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Mechanization of Small-Scale Peasant Farming

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Few countries in the world can match the accomplishments of Japan in small-farm mechanization. How relevant is this Japanese experience to the problems of small-scale farmers elsewhere in the world, and especially in other parts of Asia?

Japan's mechanization occurred in a setting unlike that of most other Asian countries. Nonfarm employment opportunities were growing steadily, even in rural areas, and labor was a scarce commodity. Today most Japanese farm families look to off-farm sources for a large share of their income.

Japan shares one goal, however, with every other Asian country—that of making each unit of land produce as much as possible. Japan's particular emphasis on rice as a staple crop may also offer some technological perspectives.

Mechanization of small-scale agriculture is something that must be examined seriously if the world is to deal with one of the most critical problems it will face in the next two decades; the lot of the disadvantaged rural poor. Are there steps in mechanization that can help the rural poor time their cropping operations more effectively, so as to increase production? What possibilities does mechanization offer for energy saving? Are there technologies that can make land more productive? Not least important, are there ways that mechanization can, without raising costs or reducing productivity, make the day's labor easier for the farming family?

These were the kinds of questions addressed, in at least a preliminary way, at the *Seminar on Mechanization of Small-Scale Peasant Farming* held in Sapporo, Japan, from July 7 to 10, 1980, under the joint auspices of the Agricultural Development Council (A/D/C), the Japan Center for International Exchange (JCIE), and Hokkaido University.

The seminar's primary goal was to explore the resources and constraints faced by the rural poor, the ways mechanization might release some of these constraints, and the policy steps governments must consider taking in order to improve the quality of life of their rural populations. Japan was chosen as the site for the seminar for two reasons. First, it was felt that data on the generally highly successful Japanese experience in small-farm mechanization, both achievements and errors, could benefit other Asian countries as they begin to mechanize their agricultural sectors for increased food production. Second, it was believed that Japanese professionals—who continue to wrestle with such difficulties as how to increase farm size and the scale of mechanization—can learn from the experience of newcomers to the farm mechanization undertaking.

In addition, it was the purpose of the seminar to put Asian professionals, particularly younger people, in touch with one another and to establish communication links between the people who are shaping agricultural policy in Japan and persons in similar positions in other countries. All of the seminar participants—economists as well as several engineers and other technical specialists—were people concerned with the problems of mechanization. They came from seven Asian countries as well as from Japan and the United States and included representatives of the International Rice Research Institute (IRRI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

A field trip on July 7, organized jointly by Hokkaido University and the Hokkaido Central Prefectural Agricultural Experiment Station, showed the extent, effects, and implications of mechanization in this region of northern Japan. Seminar participants visited a land improvement project, wheat/barley/rice drying and preparing facilities, an onion farm, a multicrop laboratory farm, and a dairy farm. It was evident that mechanization is almost complete in Japan, and that government subsidies have played an immense role in the process. The Japanese experience in mechanization was described in six papers presented on the first day of the seminar. On the second day, seven participants elaborated the situation and needs elsewhere in Asia, and these presentations were supplemented by a report, by a representative of IRRI on external assistance. The third day of the seminar was devoted to follow-up discussions and to the examination both of studies that are currently under way and of plans for other, future studies.

The discussions focused on a number of important issues: the problems of adapting to differing local conditions, energy saving, livestock mechanization, economic and social implications, labor displacement, choice among types and strategies of mechanization, and the need for international and interdisciplinary exchange of information. The urgency of increasing land productivity, probably the most crucial issue of all, permeated every discussion throughout the seminar. There was agreement as to both the desirability and the feasibility of translation the Japanese experi-

ence into a model with relevance for contemporary Asian peasant farming.

THE JAPANESE EXPERIENCE

Highlights of Japanese Presentations

Keizo Tsuchiya reported that in small-scale Japanese agriculture between 1955 and 1966, mechanization helped reduce costs per unit of rice produced. Mechanization did not however, greatly increase farm-labor productivity. Increasing labor productivity requires an increase in the scale of farming and an accompanying increase in the scale of mechanization, from small to medium or large. It will be a long time before larger-scale mechanization will be widespread because it often requires costly land-improvement measures. In addition, large-scale mechanization sometimes results in lower, or at least less consistent yields. A further complicating factor is that large-scale mechanization is most useful at the times of planting and harvesting, when the pressure of work is great. It is often difficult for farmers to do the careful planning necessary for the efficient use of machines and timely completion of farm work.

