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Agricultural Technology and Development

Development and Agriculture

Technology transfer is most difficult in agriculture because of the differences in natural conditions, such as weather, geographical features, plant ecology, and irrigation, which overlap social and institutional restrictions.

When an agricultural technology is stable as a result of the limitations imposed by the existing national conditions and social system, the limits of production are empirically foreseeable. The size of the population that can be supported and the standard of living that people can afford are also thus defined. At this stage, agricultural technology forms a strong, independent system, that is stable and fixed and shows a resistance to new technology and the instability inevitable in a new technology.

If a population explosion occurs, the agricultural sector is forced to attempt to cope with the greater demand, but because of the fixed and independent nature of agricultural technology, a serious difficulty arises. The response by agricultural technology is either (1) to maintain the technology at the same level, aiming at extensive development, that is, enlargement of the area farmed, or (2) to realize spontaneous development in technology and productivity. Only in lucky situations are both possible.

However, in the case of a rapid population increase, such as a doubling in 20 years, the surplus required for either 1 or 2 will have been exhausted. Furthermore, the existing materials and facilities will have become worn from excessive use. Here lies both the fundamental difficulty of development and the urgent necessity for it.

Viewing the current situation in developing countries, we can see that the population explosion in Japan beginning at the end of the eighteenth century and the prevailing technological conditions were identical to those to be found now in the developing countries. In Japan also, rapid and abnormal expansion of urban population occurred, and as the great political changes of

the Meiji Restoration paralysed the functions of the existing system, the damages from natural disasters became serious and widespread. This caused a rapid increase in the number of uprooted peasants, and, as previously pointed out, many of them moved into the cities—to form new classes of urban poor. However, because the population tripled over a period of 100 years, the increase was not so explosive as in today's developing countries.

Japan found solutions in industrialization and raising agricultural productivity. One result of this, however, has been a loss of self-sufficiency in food, except for rice. In terms of calories, Japan has only 50 to 60 per cent self-sufficiency, a level similar to that in West Germany. A greater dependence on industry and specialization largely account for this.

Formerly in Japanese agriculture double cropping was common, and, at the initial stage of industrialization, Japan's agriculture sector was able to satisfy industry's demand for raw materials. But nowadays, farmers specialize in rice, and cultivation is carried out on a much larger scale. As a result, agriculture now depends on industry for fertilizers, agricultural chemicals, machinery, and fuels. Indeed, agriculture has deepened its dependence on the industrial sector.

Recently a nutritionist made the noteworthy observation that one reason Japanese agriculture rushed from the double-cropping system to a rice monoculture is that the calorie per unit production area is much higher (about two times) for rice than for wheat or potatoes, besides the traditional preference for rice. And, while rice requires an input of labour three times what is required for wheat, its employment absorption capacity is higher. In other words, the emphasis is on productivity of the land rather than on productivity of labour. This means, however, that the mode of rice production continually absorbed the growing labour force resulting from a rapidly expanding population and, simultaneously, pushed agricultural labourers close to the point of starvation.

The successful transition to rice cultivation illustrates the adaptability of Japanese agriculture and farmers in the face of changing needs and demands. One reason for this was that in Japan even the non-landholding tenant farmers were free to manage the fields they were renting—free to decide what to grow, how and when—unlike in the developing countries of today. In addition, as a result of having been monoculturized, Japanese agriculture has come to resemble colonial agriculture. The difference, however, is that Japan has also acquired industrial power.

With the aid of fertilizers and agricultural chemicals, Japanese farmers yield the greatest volume of rice per unit of area in the world. However, the use of chemicals, especially over the past 20 years, has caused the soil to lose rapidly the fertility that had been built up over more than 100 years by the use of organic fertilizers. The loss of fertility has necessitated additional input of chemical fertilizers. Input per hectare in Japan (372 kg) is the third highest in the world, following the Netherlands (789 kg) and West Germany (471 kg). When crop type is taken into consideration, Japan is the highest among countries cultivating rice, that is, 2.4 times greater than in China, 5.9 times

Indonesia, 12 times India, and 22.9 times Thailand (according to a 1980–1981 FAO survey). It should be noted, however, that these data do not account for individually supplied fertilizers, so that a simple comparison may not be valid.

