Special Contribution

World Irrigation VI.
Agriculture and Irrigation in Japan

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Foreword

The author has been preparing a series of papers entitled "World Irrigation", referring to issues related to irrigation and agricultural problems prevailing outside Japan. But he now wishes to introduce agriculture in Japan, particularly rice production and related water management, to those who are not familiar with the subjects in question. The paper mainly discusses the technical and social aspects without placing emphasis on economic and political implications. As is well known, Japanese rice production now faces very serious political problems due partly to rice import liberalization resulting from the GATT-Uruguay Rounds. Some have said that there will be, in the future, no rice production in Japan as it will not be economically sustainable. The author does not agree since rice cultivation plays a substantial role not only in the economic sector in Japan, but also in conserving the environment and providing amenities for the Japanese people at large. Agriculture in Japan is no longer considered a mere economic activity to produce food; it plays a vital role in social welfare and environmental conservation and amenity creation.

The author wishes to express his willingness to write another paper, in the near future, highlighting the non-economic issues of Japanese agriculture, placing emphasis on the role of agriculture in environmental conservation and amenity provision.

For preparing the paper, the author referred to his paper "Rice Irrigation in Japan" which was published by FAO/UN in 1967. He found that irrigation technology in Japan has made tremendous progress in the last 30 years, but the basic concept of irrigation, which is to provide crops with optimal water conditions, remains unchanged.

Reviewing the 30-year-old paper took me back to my days at the FAO, where I served for 25 years. I would like to conclude my foreword with my words of appreciation to FAO.

Chapter 1. Japan’s Land and Climate

1.1 Topography and Climate

Japan consists of some 4,000 islands. The four main ones are Hokkaido, Honshu, Shikoku, and Kyushu.

These islands lie in a northeast to southwest arc along the eastern part of the

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Figure 1-1  A regional map of Japan
Eurasian continent. The island chain stretches about 3,000 kilometers in length, from 45° to 25° north in latitude. The total land area amounts to 378,000 square kilometers, about 1.5 times larger than the United Kingdom, approximately the same as Germany, and 0.7 times the size of France. Although the area of Honshu, the largest island, amounts to 227,000 square kilometers — approximately the same area as that of the United Kingdom, the island is 1,700 kilometers long, and its width is only 250 kilometers at the widest section.

Mountains form a backbone down the middle of the Japanese archipelago, and include Mt. Fuji (3,776 meters). There are 12 mountains over 3,000 meters and as many as 580 mountains exceeding 2,000 meters above sea level. The mountains constitute part of the circum-Pacific volcanic belt, and some of them are still active (see Figure 1-2). As the altitude of the mountains is comparatively great in relation to the width of the island, many parts of the land are steep: 55% of the total land area has a gradient of over 15°, and 17% of the total land has a gradient over 30°.

Level land and basins account for a comparatively small area. Precipitation is high, resulting in a complex topography with many short and torrential rivers. Practically speaking, no rivers are used for transportation, except in coastal areas.

The climate is affected by monsoons and typhoons, since the archipelago lies in
As a result of these geographical characteristics, the climate has four distinct seasons, and there are marked regional differences (see Figure 1-4). In January and February in Hokkaido, the northernmost island, the average temperature is below 0 °C, and the Sea of Okhotsk is frozen. In some Sea of Japan coast areas of Honshu, the main island, snow falls several meters deep, while rapeseed flowers bloom in southern Honshu and papaya trees bear fruit in the areas even further south. April and May are Japan's most beautiful months, as the flowering time of the cherry blossom advances from south to north from mid-March until the end of May.

The rainy season (except in Hokkaido where there is none) lasts for about one month, from mid-June to mid-July. In the past, rice was planted during this season, primarily because irrigation facilities were insufficient. Summers are hot and humid in Japan.

Even in Hokkaido, the maximum temperature exceeds 30 °C in summer. As seen in Figure 1-4, there is not much difference in the climate in summer between the northern part and the southern part of Japan. Thus, a combination of high temperature and abundant rainfall has made rice cultivation possible throughout Japan. Toward the end of summer and during autumn, many typhoons strike Japan with violent winds and torrential rains, causing floods, landslides, and marine accidents.