There are as yet few combines of ordinary types in Japan, but medium-sized rice planters and combine auto-threshers are widely used. Thus Japan, fully mechanized and modern in its use of medium-scale farm machinery, still has its share of problems in using large-scale machinery. The number of cooperative groups for joint use of agricultural machines has been increasing.

Osamu Kitani explained that farm mechanization in Japan began with improvement of traditional equipment (local rural inventions). This was followed by the transfer of some designs from abroad, and finally by local modifications of foreign farm machines and mass production for better quality and prices. Government has played a vital role in this whole mechanization process.

Energy represents the major future constraint to mechanization. Measures to relieve dependence on petroleum deserve high priority attention.

Hiroyuki Nishimura pointed out that farm mechanization grew rapidly in post-war Japan because of the need to cope with the diminishing labor force. The pioneers of the Japanese machinery industry at the end of the last century were the carpenters and smiths of farm villages.

By 1976 there were 425 farm machinery manufacturers, but the biggest four dominated the market. These four manufacturers produced up to 40% of all power cultivators and 70% to 90% of tractors, transplanters, and combines. They have captured the advantage of mass production as the market has enlarged, and they have put great effort into research and development as well as sales promotion.

They are also keenly aware that after-services are of great importance to farmers. Prompt and courteous repair and maintenance of machinery are needed. The fact that concentrated markets may be necessary for the required level of after-service raises the question of how to achieve a high level of mechanization in areas of dispersed farming.

Yoshiharu Kubo told how in the Tokachi Plain, a newly developed region in Japan that produces field crops and supports a dairy industry, farm mechanization has simplified cropping systems, increased yields per hectare as well as labor efficiency, and enlarged farm size. On dairy farms, mechanization has permitted specialization and enlargement of scale.

Mechanization has also demonstrated the capacity of farmers themselves to modify institutions and practices, where necessary, to make use of new technology. For example, joint-use systems made some kinds of mechanization possible in the region. Moreover, today's joint-use systems are vastly different from those originally set up. Farmers have made continuous rational modifications to facilitate mechanization and to accomplish other goals of their family enterprises.

Zyuro Kudo described dramatic changes in mechanization of rice harvesting that have occurred in the Saga Plain, a highly mechanized, traditional rice region of Japan. To focus on the process of introducing a particular machine may result in failure to consider the advantages of using that machine as compared with some other way of doing a given job. (It will often be useful in mechanization research to keep the foregoing in mind.)

There are three patterns of utilization in rice harvesting on the Saga Plain: binder, reaper, and combine. The binder pattern is the least economical, but it is suitable to the smallest-size operation. The combine pattern is the most economical, but it is well suited only to the largest-size operations. Use of the combine has been facilitated by local design modifications to meet local conditions, by new grain varieties better suited to mechanization, and other land improvements.

Farm mechanization has been stimulated by the strong demand for labor in other industries; as the latter have drawn workers from the land they have raised fixed-wage rates. Farm mechanization in Japan has thus been motivated by a complex mixture of urban "pull" and rural "push."

Toshio Kuroyanagi reported on an inquiry into such governmentally funded programs as those of land consolidation, drainage and irrigation, and government loans have influenced the course of mechanization. An econometric analysis suggests that land consolidation programs stimulated mechanization the

most but also often encouraged farmers to become overextended and failed to help increase their income. Drainage-irrigation programs seemed to stimulate mechanization only marginally. (The favorable effect of the latter programs on net income was substantial, however, and seminar participants noted the importance of a rising net income in permitting farmers to mechanize.)

Discussion

Questions and comments centered around the issues of the effects of mechanization on output and the reorganization of farming systems. The crucial role of government subsidies was noted, and the level of research and investment by the public sector was discussed. The role of the nonfarm sector in promoting mechanization was stressed, as was the demonstrated usefulness of machinery cooperatives in disseminating machines.

