12. DISTRIBUTION SYSTEM OF IRRIGATION WATER IN JAPAN

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I. Introduction

Paddy field irrigation in Japan has a history of more than 2 000 years. The paddy yield has been increased during this period in pace of following figure.

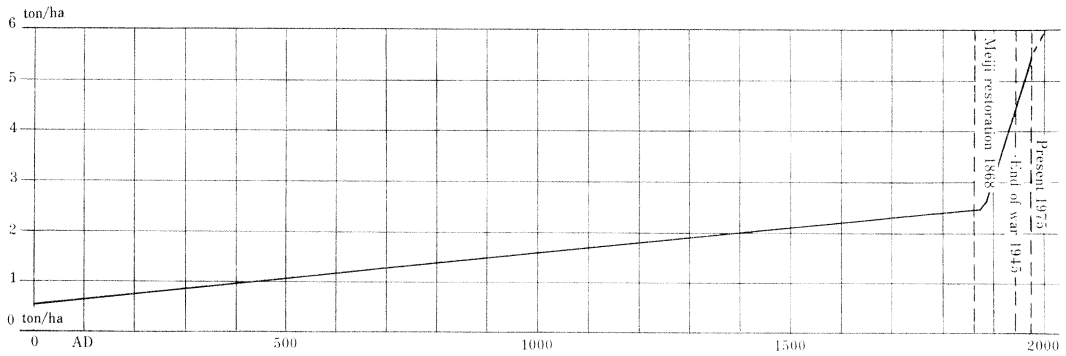

Fig. 1. Historical paddy yield in Japan

It is evident that there has been a remarkable progress since the Meiji Restoration in 1868. The average yield of 2.5 ton/ha has been doubled in less than one century.

Undoubtedly, improvement of varieties and better cultivation methods has been contributed to this successful result, but the most effective measure was the land improvement encouraged by the government. The Irrigation Association Regulation in 1889, the Arable Land Readjustment Law in 1899 and finally the Land Improvement Law in 1949 was established for accelerating the land improvement activities.

These laws and regulation were concerned irrigation, drainage, land reclamation, land readjustment and water management. Following these, the government has carried out a policy promoting proper training for engineers and subsidies for farmers to further the effective land improvement. As the result, agricultural infrastructures in Japan has been consolidated and then the yield has been sharply increased.

In early stages, when cultivation was carried out solely by man power or by domestic animals, the land readjustment works with small farm plots (less than 0.1 ha) was mainly carried out. Then, traditional irregular shaped plots have gradually disappeared, and dual purpose canals and ditches have been separated into irrigation and drainage independently.

After the World War II, the second stage of our land improvement began for corresponding with the emergency food requirement. The priority was given to the land reclamation works for an extension of our farm land. Water source develop-

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ment works such as the construction of dams and headworks were also carried out actively for the new irrigable land, parallel with these reclamation works.

The severe shortage of labour brought by rapid industrialization enforced the third stage to the agriculture. The labour productivity became more important than the land productivity. The farm mechanization has rapidly progressed chasing the industrialization. Then, the modern land consolidation works became an urgent necessity to meet the farm mechanization.

Big plots (more than 0.3 ha), wider farm roads (more than 3.5 m wide), deeper drainage ditches and pipeline irrigation systems are our target for the modern land consolidation in the third stage.

Actually (in 1975), modern land consolidation works have been completed in about 20 percent of the total paddy field area and are still being carried out at a rate of 2 percent of the total area per annum. Primary land consolidation works cover about 25 percent of the total area leaving approximately 55 percent of the paddy fields still unconsolidated in Japan. This means we have all types of distribution system from the primitive ones in the traditional system to the pipe line system in the modern consolidation area.

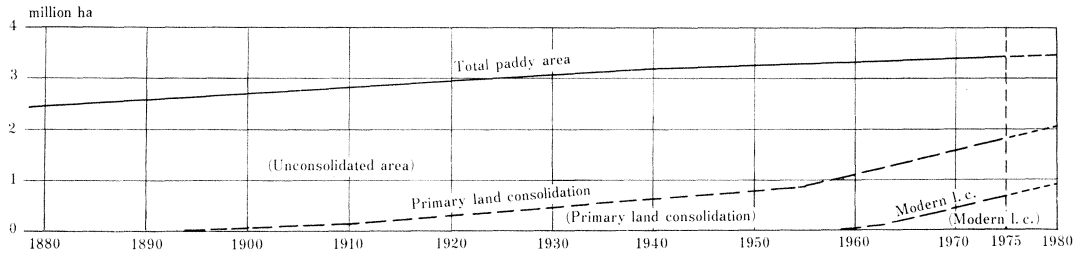

Fig. 2. Progress of land consolidation in paddy fields

II. Water Management and Irrigation Requirement

Although as Japan is located in a latitude 24° to 46° North, its climate differs to the extreme, paddy rice is cultivated from April to November throughout the territory with very few exceptions. In this period, the growing season varies corresponding to the varieties, the climates and the cultivation methods. Generally speaking, the nursery period is 30 to 40 days and the growth period after transplanting is 100 to 120 days.