Autumn is pleasant and refreshing with balmy days and bright sunshine. The sky is clear and the temperature and humidity are agreeable. The 1964 Tokyo Olympic Games were held during this season. Autumnal foliage begins in the north and higher parts of the mountains toward the end of September and

Figure 1-4 Climate of Japan (Climo-Graph of five cities)
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gradually descends south, in the opposite direction to the path of the advancing cherry blossom front in spring. After the autumnal foliage, snow begins to fall in the mountains, and the skiing season commences in the northern areas.

The complex topography, marked regional differences in climate and four distinct seasons have strongly affected the lifestyle of the Japanese people. Agriculture, in particular, has been influenced by the topography and climate. Rice, which originated in the tropics, is now grown throughout Japan. Fruit production is rich in variety, ranging from pineapples to apples. Sugar cane is grown in southern areas and sugar beets in northern areas. A variety of vegetables are raised throughout the four seasons.

1.2 Land Use

Japan’s 578,000 square kilometers of land breaks down as follows: forest and woodland: 67.0%; arable land: 14.7%; urban land: 3.80%; and other: 14.5% (see Figure 1-5). The percentage of forest and woodland is very high in Japan compared with other developed countries—32% in the United States, 8% in the United Kingdom, 28% in the former Federal Republic of Germany and 26% in France. Furthermore, 55% of the forest and woodland in Japan is in hilly areas with a gradient of 15° or more, making it difficult to utilize.

Agricultural land totals almost 6,000,000 hectares, a figure that has hardly changed since 1920. Until recent decades, the total agricultural land area had generally remained constant, the area newly brought under cultivation being balanced with the area converted to nonagricultural uses. Recently, the area being converted has tended to exceed the area being brought under cultivation. It has also been noticeable that large portions of newly added areas are grassland.

![Figure 1-5 Distribution of land use in 1985](J. of IERP No. 29 (1995))
or pasture rather than upland fields. Of the total agricultural land area, cultivated land in 1990 amounted to 5,245,000 hectares, of which 2,846,000 hectares were paddy fields, 1,275,000 hectares dry fields, 475,100 hectares orchards and 646,600 hectares pasture.

It should be noted that paddy fields account for more than 50% of the cultivated land, and the area of permanent grassland is relatively small.

As a result of government policy to increase rice production, the area devoted to rice cultivation continued to expand, reaching 5,400,000 hectares in the early 1960s. This expansionary trend, during which the area of newly added paddy fields exceeded the area converted to other uses on a yearly basis, continued until about 1970, when the government began to discourage the formation of paddy fields because decreasing demand for rice was causing perpetual supply surpluses. In 1978, a program was begun to convert 400,000 hectares of paddy fields to other uses. The program has been strengthened in the last 10 years, and 830,000 hectares were converted to other uses in 1990. The total orchard area, especially that for mandarin oranges, apples, and grapes, has increased since 1960 and now accounts for 10% of total agricultural land. The area of fields for other crops has generally decreased, owing to the low profitability of crops such as soybeans, except for areas where more profitable horticultural products such as vegetables and ornamental plants can be cultivated.

While the population of Japan has trebled in the last 100 years, the area of agricultural land has increased only 30% during the same period and has hardly risen at all during the last 50 years. Therefore, agricultural land per capita has decreased year by year. Agricultural land per capita in Japan in 1975 was less than 0.05 hectare—one-fortieth of that in the United States and less than one-fourth of that in the former Federal Republic of Germany (see Figure 1-6).

In view of the fact that most of the agricultural land in Japan is cultivated land, more than 50% of which is paddy fields with a high productivity yield per unit
area, it might be misleading to draw conclusions merely on the basis of per capita area of agricultural land. However, even taking this point into consideration, it is generally agreed that 0.05 hectare per capita is a bare minimum from the viewpoint of balanced development of land use. The National Land Use Plan developed in 1985 included a program to increase agricultural land by 1% during the period from 1982 to 1995 (see Table 1-1).

As a result of rapid economic growth, increasing residential, industrial, and transportation demands have impinged upon farmland. During the first half of the 1970s, 70,000 hectares of agricultural, forest, and woodland were converted annually for housing and factory construction. It has been estimated that two thirds of that converted area was originally agricultural land. Expansion of the Tokyo urban area was particularly remarkable, as the densely populated areas around Tokyo Bay expanded from 1,000 square kilometers in 1960 to over 2,200 square kilometers in 1980. Other urban areas have also expanded rapidly, such as the Pacific coastal areas between Tokyo and Nagoya, the coastal area of the Seto Inland Sea, and such large regional cities as Sapporo, Sendai, and Kitakyushu.