Ways in which the Japanese setting differs from many other parts of Asia were outlined. Japanese farmers, and the Japanese economy as a whole, could afford mechanization for they did not have to fear it as a threat to the employment of farm laborers. The opportunity costs of labor have been high. Government policy has been used to change cropping patterns (in the process, distorting the pricing system). Finally, farmers are powerful enough politically to make their demands heard. The last factor is in particularly sharp contrast to the situation in other Asian countries, where decisions are usually made by an urban elite. Moreover, policy makers in the rest of Asia have to deal with political instability, and they know that riots occur in cities rather than in rural sectors. This fact partially explains the heavy food subsidies for urban centers.

Other Asian participants would have welcomed significant evidence that farm mechanization in Japan (particularly small-scale and medium-scale mechanization) has resulted in increased production. In general they felt that such an outcome would be required to justify full-scale mechanization in their countries even if it is not necessary in Japan, where 87% of farm households are part-time farmers. A U.S. participant pointed out that since mechanization reorganizes the relationship between land, labor, and capital, the question of output versus reorganization would become a policy matter. It was considered encouraging that in Japan, where farmers played a role in mechanization decisions, machines for small farms could be developed, whereas in the U.S. mechanization tended to expand the farm scale.

Asian participants were also interested in learning about the impact of mechanization on land productivity in the Japanese context. In countries with a high man/land ratio—where labor is cheap but land is costly—it is essential that any kind of mechanization lead to greater land productivity. As yet, unfortunately, we have only conflicting and impressionistic data on the effectiveness of tractor mechanization in increasing land productivity.

SITUATION AND NEEDS IN OTHER ASIAN COUNTRIES

Highlights of Presentations by Other Asian Participants

Young Ku Shim (Korea) pointed out that the high responsiveness of farming to changes in price relationships must be taken into consideration in planning mechanization. In the Korean context, it was a decrease in number and quality of farm workers and an increase in farm wages as well as the land factor that necessitated higher productivity and hence the use of machines.

Constraints to mechanization in Korea are climatic conditions, the uneven demand for labor, land limitations, low farm income, changing cropping patterns, underdeveloped manufacturing technology, the small number of farmers trained to operate machines, and the limited availability of institutional loans. Among the forces available to overcome these constraints are group farming, cheaper operating cost of machines, increased institutional loans, development of upland farming machines, land consolidation, and a supply of good machines. The Korean experience shows that when real wages are increasing, there is a case for mechanization.

Le Xiumei (China) noted that despite the differences in countries' social and economic systems, many important conclusions about mechanization can be applied internationally. In a large country, local variations in climate, cropping practice, and tillage—even economic and social settings—are usually so great that farm machinery must be developed to suit regional, not national, mechanization plans. Ways must be found to capitalize on what is available locally, to develop regional initiatives, and to design machines that suit each region's conditions.

In rice production, the need for timeliness of field operations is a strong force for greater mechanization. Grain dryers that use local energy resources are being developed, and energy economies through methane and hydroelectric power sources are being sought. If development of industry occurs simultaneously with release of the farm labor force by labor-saving equipment, the whole economy benefits.

Ahmad Mahdzan Ayob (Malaysia) commented that double cropping of rice imposes a stringent time schedule for each operation. This practice, in Malaysia, has created a labor shortage that has played a

significant role in mechanization. It is the farmers who have larger areas to be harvested and who are getting high yields per unit of land who are most likely to be using mechanical harvesters.

Cooperatives or other sources of machinery service play an important role in controlling the rates charged by commercial providers of farm machinery. In addition, although commercial sources may be able to provide adequate service for the heaviest and geographically most accessible users, cooperatives or other organized supplementary services are often necessary to meet mechanization needs not met by commercial firms.

Rudolf S. Sinaga (Indonesia) commented on the effects of monetary, fiscal, and trade policies. Where mechanization depends on import and international trade policies, the welfare of farmers and farm laborers is profoundly affected by such nonagricultural issues as import duties, interest rates, government subsidies, and foreign exchange rates, the last being an extraordinarily important variable.

