure determines the size of the ownership and cultivation unit and indirectly affects the technique6 of farming. Broadly, there are three kinds of tenural classes on farms in Pakistan: 1) noncultivator owners, 2)nonowner cultivators, and 3) owner cultivators or peasant-proprietors. Out of 3.7 million farms in Pakistan, 42% are operated by individuals who both own and rent land. Farmers who own land form the

Table 3. Number and area of farms classified according to operational farm size in Pakistan, 1972.

Farm size in ha	No. of farms (000)	Av. farm size (ha)	No. of farms %
Upto 3	1,639.0	1.5	44
3 to 5	920.0	3.9	24
5 to 10	793.9	6.7	21
10 to 20	289.2	12.9	8
20 to 60	102.6	29.2	3
Above 60	16.2	112.3	+
	3,761.7	166.5	100

Source: Government of Pakistan, 1972, Pakistan Census of Agriculture, Ministry of Agriculture (Provincial Data).

heaviest concentration on the holdings up to 3 to 10 ha category. Farmers who operate rented lands constitute 34%. Table 4 shows farms according to land tenure during 1972.

Land reform

Through the reforms of 1972, land ownership was reduced to 60.73 ha irrigated or 121.46 ha unirrigated from 202.43 ha irrigated or 404.86 ha unirrigated. The resumed lands were distributed among landless tenants or those who possessed lands below subsistence holdings. In January 5, 1977, the ceiling of ownership of lands was reduced to 41 ha irrigated or 82 ha unirrigated. The resumed lands once again were distributed among landless tenants or those who possessed land below subsistence holding.

The implementation of land reforms has idcreased the number of land owners in the agrarian society. The average size of holding is about 5.27 ha, 90% of the farms in the country are below 20.26 ha. These farms need small tractors and implements available at a modest price. This situation creates a task for agricultural engineers to design machines and implements for small holdings. The situation is also conducive for the import or manufacture locally of small and low horsepower tractors, which may consume less fuel with maximum output. These machines suit the needs of a major of Pakistan's farms.

Table 4. Farms according to land tenure in Pakistan, 1972.

Farm size in ha	Owners	Owner-cum-tenants	Tenants	Total
up to 3	54	16	30	100
3 to 5	28	26	46	100
5 to 10	31	32	37	100
10 to 20	38	34	28	100
20 to 60	49	35	16	100
Above 60	63	28	9	100
Total farms	1,569,000	897,000	1,296,000	3,762,000
Percent	42	24	34	100

Source: Government of Pakistan, 1972
Pakistan Census of Agriculture
Ministry of Agriculture
(Provincial data)

AGRICULTURAL LABOR USE

Agricultural labor engaged for at least 6 months continuously is called permanent and casual laborers are those engaged and paid daily. A special category is seasonal labor, temporarily employed for specific agricultural operations such as harvesting, cotton picking, transplanting of rice, and weeding. Such labor is usually migratory. Normally the daily wage rate for casual labor appears to be higher than that of permanent labor. It is due to seasonal operations when there is an increased demand under a specific time limit. Casual labor is often unemployed for long periods during the slack season and if work is available during such season the wages are low. Wages vary with the degree of skill required in work, proximity to urban centers, intensity of cultivation, size of crop, and mobility of labor. Payment in kind is not uncommon for all types of labor.

A survey conducted during 1971-72 reveals that female labor participation in rural areas is higher than in urban areas.

Table 5. Composition of agricultural labor force according to farm size during 1972.

Farm Size	Total farm labor (000)	Composition of Labor			
		Family worker (10 yrs or above)		Permanent hired labor	
		No. (000)	%	No. (000)	%
1	2	3	4	5	6
up to 3	3,995	3,946	95	49	1
3 to 5	2,826	2,771	98	55	2
5 to 10	2,971	2,866	96	105	4
10 to 20	1,375	1,273	93	103	7
20 to 60	594	490	82	104	18
Above 60	124	72	58	52	42
Total:	11,887	11,417	96	490	4

Source: Government of Pakistan, Pakistan Census of Agriculture, 1972.

Female participation is about 10% while male labor participation is 81.6%. Though it is difficult to categorize, in the case of family farms, who is in the labor force and to what extent, generally women and girls participate in the harvest and assist in the care of animals. Table 5 shows the structure of the agricultural labor force according to farm size in Pakistan during 1972-73.

On small farms the bulk of labor input is contributed from family sources. But more than 50% of those classified as farmer-operators are tenants or part-tenants. There is always an acute labor shortage during peak work-load days.

LEVEL OF MECHANIZATION TECHNOLOGY

In Pakistan, increased tractor use has been criticized as a labor displacing factor. But tractors have definite advantages. They are mainly used for field operations and also for transportation. Presently, the tractor work on farms is not properly organized.

Farmers use tractors mostly to handle urgent farm operations. Only plowing and leveling are usually planned before each season. Tractor use is extensive in double cropping where the same piece of land is to be utilized within a short time. Tractors also provide power to run heavy, improved implements and help carry out deep tillage that regenerates soil fertility and increases yields.

Tractor use accelerates land preparation and harvesting operations, facilitates multiple cropping, and increases labor productivity and employment. Use of tractors no doubt displaces labor but only for certain operations. Mechanization increases employment opportunities due to the increased cropping intensities, higher yields, and changes in cropping patterns. Tractors provide much cheaper draft power than is available from animal sources.