In terms of densely inhabited districts (DIDs), urban areas amounted to 6,400 square kilometers and accounted for approximately 2% of the total land area in 1972. However, the absence of effective programs backed by legislative control for land utilization during the 1960s caused the disorderly sprawl of urban areas in many parts of Japan. To remedy the situation, the City Planning Act (new act) was enacted in 1968, and the Agricultural Promotion Areas Act was enacted in 1969. The enactment of these laws made possible the regulation of land use in urban areas by introducing zoning in connection with both city planning and agricultural development. Further, the National Land Use Planning Act was enacted in 1974 as a basic law to regulate land use.

Table 1-1 The national land use plan (1985) (thousand hectares)

<table>
<thead>
<tr>
<th></th>
<th>1982</th>
<th>1995 (planned)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>5,540</td>
<td>5,590</td>
</tr>
<tr>
<td>Forests</td>
<td>25,330</td>
<td>25,550</td>
</tr>
<tr>
<td>Wasteland</td>
<td>520</td>
<td>230</td>
</tr>
<tr>
<td>Rivers and lakes</td>
<td>1,310</td>
<td>1,360</td>
</tr>
<tr>
<td>Roads</td>
<td>1,030</td>
<td>1,270</td>
</tr>
<tr>
<td>Residential areas</td>
<td>1,450</td>
<td>1,700</td>
</tr>
<tr>
<td>Residences</td>
<td>(900)</td>
<td>(1,060)</td>
</tr>
<tr>
<td>Factories</td>
<td>(150)</td>
<td>(170)</td>
</tr>
<tr>
<td>Other</td>
<td>(400)</td>
<td>(470)</td>
</tr>
<tr>
<td>Other</td>
<td>2,800</td>
<td>2,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>37,780</td>
<td>37,800</td>
</tr>
<tr>
<td><strong>Urban area</strong></td>
<td>1,000</td>
<td>1,330</td>
</tr>
</tbody>
</table>

Note: Based on DID in the National Census of 1980.
Although legislation to regulate the expansion of urban areas was available, urban areas have continued to expand, owing to the increase in population and to economic activities.

Urban areas increased by 3,600 square kilometers from 1972 to 1982. Although residential areas increased by 200 square kilometers, demand for land in metropolitan cities caused land prices to skyrocket. The National Land Use Plan was modified in 1985, a year in which a 1,600-square-kilometer increase in residential areas and a 3,500-square-kilometer rise in urban areas were expected. Thus, although urban sprawl seems to be under control to a certain extent, Japan still faces two important policy issues: the increase in residential areas and the orderly development of urban areas.

With respect to protection of the natural environment, the National Park Act was enacted in 1931 to protect scenic districts by designating them national parks and forbidding private development. However, the Nature Park Act, enacted in 1957 (a revision of the National Park Act), and the Nature Conservation Act, enacted in 1972, have enabled stricter regulation over a wider range of areas than before. At the moment, areas amounting to 53,290 square kilometers have been designated nature park areas. Districts covering 850 square kilometers, which require special protection because of their particular natural conditions, have been designated environmental protection areas, and their development has been placed under strict control.

Chapter 2. Agriculture in Japan
—Historical Development and Strategy

2.1 Reconstructing Agriculture and Industry

Some fifty years ago, Japan lay in ruins. By the end of World War II, whole cities had been burned to the ground, industries had been completely destroyed, and agriculture had been devastated. Today Japan has the second largest gross national product in the world, and exports high-technology products to every corner of the globe. Yet Japan's transition from an agricultural to an industrial society was made only thirty years ago, though the secondary industry exceeded the primary sector in national income by the end of the 1920s.

After World War II, Japan was faced with rapid inflation and acute food shortages. The reforms intended to combat these problems began with the dissolution of the Zaibatsu (rule of the rich) system of economy. Democracy and land reform soon provided fuel for economic development. They allowed competition to flourish, and labor and capital to work beneficially together.

As well as increasing individual incentives, the reforms were specifically intended to improve farming techniques. Extension services were introduced, access to information was increased, and the desire for knowledge carefully nurtured.

An efficient and comprehensive system of agricultural cooperatives also contributed to growth.
Government helped by investing in agricultural infrastructure, supporting crop and livestock prices, providing finance for agricultural development and initiating a crop insurance scheme.

As a result, the agricultural sector, which had been almost static in the decades before the war, began to grow rapidly. During 1950–61, production increased by more than 50 percent and rural living standards improved dramatically.