The case of tractor imports in Indonesia was cited as an example. Despite low real wages, tractor power was artificially priced at an even lower level through fiscal (low import duty) and monetary (credit availability at low interest) policies. Such a situation calls for abolition of cheap credit for tractor purchase or adjustment in the exchange rate to avoid further deterioration in employment and income distribution.

Most countries with a large rural population will share the three objectives of the Indonesian government: better income distribution, higher productivity, and greater employment. It is desirable and should be possible to mechanize agriculture in ways that simultaneously meet all three goals.

Changes in mechanization always potentially redistribute income and benefits. Changes in institutions may be necessary to ensure that technical change does not promote inequity.

M. Abdul Jabbar (Bangladesh) reported that in his country increasing population pressure has resulted in more of the demand for draft power in agriculture being met by the use of cows. Yet the use of cattle as draft animals appears to decrease their reproductive capacity and hence, ultimately, to decrease the supply of animal protein to the nation. For this and other reasons, government mechanization policy may have a different meaning in Bangladesh than in some other countries.

Policies to encourage better use of animal draft power require attention to the health of both cows, bullocks, and/or buffaloes. The tendency to view animal husbandry as one field and agriculture as another has separated important elements of the mechanization process in an arbitrary and unproductive way.

Improvements in animal draft power will not occur overnight. Interim efforts to use tractor power should include careful attention to (*a*) making sure the machines imported are suited to Bangladesh field size and land conditions, (*b*) putting them in the hands of the right people, and (*c*) ensuring that they are well-maintained and operated properly.

R. D. Ghodake (India) urged that a sharp distinction be made between the land-augmenting and the labor-saving consequences of mechanization. Few countries can afford mechanization simply to improve income distribution; mechanization must also result in higher total productivity from the land area available.

Policy makers may underestimate the gains that can be made through improvement of simple hand tools and traditional equipment. If a tool is being used by most farmers, even a small increase in its usefulness may mean a large gain for agriculture as a whole. Here also, appropriate technology and proper institutional change must be introduced simultaneously.

Discussion

Discussions of the Asian presentations focused on the income-distribution and labor-displacement effects of mechanization. Attention was focused particularly on the maintenance of imported farm machinery (in order to prevent machines from lying idle due to the lack of parts) and on questions of institutional credit and draft power.

Except in parts of Korea and Malaysia, where labor shortages sometimes give an economic advantage to mechanization, most Asian countries are faced with a dilemma of, without technology, no development; with technology, inequitable distribution. It was repeatedly stressed that a combination of appropriate institutions and proper technology could make progress and changes in an economy. Some of the Japanese participants' observations on the productivity question were as follows:

- Gross labor productivity increases with mechanization, but net labor productivity (income less input costs) does not usually increase very much.
- Land productivity in physical terms increases a little.
- Productivity is the result of changes in a complex of inputs. Even though the contribution of machines cannot yet be pinpointed, it is generally agreed that if no mechanization were used in Japan, productivity would drop. Mechanization opened opportunities for the reorganization of agriculture, which in turn permitted greater yields.
- Separating the contribution of mechanization from that of other kinds of technological inputs is extremely difficult.

It was felt that the results of the Japanese experience should be viewed in light of criteria that other

Asian countries must meet if they are also to reorganize resources to increase land productivity.

EXTERNAL ASSISTANCE

Bart Duff (IRRI) emphasized that three steps of technology transfer deserve emphasis: transfer of materials, transfer of knowledge, and transfer of capacity. Any of these changes may occur through multinationals, national agencies, private firms, and international agencies.

A country's mechanization may depend more on local capacity for invention than on external forces. But mechanization also requires communication among engineers and scientists who are informed about the local agricultural situation, resources, and practices.

Little planning has been done to upgrade and rationalize research on mechanization strategy. The result has been an *ad hoc* approach, the direction of which is determined largely by the political considerations of local vested interest groups and the availability of donor funding. Neither, unfortunately, reflects a sound and balanced understanding of the economic and technological needs of small farmers.