The tractor population was about 35,716 in 1973. Most were in the 45 to 55 hp range. Baylaras (Russian) and Massey Ferguson (British) dominate in numbers with 33% and 24% of the total respectively during the same year.

About 30 different makes and models of tractors were in use prior to 1957. Tractor standardization was enforced in 1958. The list of standardized tractors, which included seven makes initially was reduced to four types in 1961. It has gradually expanded to include 10 makes of tractors with 16 models in 1977. The Farm Mechanization Committee report recommended 10 makes of tractors with one model each in the range of 45 to 65 hp be kept on the standardized list. Current plans recommend the manufacture of tractors in the country under the auspices of the Pakistan Tractor Corporation.

Bullock and tractor farming

The demand for tractor power in agriculture is highly seasonal and primarily to meet peak labor requirements. The demand also depends on the motivation to approach, as nearly as possible, the productive potential of land which is determined by the economics of concentrating farm power on a given acreage. The prevailing pattern of mechanization in the country has been that of replacing about half the bullocks on farms and restricting the on-farm use of tractors to seedbed preparation. Farmers in general do not envisage the displacement of manual labor by machines because present wage rates favor use of manual labor for operations such as weeding, application of fertilizers, pesticides, and harvesting. The partial tractorization pattern appears to be stable.

Importance of farm mechanization

It is widely accepted that mechanization is an essential element for increasing production. Experts claim there are three

major factors responsible for obtaining increased crop production. One is the use of better farm equipment, a second is the introduction Of high yielding varieties and use of chemicals, third is the expanded use of irrigation water.

In Pakistan per acre yields are still low compared to countries using machines. The United States and Japan average rice yields of over 5 t/ha while the average per hectare yield of rice was 2.2 t/ha in Pakistan during a good crop year like 1971.

Since Pakistan's overall economic development is closely linked with growth in the agricultural sector, it appears a reasonable increase in crop production could he achieved by popularizing mechanized cultivation.

Small farms and the process of mechanization

During the last 10 years new technologies introduced in the country have played a primary role in the growth of agriculture. These are: 1) adoption of high yielding varieties and use of fertilizers, 2) development on a large scale of private tube wells, and 3) gradual introduction of mechanization. Since only owners of large and medium farms had the resources to support the improved technology, the resulting benefits have been unevenly distributed among the farming community. It is essential to establish an institutional framework to assure small farmers the same access to a high productivity agricultural system.

Effect of labor market on mechanization

Labor is becoming increasingly scarce, especially in peak work load seasons. During the harvesting season, labor demand increases everywhere. Due to high demand, wages rise sharply. Income earned during these periods is of great social importance to various categories of wage earners participating in the harvest, which includes migrant labor from the deserts and hilly areas. Wages are frequently paid in kind providing a built in safeguard to meet basic food requirements. This sytem is a part of an accepted social pattern and even those farmers who have a mechanized range of operations show little interest in mechanizing the harvesting operations other than threshing.

Farmers can no longer afford to pay the increasing costs of hired labor. It is in this light that farm mechanization has to be evaluated. The process of mechanization, in combination with other technologies constitutes an important aspect of the development process. Introduction of tractors and machines coupled with expansion in tube wells has caused no apparent reduction in the number of small farmers, nor has it displaced

much labor. Farms under 3.04 ha comprised 44% of the total farms during the year 1972. These farms had only 13% of the tube wells and 3% of tractors, though the use of tractors was high. Farms over 10.13 ha constituted only 11% of the total number, have 46% of the tube wells and 77% of the tractors. It can be assumed that besides quality of work, farm mechanization must have taken place due to labor shortages rather than to displace labor.

THE EMERGING FARM MACHINERY INDUSTRY

The Pakistan Tractor Corporation came into existence in October 1972. It is a limited company and all shares are owned by the Government. The main objective in creating this corporation was to make Pakistan self-sufficient on a long-term basis in the manufacture of 40 to 50 hp tractors. Plans are still in the formative stage. No substantial efforts have yet been made to design and manufacture farm machinery for small farmers which are tailored to specific crop and soil requirements. The plan is to produce initially, Massey Ferguson tractors.

At a recent Tractor Review Committee meeting, it was decided to import 15,000 tractors during the current financial year. Seventy-three million dollars has been allocated for this purpose. In addition, US$5 million has been allocated to import power tillers, rice transplanters, and other agricultural implements.

During the last decade, use of tractors and agricultural machines has been increased. The most common factors responsible are 1) lack of skilled agricultural labor during peak work-load days, 2) the short time interval available for sowing and harvesting operations which usually overlap for many rabi and kharif cropping patterns, and 3) more efficient performance of operations performed by tractors and improved implements which are not possible using bullocks and indigenous implements.

Yet, mechanization on general farms is still in transition because of many deterrents. Problems include the small and fragmented land holdings, lack of designs and manufacturing capacity in the country, lack of desired spare parts, absence of repair and service facilities in the rural areas, nonavailability of financing for farmers, paucity of technical services, high prices of farm machinery, and lack of research in agricultural engineering, particularly for standardization of tractors and implements for Pakistan soil and crop conditions. Use of agricultural machines on large farms is also restricted due to the nonavailability of appropriate size tractors, wear and tear in case of inappropriate implements, and the large numbers of share-croppers owning bullock power.