Improvements were not restricted to crop and livestock production. In the forestry sector, controls on production and marketing were removed, the National Forest Service was reorganized, and forestry cooperatives were established. Production increased by an annual average of some 10 per cent during 1950–64.

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Cooperatives were created to help reform the fishing industry. Larger boats and modern machinery led to a dramatic expansion of deep water fishing; production nearly doubled between 1950 and 1964.

Reconstruction policies were also applied to Japanese industry after the war. Initially, priority was given to coal mining and the production of iron, steel and fertilizers, because these commodities were vital to the reconstruction of other industries. As the economy began to recover, new technologies were introduced in such fields as petrochemicals, synthetic fibers, and construction, and given priority. By the 1960s, the industrial sector was beginning to expand extremely rapidly, with far-reaching effects on agriculture.

Small-scale farming provided a framework for dynamic agricultural expansion in the 1950s and 1960s. But since then it has failed to diversify and now cannot cope with the changing demand for different foods. Farm size needs to increase if Japanese farming is to remain efficient. Several reform measures have recently been enforced to cope with these problems.

Forestry and fisheries have also suffered in recent years. Demand for timber reached a peak in 1974, but the timber market has since been in decline; the forestry industry also suffers from a chronic shortage of labor. Forestry productivity has been in decline since 1961.

Japan's fishing industry still brings home the largest catch in the world; Japan is also the world's largest importer of fish. A series of international agreements and fishing exclusion zones have reduced Japanese deep sea fishing considerably since the mid-1970s, although productivity still increased about 30 per cent during 1970—85.

### 2.2 Reforming Agriculture

The government set up a Land Development Bureau in 1945 to increase the country's area of agricultural land through reclamation and development. The expansion was intended to help meet increased food demand as well as to provide employment for repatriated and demobilized Japanese.

A year later, an extensive program of land reform was begun to redistribute land from landlords to cultivators and tenants. The program was administered by regional Agricultural Land Offices and an Agricultural Land Department set up under the Ministry of Agriculture and Forestry.

A Central Agricultural Land Committee, appointed by the Prime Minister, dealt with major issues such as the price paid for land purchased by the government and the area of land that could be retained by landlords.

Detailed issues were handled by two forms of local committee. Municipal committees, consisting of five tenants, three landlords and two owner-cultivators, drew up land transfer plans; and prefectural committees, comprising ten experts appointed by the government, ten tenants, six landlords and four owner-cultivators, approved the plans drawn up by the municipal committees and handled complaints.

In 1947, municipal Food Adjustment Committees were created to set compul-
sory quotas for producers to supply staple foods to the government. This arrangement helped to stem food shortages, inflation, and social unrest.

Crop insurance had existed in Japan before the war, but the system was reorganized in 1947 and existing crop and livestock insurance schemes were consolidated under the Agricultural Disaster Compensation Law. This law also established local Mutual Relief Associations with members drawn from the farming community.

The importance of accurate information on food production was quickly realized. The Statistics and Survey Bureau and local Crop Reporting Offices were created in 1941 to collect accurate statistics on agricultural production and farm economies.

2.3 Setting up the Cooperatives

New forms of agricultural cooperative were first established by law in 1947. Prewar cooperative associations had benefited landlords more than cultivators, because the largest sales of rice were those paid as rent to the landlords. Landlords, large farmers, and merchants used the associations to turn price controls to their advantage. To combat such abuse, only farmers were given voting rights in the new cooperatives.

By the mid-1950s, about 12,500 general-purpose cooperatives had been set up covering every village in Japan. The cooperatives provide credit and technical guidance, and market farm products. They also supply farm goods and household commodities. Cooperatives have been important in helping to administer government policies such as price stabilization measures and financing schemes.

In addition to the general cooperatives, 15,000 specialist cooperatives were set up to deal with the services needed (mainly marketing) by specialized branches of agriculture such as sericulture (silk production), livestock production, and horti-
Figure 2-4 Percentage of farm production sold through agricultural cooperatives

culture. Federations of cooperatives were also set up at both local and national levels to assist in the large-scale marketing and financing of agricultural businesses.

Fisheries cooperatives were set up by statute in 1948. They control the distribution of fishery grounds democratically and organize joint fishing ventures. Like agricultural cooperatives, the fishery cooperatives also help with financing, marketing and the supply of goods. Other cooperatives provide fish processing facilities.