To improve the returns on external assistance programs, policies should have the following goals:

1. When multinational firms are involved, to encourage such firms to give preference to ventures that promote development of designs tailored to local market needs
2. To make long-term efforts to upgrade the engineering curricula of local universities
3. To make a comprehensive long-term mechanization strategy a precondition before funding agencies and institutions grant financial credits
4. To insure better communication and wider distribution of technical information (for example, better descriptions of existing designs to permit more objective assessments of the designs' potential applications in other regions and countries)

Mechanization could be facilitated by:

1. Mobilization of local industry, which might require innovative thinking
2. Exchange of staff between institutions
3. Support for the development of integrated strategy (to ensure appropriate planning when it is important to look as far as 10 years ahead)
4. Upgrading engineers' training and providing incentives for both engineers and economists to concentrate on *exante* thinking instead of *expost* thinking
5. Better planning for efficient use of resources provided by funding agencies
6. Better communication between technical specialists and economists.

WORK PLANNED AND UNDERWAY

Participants noted a number of ongoing or future studies on mechanization:

Bart Duff, in addition to studying hardware development at IRRI, is undertaking four studies on the social and economic consequences of mechanization in Java, South Sulawesi, Thailand, and the Philippines. Eight villages at each of these four sites are stratified by level of mechanization and degree of water control. The first year's data collection has been completed.

Tadashi Tenma, over the past four years, has been working with a machinery research group on a study of joint-use structures in three farming systems. The next publication on this study was scheduled for issue in the fall of 1980. Tenma is also doing research on farmer investment in machinery and on agricultural cooperative machinery centers. The latter study is particularly concerned with how centers should be established at the village level.

R. D. Godhake is studying constraints on the transfer of technology from international research centers. One portion of his research focuses on mechanization and uses *activity analysis* models. A three- or four-year study is envisioned. The objective is to design mechanization that will utilize local materials and resources, maintain productivity, and distribute gains equitably.

M. Abdul Jabbar is undertaking one study on the livestock component of Bangladesh agriculture and another on the impact of power tillers, and he is looking ahead to work on thresher use and drying technology. His colleagues are working on irrigation.

Osamu Kitani is concerned with energy problems and their probable major effect on mechanization. (This topic requires cooperation between engineers and economists, for both conceptual and methodological contributions.) Solar and biomass energy sources in crop drying are also being studied.

Satoru Nambu is studying the costs and benefits of versatility in hay making as compared with silage making.

Hiroyuki Nishimura is undertaking a proposal at the Center for Integrated Rural Development for Asia and the Pacific (CIRDAP Bangladesh) on the rural–urban balance in income and equity and on decreasing heavy work.

Ahmad Mahdzan Ayob is studying costs of manual versus contract grain harvesting (comparison of costs in process). He is also analyzing the ways in which leisure time gained by mechanization is used; one of the variables he is considering is "quality of rural life."

Ayob also proposes to compare the efficiency of small and large combines as well as the effectiveness of government programs.

Zyuro Kudo hopes to study life expectancy of machines.

FUTURE PERSPECTIVES

A number of important issues—mentioned in the introduction to this report—came up frequently enough in the discussions to signal the need to give them particular attention in further agricultural mechanization efforts in Asia.

Differing Local Conditions

The possibilities for mechanization, were seen to vary widely, reflecting variation in local conditions. Level and extent of mechanization depend on climate, water availability, cropping patterns, tillage, farm funding, labor supply, and other economic and social conditions of individual localities, as well as the technology used or likely to be used in each locality.

Local inventiveness and ingenuity are decisive, and practical farming experiences are a potent source of knowledge for mechanization. Indigenous responses are found, for example, in the boat tractors of China, deep water planting in Bangladesh, and the engine-powered propeller pumps widely used in Thailand and Vietnam.

Energy Saving

Agriculture is an energy conversion process. But since modern agriculture requires large amounts of artificial-energy input, energy becomes a major constraint to mechanization. The higher the cost and the smaller the supply of energy, the more attention must be given to its economical use.

The following were considered possible measures for reducing dependence on costly imported energy: using local energy sources for drying; improving cultivation systems (that is, minimum tillage); using small tractors instead of larger ones; finding ways to reduce waste of energy (for example, adjusting engines more carefully); making greater use of animal power, solar energy, wind geothermal, alcohol, methane from biomass, and hydroelectric. On the other hand, one cannot overlook a situation like that in Bangladesh, where there is an absolute shortage of power on small farms and thus no further economizing is possible.