In case the irrigation systems are completely furnished, early season cultivation methods (from May to August) have been introduced in order to protect paddy rice from cold weather of autumn in the northern parts, and from typhoons attacking in September in the southern parts of Japan. Where the irrigation water supply is not enough, they transplant paddies during the rainy season—from middle of June to beginning of July—and harvest them in November.

Annual precipitation in Japan is 1000 to 3000 mm, average 1600 mm. It might be quite enough for the paddy demand if its distribution were proper. But actually, sometimes heavy rains cause severe damages and droughts often attack the crops. That is why our ancestors had been making efforts to furnish irrigation systems for their paddy fields. Nowadays almost all (97%) paddy fields are irrigable as the result of their efforts.

The social condition is changing rapidly and paddy cultivation method is also being improved, especially in the last century. Our irrigation systems are demanded

to meet the new agriculture, and we are making efforts to improve them continuously.

Our traditional water management at paddy field is as follows;

(1) Nursery period: The water is ponded in furrow ditches and a surface of the seed bed is only saturated.

(2) Surface soil puddling: 100 to 150 mm of water is applied for land soaking and for preparation of transplanting.

(3) Transplanting to the primary tillering stage: Irrigation water is kept to a depth of about 90 mm in the field.

(4) Primary tillering to maximum tillering stage: Water is shallower as 40 to 50 mm.

(5) Mid-summer drainage: The water is drained off during the maximum tillering period, and water supply is suspended for 7 to 10 days in order to prevent ineffective tillering and promote the growth of roots.

(6) Young ear formation to booting stage: Irrigation is resumed again. The water is generally kept shallow.

(7) Booting to flowering stage: The water is kept deeper to meet much requirement for the plants and to avoid being felled by typhoons.

(8) Dough stage: The water is kept shallow after the flowering period and is stopped after the dough period.

Recently, the water management has been changing as follows.

(1) For making seedlings: Agricultural cooperatives contract with farmers for sprouting the paddy in a steam room. Then the farmers get the sprouts back to nurse in their own hotbeds in the northern parts of Japan. They irrigate them by hand spraying. Even in the warmer regions, farmers try to treat easy germination by using chemicals or warm water.

(2) Direct seeding: For saving labour, direct seeding method is now under trial. This method needs no water for land soaking and for preparation of transplanting but daily requirement for irrigation is bigger than the ordinary method.

(3) Shallow water applying: Where the irrigation system is complete, farmers keep water shallow in their fields to give better condition for the plant growth. They apply three centimeter at maximum and even no standing water on the field surface. This method may prevents seepage loss.

(4) Intermittent irrigation: After the mid-summer drainage, an intermittent irrigation is applied until harvest. In this case, irrigation requirement tends to become bigger than the usual method because the proper rotation of irrigation is hardly practiced.

Japan has 36 million hectares of territory and average 1600 mm of rainfall annually, and its paddy field is only 3.5 million hectares. That is why, it can be said that we have enough water for our narrow paddy field. Therefore most farmers tend to use enough water for getting maximum profit in the yield and for minimum labour.

In the special area where water supply is limited, or during a period when water shortage, farmers of course may try to save water sacrificing their labour and yield. But in most area, water saving has not been a big problem for our farmers.

Recently, a demand for industrial use is becoming bigger remarkably, and the total water supply is limited. Our balance sheet of water is facing a turning point. The irrigation water must be saved for national growth.

III. Traditional Water Distribution System

As traditional water distribution systems have been developed spontaneously, the

size and shape of field lots are subject to such restrictions as topography, natural features of the earth and land ownership. The shape of field lots are irregular because they are in many cases surrounded not only by meandering rivers and roads but also by borders provided in parallel with counter lines. The size of field lots are relatively small in general, for instance, an average size of 0.05 ha in an open country and from 0.01 to 0.03 ha in a mountainous area.

Most irrigation canals or ditches are used as drainage facilities by providing the check, and are either earth or weed covering the slope surfaces of the embankments. As for the water check, a wooden or masonry gate is sometimes provided. In many cases such handy materials as sand bags, pieces of wooden plate and wooden or bamboo poles are used for controlling the water discharge.

Concerning the water supply from an irrigation ditch to the paddy fields, farmers generally cut through the borders of a field with a plow, or install a clay pipe in the border. In case of dual purpose ditch, the intake is also used as an outlet.

Before the 19th century, a border of relatively wide surface and a crest of the ditch banks had been used as a farm road. These were of sufficient width for the persons and oxen. Recently, new road net works have been provided for even in the traditional fields which serve for modern traffics.

IV. Primary Land Consolidation

Land consolidation works in early stage were carried out to prepare a field lot of 0.07 ha or so, but after few decades the standard size of a field lot was determined to be 20 × 50 m i.e. 0.1 ha rectangular.

Each lot is furnished by an irrigation and drainage ditch independently and a farm road runs along a side of the lot. So that the farmer can manage his lot on his own way.

Farm ditches in the early land consolidation works were made of earth covered by weeds, but recently concrete lining have been provided for them as well as prefabricated flumes. An earthen (vitrified clay) pipe or concrete pipe and a concrete inlet box are provided for intake. A timber gate, rags, soil or vinyl chrolide sheets are used for controlling the water supply.