Forestry cooperatives were created under the Forest Law of 1951. The existing forestry associations were reorganized into cooperatives. All forestry owners were eligible for full membership and received equal voting rights.

2.4 Comparisons with Other Countries

Japan has similarities with many Asian and African countries in terms of farm size: most farms are small, and average farm size is also very small. In Latin America and the Near East, by contrast, although there are also many small farms, the size of the large farms far outweighs the importance of small farms, average farm size is much larger.

In theory, the Japanese ‘dispersal’ strategy of gradually modernizing many small farms should be more successful in countries where average farm size is very small. ‘Focus’ strategies, where a small sub-sector of farm enterprises are suddenly and substantially modernized, should be best suited to nations where the bulk of farmland can be found in relatively few, very large farms. The strategies that worked in Japan could therefore help to increase agricultural productivity in Asia and Africa.

This general picture masks the differences in agrarian structure and agricultural productivity amongst nations even from the same region. For example, the size of the labor force per unit of agricultural land is increasing in Asia and Africa, whereas it is decreasing in Japan. In monsoon Asia, in particular, the dry season
leads to enforced idleness and low productivity for many rural people. Japanese strategies need to be adapted in these regions to provide labor-intensive rather than machinery-intensive small-scale development.

The best strategy may therefore be to increase yields and the number of different crops grown. This can lead to diversification capable of coping with increased demand and expanding employment on and off the farm. These tactics have already been employed in the Green Revolution in parts of Asia.

Some developing countries are still unable to feed their growing populations and require basic help to introduce irrigation and other inputs such as fertilizers. Other Far Eastern countries have already undergone their Green Revolution. They are currently becoming industrial societies and experiencing similar problems to Japan in making the transition. In both cases, institutional reform is crucial.

Japan has found that most technological improvements in agriculture can be traced back to motivating farmers to produce more, and to public measures in support of farming, including improvements to institutions and infrastructure. These are lessons that can be applied throughout the developing world. The chapters that follow examine each of these issues in more detail, starting with the institutions and policies of Japan's postwar government.

2.5 Issues Contributing to Success in Agriculture

In most countries, small-scale producers are neither efficient nor productive. Why is the situation different in Japan? There are essentially five answers: Japan has devised effective policies; provided a sophisticated rural infrastructure; encouraged the use of farm inputs; harnessed science and technology for the benefit of the small-scale producer; and made efficient use of human resources. These five topics are analyzed separately in the pages that follow.

Japan's agricultural policies have been successfully integrated to provide an allround attack on the problem of increasing the output of its small-scale food producers. As the charts of government expenditure show, concerted and sustained attempts have been made over the years to stimulate production, improve the quality of agricultural land, promote—agricultural research and extension, improve the rural infrastructure, augment farmers' incomes through price stabilization and support, and improve rural living conditions.

Government expenditures on price stabilization and support policies have been very high since the early 1970s; additionally, farmers' incomes have been buttressed by means of import controls. Support to the rice sectors has been particularly heavy, although in recent years the producer price of rice has been reduced with the aim, together with other measures, of preventing excess production of this commodity.

Land reform

Both the impetus for postwar agricultural expansion and the current agricultural stagnation can be traced to the reform of the land tenure system which began in 1946 when all land belonging to absentee landlords was compulsorily pur-
chased. In most areas, even resident landlords were permitted to keep only 1 hectare (4 hectares in Hokkaido). They were paid for their land with Agricultural Land Bonds, repayable over 22 years at an interest rate of 3.65 percent. The government then sold the purchased land to the tenants who had cultivated it. Tenants were able to pay off their debts in annual installments over 24 years at 3.2 percent at annual interest.

Land reform created a network of small-scale farms. The proportion of tenanted land declined from 44 percent in 1946 to 6.7 percent in 1960. Owner cultivators made up only 33 percent of farmers in 1946. This proportion had risen to 62 percent by 1950. The number of farms with more than 2 hectares of land decreased, and the number of marginal farms with less than 1 hectare increased.

The land reform program was largely completed within two years. The speed with which the reform occurred was partly due to Japan’s historically advanced administrative system under which all land had been registered at municipal offices before 1900. The pace of land reform was also accelerated by low land prices and high inflation, enabling most of the new owner cultivators to purchase their land outright in cash.

Land reform was not intended to abolish tenancy completely, but to modify it. Security of tenure was guaranteed. Rents were kept low even though the price of rice rose almost every year.