Livestock Mechanization

Mechanization through the livestock sector, neglected in the past, deserves more study.

The discussions focused on whether animal draft power raises its own special problems of machinery design and whether meat and milk products compete directly with the use of animals for draft power. In what circumstances should animals be used primarily for draft power? Primarily or solely as a source of food? For both purposes?

Even the soil texture and timing of rainfall affect the choice of source of draft power for tillage (for example, animal or power machinery). There are wide intercountry and interregional differences. Adapting machines to the kind of draft power available could effect substantial economies.

Health of livestock, which are still a major source of power in countries like Bangladesh, is a serious concern. Where cows are used increasingly and their health gradually deteriorates, one can infer less availability of actual and effective draft power than the number of animals in use would suggest. Neglect of the livestock sector gives advocates of high technology an opportunity to consider tractors and tillers as suitable substitutes for bullocks.

Some studies indicate that power tillers are more suitable than tractors to many conditions in Asia. Comparisons with bullocks have been made less often, but they suggest that tillers (*a*) have a less positive effect on land productivity than do bullocks, (*b*) cause net labor displacement, and (*c*) benefit the wealthier farmers. A question was raised as to whether the government program on mechanization in Bangladesh is actually based on a full and clear understanding of the nature of the power problem there. Since the draft-power shortage contributes directly to the growth of unemployment, solving the food production problem will involve solving the power problem. In countries like Bangladesh it may be desirable to look for ways of restoring the cow to milk-producing status and to make efforts to improve the health both of cows and of power animals. The latter might be accomplished by developing better ploughs and by establishing programs to identify good-quality draft and milk breeds and to initiate breeding practices for both types of animal that may result in higher power and milk output. Recognition that the health of a draft animal is an aspect of mechanization emerged out of the discussions. The health of a draft animal is really, in principle, no different from the quality of motor tune-up, repair, and maintenance of a tractor. Moreover, the costs of neglecting each are similar.

Economic and Social Implications

Farm mechanization is a complicated process. It is not a merely technical process; economic and social factors play a vital role. And despite wide differences in economic and social systems and agriculture types among the countries represented at the seminar, par-

ticipants found themselves stressing similar points and drawing similar conclusions.

A consensus emerged that in the future, to promote farm mechanization it will be necessary for agronomists, engineers, economists, sociologists, and even anthropologists to share information and ideas.

Mechanization always potentially redistributes income and benefits; this income-distribution effect is its most important socioeconomic aspect. Japan presented a unique case. Mechanization actually led to more equitable distribution of rural incomes. By releasing farm labor, mechanization contributed to the development of secondary industry. By 1977 Japanese farmers' income from secondary industry had reached the same level as their agricultural income. Small farmers obtained 80% of their income from nonfarm business and only 20% from farming; large farmers obtained only 10% of their income from nonfarm business and 90% from their farms. But the standard of living throughout the village was more or less equalized.

Quite the opposite effect was noted in some other Asian countries, particularly Bangladesh, India, and Indonesia. The rural landless do not even qualify for mechanization's benefits, and the social systems in these countries are such that even the landed rural poor can rarely come together to form cooperatives. In the poorest countries, capitalist farming may bring some additional output, but it may also create unemployment and income inequality. Even in China, mechanization has the potential to cause inequitable distribution of benefits among regions.

In those parts of Korea and Malaysia where labor shortage is a problem, timeliness becomes more crucial and mechanization becomes necessary.

Seminar participants stressed repeatedly that suitable institutions are essential to ensure that technical change does not promote inequity. At the same time, it was argued that mechanization to improve income distribution will not get high priority unless such mechanization also results in higher total productivity from land area available.

Mechanization, it was agreed, is a means to an end and not an end in itself; one has to be clear about what the end really is. Agricultural policy in most Asian countries shares three national objectives:

1. To increase agricultural output
2. To create employment opportunities
3. To reduce rural poverty and promote equity in income distribution.

It is desirable to mechanize agriculture in ways that meet all three goals at once, and it is essential to try to avoid a strategy that adversely affects any one of them. The foregoing point was made with the recognition that in some cases development involves adjustments, progress involves disequilibrium, and changes introduced with the long-term goal of higher income and greater productivity will often unavoidably strain income distribution.