A rising reliance on new fertilizers and agricultural chemicals, however, is not without harmful side effects; indeed, ecological changes will be produced that give rise to a situation like that described in Rachel Carson's *Silent Spring*. In the early 1970s, it was reported in Japan that 40 farmers die every year from poisoning by agricultural chemicals. It is said that chemical fertilizers have made the soil so hard that it cannot be turned except by tractor. While countermeasures are being applied, this is not a situation that can be quickly resolved.

The most promising measure is the recommendation for a breakaway from a rice monoculture to a diversification of crops. It is argued that, just as modern industrial technology has developed by virtue of converting the mass production of one commodity to the production in small quantities of various commodities, agriculture has no other course than to change from rice cultivation to the cultivation of different crops. Even though a market has been secured for farmers in which they are able to sell their rice at the world's highest prices, their relative income has continuously fallen and cannot support them.

This latter is one reason for the increase in category-2 rice farmers—that is, farmers with side jobs (who earn bigger incomes from the side jobs than from rice cropping). On the other hand, however, the average age of farmers is too high to expect an immense volume of labour input required by the change to crop diversification, and there are few among the younger generation willing to undertake the intensity and long hours demanded by agriculture.

The Change in Agricultural Technology, from Emphasis on Land Productivity to Emphasis on Labour Productivity

Pre-Meiji Agricultural Methods

During the more than 200 years preceding the Meiji Restoration, the Tokugawa shogunate promoted agricultural development in various ways, and it also exercised strict control over the use of natural resources. Despite the abuses that come with a long-term, stabilized political power, in general, the Tokugawa government was remarkably diligent in working to preserve the environment. This was because its material basis was in agriculture, which, of course, depends on nature. Thus, its policies of forestry conservation and river improvement constituted an important basis of the rice-culture economy.

In the shogunal domain of Kiso, famous for its Japanese cypress forests, cutting trees was strictly controlled by the administration. This kind of severe

control was exercised not only in Kiso but also in the domains of other clans, because the forest was regarded both as a supply of wood and as a major reservoir of water, essential for agriculture. Cutting small trees was allowed because it was believed to benefit the larger ones; the cycle of cutting and regrowth was wisely maintained.

In the Seto area, control over the forests (and forest resources) was relaxed after the Meiji Restoration and after the production of pottery for export had increased. As a result, the reckless exploitation of the forest resources began. The devastating landslides and floods that came as a result, however, eventually brought the exploitation to a halt. Attempts at the autonomous administration of basic natural resources, that is, plans for forest reserves, appeared, and progress was made in energy conversion (in the beginning, this took the form of a change in the place of supplies and then in the materials themselves). During the Edo period, the development of salt farms required the felling of trees in the domains of some clans along the Seto Inland Sea. For purposes of conservation and river improvement, however, it was necessary for these clans to reforest these areas.

Many reformers of agricultural technology appeared in Japan in the nineteenth century, and a number of agricultural handbooks became popular.[23] It is noteworthy that most of these books were concerned with the technology of civil engineering and, in relation to treating the water problem (construction of irrigation-fed paddies and dry-rice fields reliant on surface or underground drainage), urged crop diversification.

These practical reformers, or agricultural "wisemen," appeared on the scene just when the modern population explosion started. The crisis in agriculture and in the peasant household created a need for the wisdom and rich experience of these farmers, and in fact, their technology played an important role in increasing production.[24]

After the Meiji Restoration, new agricultural technology was introduced into Japan from Europe. Agricultural colleges were established in Tokyo and Sapporo. As Sako Tsuneaki, a student in one of the schools of those days, said: "What we learned was not Japanese agriculture but British agriculture." Tamatsukuri Yoshizo, another student, said, "We had no knowledge at all of Japanese agriculture." And it seems what was true for the students was true for the teachers (all of whom were foreigners). The innovative agricultural scientist Yokoi Tokiyoshi (1860–1927) was a later student of one of these agricultural schools. At the turn of the century, however, modern Japanese agricultural science had not yet been created.