Absentee landlords resisted the reform by filing lawsuits, making arbitrary evictions, insisting that they themselves worked all their land, and by such devices as assigning large areas of their land to ‘nominees’. The government stood firm, however, and with the help of the occupying forces overcame such ploys.

Land reform encouraged farmers to invest more capital in their farms. The cost of standard farm outputs such as rent, interest, and wages amounted to 23 percent of farm expenditure in 1934–6 but to only 3 percent in 1950–53. As a result, private agricultural capital formation --- the proportion of agricultural turnover that was saved by farmers themselves --- rose from 7 percent in 1933–37 to 17.6 percent in 1958–60.

Even so, many of the new owner cultivators created by land reform could not afford to invest large sums in land development. The government responded by providing assistance in the form of cheap loans for land improvement and the introduction of improved farming techniques.

As the agricultural labor shortage developed in the 1960s, government finance was also in demand for machinery to replace the missing workers. Investment in new equipment soon made Japanese agriculture very capital-intensive. The agricultural return on capital began to decline as production costs increased, mainly because of an inefficient distribution of capital and labor on the country’s small farms. Many of them became under-manned and over-equipped.

Controls on farm land sales and leasing, along with high urban and low rural wages, soon led to part-time farming and the overproduction of some major crops.
However, competent full-time farmers, with sufficiently large holdings to permit efficient land use, have found farming increasingly profitable over the past few years. Thus, although land reform improved the living standards of food producers --- increasing disposable income by more than 40 percent during the two decades beginning in 1935 --- it led directly to an agrarian structure that has not been able to adapt to changing economic circumstances because of the difficulties of enlarging farm size.

After enactment of the Agricultural Basic Law of 1961, aiming at increasing farm income through improvement of the agrarian structure, a number of policies have been used to counteract the problems caused by small-scale farming. These have encouraged cooperative farming, more efficient family farming, and increases in farm size through controlled leasing. These efforts culminated in a 1980 measure, the Law for Promoting Effective Use of Farmland. Under this law, additional land can now be leased by fulltime farmers providing the lease is authorized by the municipal authorities. These contracts are exempt from the laws limiting the size of land holdings.

**Income support**

Price stabilization (a form of income support) has been an important national policy for promoting agriculture, fisheries and forestry. Price stabilization measures --- which affect nearly 80 percent of the value of Japan’s agricultural production --- fall into five categories.

**The controlled price system** is used for rice and leaf tobacco. Marketing, purchase, and selling prices are all under government control. Purchase prices are calculated from production costs that assume urban rather than rural wage rates, and the government purchases a certain proportion of the commodity.

**The stabilization price band system** is used for beef, pork, and raw silk. The government sets maximum and minimum prices for the commodity on the basis of prices in a base year and production trends. In recent years, import controls have begun to be liberalized and the price stabilization system revised.

**The minimum price guarantee system** is used for wheat, barley, potatoes, beets sugarcan, and sweet potatoes that are to be processed. If the market price falls below the guaranteed price, the government purchases the commodity to maintain its price. The guaranteed price is based on prices during a base period, taking changes in the agricultural parity index into account.

**The government payment system** is used for soybeans, rape seed, and milk that is to be processed. The government fixes a price according to changes in production costs. Any difference between this fixed price and the price received by the farmer is paid by the government.

**The stabilization fund** is used for certain vegetables and fruits for processing, beef calves, and eggs. Market intervention is not normally suitable for perishable products such as vegetables, fruit, and eggs, so overproduction of these commodities is often simply destroyed to keep market prices up. But there is also a stabilization fund to which central and local government and producers contrib-
ute. This fund provides assistance when markets are dull.

In common with much else in Japanese agriculture, the cooperatives have concentrated on rice. A major part of the income of the cooperatives comes from charges on the government for handling and warehousing rice. Unfortunately, giving the highest priority to rice in operating price stabilization measures has led to a failure to diversify into other food commodities, adding to a growing gap between supply and demand.

2.6 Harnessing Science and Technology for Small Producers

Strategies for promoting agriculture through science and technology include both conventional research and development and the provision of appropriate technology for small-scale producers.

One of the important factors that contributed to the strength of Japanese agriculture in 1900 was the dissemination of good seed varieties. Since World War II, improved rice varieties and fertilizer use have been the two most important means of producing higher yields. These technologies are complementary in that new varieties were bred specifically to respond to fertilizer. Other improvements also led to the ‘fertilizer-consuming rice culture’, including advances in application techniques and soil improvement.