The terminal facilities do not have any measuring devices because the quantity of consumed water has not been taken into consideration for an assessment of the irrigation water supply.

As for the drainage ditches, complete lining is rarely seen in Japan. In general, concrete blocks are placed on the surfaces under the ordinary water level, and sodding either strip or blanket the upper section for protection.

The density of farm roads and ditches in a standard block in a primary land consolidation area is as follows:

farm road: 150 m/ha farm ditch: 200 m/ha farm drain: 100 m/ha

V. Modern Land Consolidation

Modern land consolidation works have been carried out with the new design standards for the past thirteen years to cope with the modernization of agricultural infrastructures for utilizing heavy equipment. In these works, farm lot sizes are designed to be more than 0.3 ha and farm roads, irrigation and drainage ditches are constructed to fit the farm mechanization. The standard shape of a farm block is the same as of the primary land consolidation as shown in figure 3.
(in case of primary one, size of a lot is 50 m × 20 m, block size is 100 m × 200 m)

Farm roads are designed in width of 3.5 to 5 m paved by gravel or sometimes by asphalt so that a heavy machinery can go through.

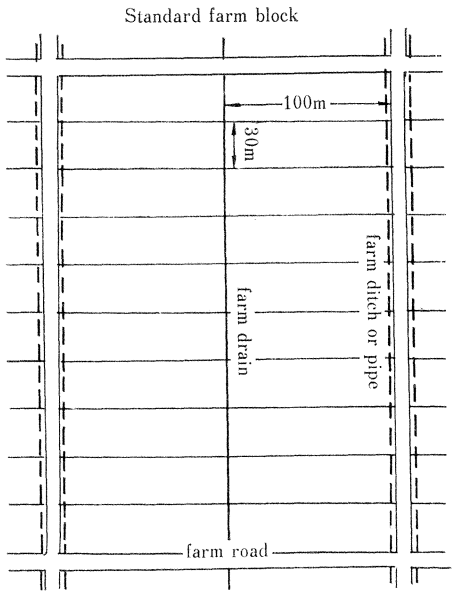

Fig. 3. Standard farm block

For the irrigation system, an open channel with concrete lining or a prefabricated U-flume are generally used. However, pipe line networks have been introduced also for the smooth operation of farm machineries and for easy water management. In general, the construction cost of a pipe line system is higher than that of an open type system, but the former has more advantages from the view point of making the maximum utilization of the area for the facilities, proper water management and easy traffic of farm machinery. Moreover, introduction of the pipe line system is sometimes essential for automatization and centralization of water management. And it will be our future irrigation system.

Automatic intake devices have been developed in many types and some of them have already been used in paddy fields on trial basis. They are designed to control the water level in a field by operation of a valve or gate moved by buoyancy or electric power. It may be possible to carry out an automatic rotation of intermittent irrigation by combined operations of some valves or gates.

Under drain systems are also developed widely in Japan where the water table is high and the water contents in the soil is more. It is possible that even drainage systems wlil also be burried in the soil just like the pipe line irrigation systems. Then, there will be no obstacles on the field for machinery operation.

An automatic control pipe line system for irrigation and drainage is the final solution for the water saving compatible with the labour saving in Japan.

Question and Answer

Wiyoto, Indonesia: In your technical report, it is mentioned on page 6, density of farm ditch is 200 m/ha.

But it is also told in the Symposium by Dr. Soekarso Djunaodi, that according to ADB workshop the density is only about 60 m/ha.

Please explain the difference.

Answer: Farm ditch density of 200 m/ha is that of a standard farm block of the primary land consolidation. In the traditional system, it is about 60 m/ha or so.

J. A. Lewis, Sri Lanka: Under the modern land consolidation scheme. On what basis the farm lot 100 m × 30 m was decided. Was it on the basis of farm out let and on the physical properties of the soil and on the water depth requirement for rice.

Answer: The farm lot size 100 m × 30 m is decided as follows:

(1) Topography; bigger size needs much cost for earth moving.
(2) Drainage; longer lot (more than 150 m) has difficulty for drainage.
(3) Ownership of farm land; average farm holding is only one hectare, bigger lot gives them a difficulty for reallotment.
(4) Heavy machinery operation, the bigger, the lot, the more, the efficiency, but increasing rate of efficiency of machinery comes at a turning point at 0.3 ha lot. Of course, the physical properties of the soil effect largely to the drainage condition, so we adjust this standard accordingly.

S. Okabe, Japan: (1) To what extent do you estimate the total water requirements per unit paddy field have been increased after establishment of the modern type of land consolidation as compared to the traditional system and also to the primary land consolidation?

(2) What proportion of the irrigation systems in the country has a dual purpose; irrigation and drainage?

Answer: (1) Average 10–15% of water requirement increases after land consolidation. Increasing rate varies mostly due to drainage improvement and to earth moving. If no change in drainage condition and little or no earth moving, usually no increase in water requirement.

(2) There is no exact datum about the subject. It is assumed 30–40% of the total paddy field is still under the systems of dual purpose canal.