Introduction of Horse Tillage and the Reorganization of Farm Lands

The development of the agricultural revolution through the efforts of the agricultural reformers of Meiji was ahead of the industrial revolution in Japan, much as in England, where the Norfolk agricultural system developed before the Industrial Revolution. The core of British agriculture was stock-raising and the cultivation of wheat. The technological system and conditions

of British agriculture were quite different from agriculture in Japan, where horses or cattle were used as work animals in the cultivation of rice, in which irrigation was the decisive factor.

However, the two did share some common characteristics. In the Norfolk system, scattered, small farm lands were integrated within enclosures, and a system of rotation of crops for cereals, pasture, and root-crop feed was adopted. An important element of this technological change was deep tillage by horse-drawn plough. Deep tillage using draught horses was developed in Kyushu (especially in Fukuoka) also as a new agricultural method. The Japanese counterpart of the British enclosure was a rearrangement of agricultural lands by which land that had been divided into small pieces was repartitioned or integrated into a larger unit. Irregular paddies were thus transformed into square or rectangular shapes with one acre as the basic unit. Odd-shaped fields disappeared, and planting in check-rows increased yield.

The rearrangement of farm lands and a reconstruction of irrigation and drainage ditches and straightening of farm roads (which increased transportation efficiency) constituted a fundamental reform of the system and contributed to greater efficiency of irrigation-based farming. As such, the reform required a consensus among all interested parties and also capable leaders co-ordinating the various interests. A well-planned reorganization of agricultural lands not only increased efficiency but also often meant an increase in total acreage. Even when progress was modest, it was of incomparable value for the peasants.

One technological characteristic of the Norfolk system was intertillage by means of drill and plow. Intertillage is a common component of agriculture in humid areas, and it has been taken for granted in Japan, while in the West, contrarily, it was more commonly associated with gardening than with agriculture.

The wheel-less plough in use in Japan was comparable to the Norfolk tiller.[25] This plough was an upright holding plough and its operation required skill and strength; however, because it made deep tillage possible and raised production, "ploughing instructors" were in demand throughout the country. Many improvements were made to it until eventually a new type of short-bottomed plough was developed that eliminated the heavy work required in operating the earlier wheel-less plough.

Then, at the beginning of this century, a short-bottomed plough with a head that could swing both right and left was invented; unlike its predecessor, this new swing-type plough made it possible to turn the soil in the same direction both coming and going. The plough was well suited to flat-land tillage and represented an epoch-making improvement in Meiji agriculture.

A basic difference between Meiji agricultural methods and Norfolk-type Western agriculture was that the latter required a large capital investment and relied on the economic advantage of labour-saving, large-scale operation, while Meiji agriculture was characterized by small, mixed-crop management. Since pre-Meiji times, a high input of labour was accepted as natural, and cultivation and the application of home-produced fertilizer using family

labour was the norm. This system inevitably led to small-scale farming and multiple cropping. The introduction of tillage innovations in Fukuoka, however, made possible a yield of as high as three times the national average. Once horse-plough tillage spread all over Japan, agricultural productivity was raised by 50 per cent.

The Fukuoka method was suitable only for dry fields, however, and so it could not be used in the wetland areas of eastern Japan. A huge investment in drainage facilities was necessary to create dry fields.

The Meiji government employed the Dutch-type low-water engineering method for agricultural development, especially for irrigation facilities, and while it was difficult to apply to the drying of fields and thus posed somewhat of a technological bottle-neck for Meiji agriculture, the government adopted the method because it accommodated the water-borne transportation system that existed at the time. Until the 1910s, when the railways became popular and a transportation system combining horses and the railway was established, water-borne transportation was vital for the transportation of heavy cargo, and, in general, was responsible for meeting more than 50 per cent of all transportation needs in Japan.

Flood damage caused by the low-water engineering system is said to have occurred every three years. But, as the flooding also provided needed enrichment to the soil, it didn't cause the farmers serious concern. Nevertheless, productivity was low and unstable, and measures were necessary to raise productivity and maintain it at a higher level. One such measure was the prevention of floods through high-water engineering, which was combined with a modernization of irrigation and drainage facilities. With the big flood near the turn of the century (1898) as a turning point, high-water engineering and, at the same time, irrigation using the major rivers gained widespread currency.