Some government credit policies unwisely make capital artificially cheaper than labor. A need was expressed for more intensive study of the relations between stages of economic and social change, the development of rural institutions, and the process of mechanization.

The costs and consequences of mechanization are still not clear. Methods of evaluating costs and benefits of particular kinds of mechanization are not uniformly agreed upon; hence research results are hard to compare.

Labor Displacement

Since any form of mechanization assists or replaces hand labor in agriculture, it inevitably displaces some portion of the rural labor force. The resulting dislocation may be alleviated in part by local diversification of the economy. Mechanization proceeded in the face of labor shortages in Japan, Korea, and Malaysia, but caution should be exercised elsewhere to make sure that displaced laborers have alternative employment.[1]

Mechanization Types and Strategies

Type and extent of mechanization is determined by factors such as irrigation, cropping pattern, type of soil, man–land ratio, working animals, and rainfall pattern. This variety of determinants underscores the importance of a selective approach in terms of farm operations and areas.

Mechanization of irrigation and drainage receives highest priority, since most other mechanization can flow from availability of water. Moreover, the value and scale of farm machinery at the micro-level is determined mostly by the extent of irrigation. However, there was disagreement among the participants. Whereas a paper by one Japanese participant argued that irrigation and drainage had only a marginal effect in promoting mechanization, other papers reported that irrigation has been a tremendous force in stimulating mechanization.

One report indicated that mechanization of the threshing phase (quick threshing, for example) could save up to two-thirds of total yield, and another identified the harvesting machines as the most labor displacing.

[1]One study shows that there is a complete linear-function relationship between the number of people engaged in agriculture and tractor density per hectare: On the average, it took about Y811,000 to replace one agricultural worker by agricultural machinery over the past 20 years in Japan.

Need for International and Interdisciplinary Exchange of Information

Broader exchange of technical information on the design and application of machines is necessary. It is no longer feasible to centralize either research or inventiveness.

Although the issue of communication was overshadowed during the discussion by the questions of productivity and of other social and economic implications of mechanization, it was agreed by economists, engineers, and other technical specialists that future work on technological improvements will have to be better coordinated.

Farm mechanization is too broad a subject for its costs and benefits to be sharply defined, particularly since it must take economic and social factors into consideration and suit local instead of national or regional needs.

Participants from other Asian countries found the Japanese experience with farm mechanization relevant to their situations despite differences in economy and structure of agriculture. It was equally clear that local conditions—climatic, crop, soil, economic, social, and institutional—place each region in a unique position in devising a sound mechanization strategy.

Participants noted the value of the seminar in maintaining linkages among themselves and with others. They also noted that on issues of farm mechanization there are mutual benefits to both developed and developing countries. Each had useful lessons and insights to offer in the process of mutual exchange.

APPENDIX 1

Papers

Ayob, Ahmad Mahdzan. *Mechanization of Small Farms in Malaysia: Recent Development and Future Needs.*

Duff, Bart. *Providing External Assistance in the Mechanization of Small Farms.*

Ghodake, R. D. *Status and Needs of Farm Mechanization in India.*

Jabbar, M. Abdul.. *Need for Mechanizing Tillage Operations in Bangladesh.*

Kitani, Osamu. *Mechanization of Small Scale Farming in Japan.*

Kubo, Yoshiharu. *Impact of Farm Mechanization on Farm Organization: A Case Study of Typical Field-Crops Producing Area in Eastern Hokkaido.*

Kudo, Zyuro. *Operating Cost of Rice-Harvesting Patterns in Saga Central Plain Area.*

Kuroyanagi, Toshio. *Economic Effects of Government Investment in Farm Mechanization—A Japanese Experience.*

Le, Xiumei. *The Priority and Sequence of Agricultural Mechanization in China.*

Nishimura, Hiroyuki. *The Farm Machinery and Farm Mechanization—In Reference to Rice Production in Post War Japan.*

Tsuchiya, Keizo. *The Development of Farm Mechanization in Japan after the Second World War.*

APPENDIX 2

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