Soil improvement and fertility

Paddy soil fertility research began during World War II in response to a severe fertilizer shortage. Successful measures have included dressing degraded soils with clay, deep ploughing, and the application of iron- and base material.

Considerable research has been carried out into the relationship between soil types and appropriate fertilizer application. Demonstration fields are used to show farmers how effective different fertilizer applications and techniques can be. The application of different fertilizers at different stages in plant growth has proved very effective.

As the importance of livestock and vegetables has increased, research into crop rotations, between lowland and upland crops, and the fertilizer applications that such rotations need, has accelerated. Shortages of farm labor have also stimulated research into less labor-intensive ways of applying fertilizers.

Disease control

In the postwar period, a common result of fertilizer application was crop losses caused by increased damage from disease and insects. Pathogens of all kinds thrived on the additional foliage encouraged by the increased fertilizer application.

Rice blast became a serious problem. The search for a solution led to an integrated strategy which combined planting blast-resistant varieties, producing healthy seedlings, and applying only moderate doses of fertilizer. This helped, but it was not the full solution. In 1958, however, an antibiotic Blasticidin S was isolated that proved effective.

This discovery helped lay the foundation for a new era of agricultural technology. Since then many other antibiotics have been developed for agricultural use.
As a result, the production of agricultural chemicals against disease and pests, and the use of power sprayers and dusters, has increased sharply.

A system of 2,000 sample fields was set up in 1953 to forecast disease and pest problems. The information collected, together with the results of experiments and surveys, are broadcast to the farming community.

**Improving rice crops**

The original fertilizer-responsive rice varieties introduced after World War II were late-maturing and vulnerable to damage during cool years. Cold-resistant varieties have now been bred and are used in northern Japan. They have stabilized yields in these areas, and have extended the northern limit of rice cultivation.

The mass production of vinyl sheeting has promoted wide usage of covered nursery beds for rice seedlings. Covered nursery beds have allowed earlier planting and harvesting, reducing damage from cold weather and typhoons. In conjunction with the use of rice varieties that mature at different times, covered nursery beds have alleviated the labor bottleneck at transplanting time.

Mechanization began to have a dramatic impact on rice production in the late 1950s, when small powered cultivators began to be widely adopted. This was followed by the arrival of rice harvesters. Japan’s present Institute of Agricultural Machinery was set up in 1962. Since then, automatic transplanting machines have been introduced, and have contributed significantly to speeding up this usually laborious work and combining with seedling raising in boxes to increase yields.

**Recent changes**

Networking the experimental stations of central and local governments has been very effective with respect to research into farming techniques. Prefectural experimental stations are engaged in research into practical farming methods suited to local conditions, following up the results of basic research carried out by the national research institutions.

Research activities and institutions have also tended to become more specialized in recent years. There are now research centers for field crops, agro-environment, agrobiological resources, veterinary science, livestock production, sericulture, horticulture, the tea industry, agricultural engineering farm mechanization, plant viruses, grassland, tropical agriculture, and ornamental crops. All these centers are organized and funded by the Agriculture, Forestry and Fisheries Research Council, which was set up in 1956 and which reorganized the agricultural research system six years later. The Council now emphasized interdisciplinary research and the application of high technology from other sectors to agriculture.

Most of the advances described above are equally applicable to small and large farms. But, particularly as far as mechanization and equipment are concerned, they have been applied mainly on small farms. In fact, for many years, Japan’s agricultural research concentrated specifically on the needs of small-scale producers. Since the revision of the Agricultural Basic Law, however, more emphasis
has been placed on improving agricultural efficiency than on research directly applicable to small-scale farming.

2.7 Efficient Use of Human Resources

According to one calculation, about half the increase in Japan’s agricultural output between 1880 and 1990 was the result of government expenditure on education, research, and extension services.

The extension services have been particularly important in informing farmers of advances in research. Technical advice has also been provided through the cooperative system. But without increased levels of literacy and education, this information could not have been disseminated successfully.

The Japanese education system comprises six years of primary education, three years of Junior High School, three years of Senior High School and four years of college education. About 98 percent of farmers’ children advance from Junior High School to Senior High School, and about 43 percent of these go on to college. Some of the Senior High Schools provide a special professional education in agriculture—the Agricultural High Schools. Most people who have opted for a career in agriculture now go to general or agricultural high schools, and the number of farmers with a college-level agricultural education is also increasing.