Establishment of the Modern Irrigation System

From the 1910s to the 1920s, notable improvements were made in water-supply facilities, in waterways and water distribution (to individual fields). Full-scale development started in 1923 with a government "project for the improvement of arterial waterways for irrigation and drainage" that stretched across several perfectures. This meant that, from around this time, the traditional small-scale irrigation integral to Meiji agriculture would undergo a complete transformation. Meanwhile, the adoption of high-water engineering corresponded to the spread into agricultural villages of the railway and other replacements of water-borne transporation.

Another important change occurred around this time; namely, a shift in agricultural investment initiative and activity from the large landlord class to that of small and medium landlords and landlord-farmers.

The price of rice, which had been on the rise since the beginning of the Meiji period, tended to fall in the 1910s as good-quality rice began to be produced in large quantities and supplied on a regular basis. This did not

mean, however, that Japan had attained self-sufficiency in rice or that the peasants could have rice three times a day. There were more than 4.5 million households of tenant peasants—more than 50 per cent of the agricultural population—and they had to pay an average of 55 per cent of the yield to their landlords for rent. Scholars have defined the relation between landlord and tenant at this time as "semi-feudalistic." Exploitation was harsh, and the population explosion intensified the competition for tenant farm lands, which made it possible for owners to maintain high-level rents.

Around 1890, one per cent, or approximately 40,000, of the agricultural population in Japan consisted of big landlords with more than 10 hectares of land each; 470,000 middle-sized landlords with 2 to 10 hectares; and 3.5 million landlords holding smaller parcels of land. From around the turn of the century, the big landlords and the wealthier middle-sized landlords became absentee landlords. As the big landlords became less interested in investment to improve the land, the middle-sized and small landlords, especially the landlord-farmers, began to initiate their own projects. This class of farmers did not have the financial capacity, however, to bear the expenses of constructing irrigation and drainage waterways off the major rivers, so it was necessary to rely on government aid.

The government adopted a formula in which the farmers first co-ordinated the interests of the concerned villages and towns, after which it reviewed a project's technological feasibility before accepting or rejecting it. The system encouraged the farmers to take the initiative, while the government avoided direct involvement in the difficult matter of the engineering aspects of the projects, leaving it to the farmers. The leaders of the agricultural associations involved in irrigation or land improvement projects were not necessarily from the influential landlord families. They had a thorough knowledge of the customs of each farmhouse regarding the use of farm land and irrigation water and a great talent for mediation and documentation required in negotiations with the government.[26]

Such strong leaders could be found in many areas of the country, but not all villages and towns were so blessed. And the differences resulting from their presence or absence are apparent even today (Hatate 1981).

The Emergence of Tenant Problems

Poverty and frequent tenancy disputes characterized Japanese agriculture in the 1910s and 1920s. The disputes began sporadically immediately after the Russo-Japanese War and increased rapidly in the 1920s. As a general tendency, they spread gradually from western Japan, an agriculturally advanced area, to eastern Japan, and after the depression of 1929, to Tohoku and Hokkaido. In response to the tenancy disputes (and also the labour disputes) the government intervened and brought harsh oppression to tenants. Eventually however, because it was obvious that increased agricultural production depended on tenant labour, the tenancy disputes were successful in bringing down the rents.

Many poor peasants were compelled to send their young daughters to work in cotton-spinning factories, receiving a small amount of advance money on indentures. The peasants' poverty aroused a strong sense of crisis among young military officers. As healthy young men were conscripted from poverty-stricken families, the militarists became seriously concerned about a further deterioration in living standards of peasant families, who were contributing their most important labour resource as soldiers for the state.

The military fascists urged the reform of "landlordism." As far as a perceived need for social reform was concerned, the right-wing and left-wing radicals shared the same understanding of the issues; the nature of the proposed reforms, however, differed greatly between the two. Whether reform in the name of "national polity" (i.e. the Emperor) or by workers under the name of socialism, the need for social justice was clear to both.