The growing diversity of Japanese agriculture has had a tremendous impact in recent years. As Japanese agriculture has moved away from intensive rice production, education has placed more emphasis on horticulture, livestock farming, mechanized farming, and the processing of farm products.

The decline in the agricultural labor force, particularly the drift away from rural employment of higher educated youth, created a critical shortage of farm managers. The Ministry of Agriculture responded to this problem in 1970 by creating a National Farmers Academy to provide the necessary education and create a new generation of modern farm managers with a wider vision than in the past. In 1977, the Prefectural Farm Youth Training Farms were reorganized to concentrate on producing farmers and farm managers.

Japan, even prior to these changes, had enjoyed the benefits of a generally high level of literacy and education. As a result, the extension services were able to introduce new farming systems and practices. The education system has now been restructured to provide training for farmers and farm managers able to handle the new Japanese high-efficiency, high-technology farming.

Chapter 3. Present and Future Rice Culture Techniques

3.1 Characteristics of Cultivation Methods to Achieve High Yield

A survey on the characteristics of rice giving high yields in excess of 9 to 10 ton/ha in brown rice weight shows that there are certain common traits: more than 400 panicles per square meter, more than 38,000 glumous flowers per square meter, and more than 80% as the rate of ripened grains.

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High-yield rice grows differently in cold and warm districts, and generally, its dry weight is smaller in cold districts and larger in warm districts. A similar difference exists in LAI (degree of leaf luxuriance) progress; LAI is large in warm districts and small in cold districts. There is also a difference in paddy/straw ratio; the proportion of paddy is large in cold districts and small in warm districts.

To achieve high yield, the selection of rice varieties to be used is also important; they must have strong culms and be resistant to diseases. Cold resistance is especially important for varieties cultivated in cold districts and adaptability to heavy manuring is important in the warm, southern districts. In central Japan, resistance to rice blast is important.

To be high-yielding, rice must be in a satisfactory nutritive condition, and the nitrogen nutrition is especially important. To achieve high yield, rice plants should absorb a large quantity of nitrogen, and the nitrogen concentration in their leaf blades must be kept high until the latter part of the ripening stage. This can be understood from the fact that, in high-yield rice, 20 to 30% of nitrogen absorbed at all stages is absorbed at the ripening stage. There are regional differences in the amount of nitrogen absorbed by high-yield rice. Generally, southern rice absorbs more nitrogen than northern rice of the same yield.

Everywhere in Japan, it is a condition of high yield that rice plants must be caused to absorb much nitrogen and, at the same time, lodging must be prevented and a high rate of ripened grains maintained. But, for this, soil conditions must be favorable. Important soil conditions are the great depth of cultivated soil, its fertility, and the suitability of subsoil percolation.

**Increase of Yield Per-ha**

Further progress will be made in the breeding of excellent rice varieties, fertilizing techniques, and techniques of disease and insect pest control. The yield of rice per unit area will be increased further by a well-balanced combination of these techniques.

**Qualitative Improvement of Rice**

Rice varieties bred in past periods of food shortages with the sole objective of increasing yield will be more and more avoided, and varieties producing tasty rice will be preferred. Under these circumstances, varieties of excellent quality will be bred, and cultural techniques aimed at the production of high-quality rice must be devised and carried into effect.

**Reduction of Natural Damage**

It is expected that the future will see further improvement of techniques to control rice blast, which has frequently caused heavy damage; sheath blight, which spreads in years of high temperature; and rice leafhoppers, which arrive in Japan across the sea from the south.

Against cool-weather damage, cold-resistant varieties will be bred; the time of rice heading will be advanced by raising excellent seedlings and by other techniques. In addition, growth-adjusting agents will be developed to reduce cool-weather damage.

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Furtherance of Labor Saving

Labor saving in the raising of seedlings, transplanting, weed control, the application of fertilizers, harvesting, and drying will make further progress through the development and improvement of machines and the development of new fertilizers and new agricultural chemicals.

As seen above, Japanese techniques of rice culture seem likely to develop further, and these advanced techniques will be able to greatly contribute to overseas rice cultivation.

It is remarkable that, in a demonstration of Japanese techniques in cold, northeast China in 1979, a yield nearly double the local yield was realized and drastic labor conservation was accomplished through the introduction of rice transplanter and combines. It is expected that, in tropical regions also, Japanese techniques of rice cultivation, if introduced, will go a long way toward increasing local food production.

(to be continued)