The rice riots of 1918 were the first eruption of the problem. A series of spontaneous urban riots continued across Japan until the autumn harvesting, bringing to light the serious structural problems (e.g., of allotment, production, and distribution) that post-Meiji modernization and industrialization had failed to remedy.

But Meiji-Taisho Japan was unable to solve these problems, and they were taken over by the "changeling" military fascists, who displayed their incompetence to cope with the problems in their rush to war and defeat. It was only after World War II that land reform was realized, as part of the "democratization of the economy," that Japanese agriculture finally saw a real turning point.

Under the restrictions of the landlord system and within the framework of Meiji agriculture, improvements in agriculture were inevitably confined to the development of technology that would effect improvements in water utilization and in small-scale farming tools. The turning point in agriculture after World War II came with a shift in emphasis from land improvement, i.e. increasing land productivity, to raising labour productivity through more efficient use of water resources and mechanization. Productivity policy, which was tied to the establishment of the landed farmer that the tenancy disputes helped to realize, shifted its priorities from the land to the farmer.

Electrification in Agricultural Villages and Water Utilization

In relation to electrification, there were some important technological changes that occurred. First, we must mention a small pump that gained wide use in the 1910s. This pump was used to raise water from lower-level irrigation channels and meant a great savings in labour. It was also used to drain water from paddy fields. The diffusion of the pump paralleled the electrification of agricultural villages, as it used surplus electricity generated by the hydro-generating system that had already been established. By the 1920s, the change-over from the engine-type to the electric-motor pump was progressing smoothly. The important point is that the widespread availability of this low-cost pump was made possible by industrial development.

Second, as the use of electricity in agricultural villages progressed, threshing and rice-milling machines became electrified, and, of particular importance, electricity was introduced into irrigation. In such areas as the Saga plain, where the level of water for irrigation was low, creek irrigation had been adopted, and electricity greatly simplified operation of the water-gate and liberated peasants from the grueling labour of pumping water by means of a pedal-powered water-wheel, which on its best day could supply no more than enough water for 1.5 hectares (Jinnouchi 1981).

Mechanization

The greatest change in post-war agricultural technology was mechanization through the rapid spread of the tractor and combine beginning in the 1970s. Mechanization dramatically increased productivity, and because mechanization in agriculture paralleled mechanization generally, fuel and repair parts were consistently available, thus eliminating many operational and maintenance problems.

This was in remarkable contrast to the failure encountered in attempting to introduce North American type large-scale (dry-field) farming into Hokkaido at its initial stage of development, a failure in part resulting from troubles with imported machines and lack of servicing capabilities. Before the machines were introduced, a rearrangement of farm lands—much like that when the horse plough for deep tillage came into use—was necessary, this time with a maximum unit of more than a hectare. Agricultural roads were expanded and reinforced, and because this was the second such reorganization, the difficulty was not so great as the first time.

The modernization, however, produced an unexpected change in the villages: a decrease of full-time farmers and a rapid increase of farmers with secondary jobs. Full-time farmers occupied 50 per cent of rural households in 1950, a rate that decreased to 21.5 per cent in 1965 and to 13.1 per cent in 1982. At the same time, the number of farm households decreased during this period from 3,080,000 to 1,220,000 and to 600,000, respectively; that is, by more than 80 per cent in 30 years.

On the other hand, farmers with sideline jobs whose major income was from agriculture occupied 28.4, 36.7, and 16.9 per cent of rural households in the specified years; the percentages for farmers whose income from agriculture was secondary increased sharply during the period, from 21.6 per cent to 41.8 per cent, and finally to 70 per cent.

Although the greater number of independent farmers resulting from the land reform contributed to the increase, it was mainly the result of mechanization introduced into small farming, where holdings of less than 0.5 hectares occupied 41.4 per cent, 0.5 – 1 hectares 28.2 per cent, and 1 – 2 hectares 21.2 per cent. Rational adjustment between the scale of operation and mechanization is usual in large-scale operations, but in Japan, farms larger than 5 hectares make up only 15 per cent of the total. This is the fundamental

difference from the EC-type operation, under which the upper 20 per cent of farmers yield 80 per cent of the total agricultural produce.

Consequently, a tendency has developed among full-time farmers who have mechanized equipment to subcontract or lease small parcels of land, for even small, scattered plots, when combined, add up to a substantial effect. The increase in part-time farmers since 1965 confirms this; that is, only farmers who thus accumulated extensive holdings could survive as full-time farmers. Furthermore, the shortage of land brought on by the urbanization that occurred during the period of high growth and super-full employment pushed land prices up, which, while raising the value of farm lands, also had non-farming urban commuters living alongside farm residents.

The enlargement of cultivation by full-time farmers under the subcontracting system is considered by some to be approaching its limit. They reason that because subcontracted lands are small and scattered, much time is needed to deliver machines and farming efficiency is deteriorating. If a return by farmers to a composite farming system is unfeasible, mechanization faces either stagnation or the necessity for a new reorganization of farm lands. Thus, we have arrived at a turning point. According to an early 1980s FAO report, the agricultural population per 100 hectares in Japan is 128, versus 98 in India, 1 in the United States, and 8 in Great Britain. Because agriculture in Japan is different in its basic conditions and crops from agriculture in the West, however, this kind of comparison is of little significance.

Rice cropping requires the input of highly intensive labour, even when mechanized. In terms of calories per production unit, however, rice is more advantageous than wheat. This is one reason why, after rejecting the recommendation to government authorities by American and European specialists ("development advisers"), farmers who settled in Hokkaido persisted in growing rice and made Hokkaido the biggest rice-producing area in Japan. They discovered they could get enough sunshine to grow rice despite Hokkaido's high latitude. Here we see the importance of not depending too much on foreign specialists.

With reference to the current situation in the developing countries, note that even though the central and local governments in Japan have made huge investments in irrigation facilities, the basis for agricultural development, their administration and maintenance, based in the villages, have been left in the hands of existing institutions. This has contributed significantly to the successful development of irrigation facilities in Japan, compared with the situations in India and Pakistan, for example. We are not "participation romanticists"; the important point is that the uselessness of the uniformism of bureaucratic control has been most readily observed in agricultural technology, in its administration and maintenance.

I wish to add that too often the role of agricultural experiment stations, which were established throughout Japan after the Meiji period, and the co-operative relations between these stations and local farmers have not been properly examined. We attach importance to the agricultural experiment sta-

tions because they have been able to respond to and meet local needs. Especially noteworthy have been the improvement in plant and horse breeds (in which the army was also engaged) and the subsequent improvement and diffusion of cultivation techniques. The task of raising agricultural technology to a mid-level in developing countries is urgent and, consequently, we are greatly interested in these stations. If there is sufficient interest, perhaps such experimental stations could be the subject of an international comparative study.

The agricultural schools have also played a crucial role. Most leaders in agriculture, including those of the irrigation associations, were graduates of agricultural schools. Many of the young leaders in agriculture today are university graduates, and their roles are still significant.[27]

The co-operative associations in Japan have also played an important part. Their activities pertaining to the supply of credit or financing have been treated in our sub-project on Technology Transfer and the Role of Financial Institutions.

A record by Namie Ken (1981), a pioneer in establishing libraries in agricultural villages, has been included in our project; it is a historical document devoted to Namie's work with farmers in a suburb of Tokyo. Namie was regarded by the military fascist regime of the 1930s as a dangerous political activist.

A study that does not mention fishery in relation to the population explosion and the food problem may be considered inadequate as a study of the Japanese experience. Nevertheless, within our limitations we had to adopt preferential policies in choosing our topics, which, we realize, opens the door to criticism, but which also ensures the unlimited possibility (ideally) for the kind of methodological exchange proposed by the United Nations University.

Very briefly, however, it is important to note that, with the increasing dependence of agriculture on industry (for fertilizers, pesticides, etc., for the development of agricultural productivity), and the resulting pollution, the fishery sector has begun to suffer great damage, which has brought these two sectors into intense rivalry.