Summary

This report is a compact paper on the features for Japanese Paddy Field Irrigation. From the aspect of this feature having a close relation with the level of land improvement, the consolidation of main irrigation and drainage facilities, land consolidation, and development of pipeline system are discussed. And then, the basic concept of irrigation planning and its differences among foreign countries in irrigation water planning, and water requirement due to land use are also discussed. Finally, the practice of water management and the organization of it are explained.

The features of Japanese paddy field irrigation were compared with those of the Southeast Asian countries and the United States of America. The differences seemed to originate in approaches to land consolidation, water requirement planning, and water management systems. The following discussion focuses on these three points.

I. Paddy Field Land Consolidation

1. Consolidation of Main Irrigation and Drainage Facilities

Before World War II, the level of main irrigation and drainage facility consolidation in Japan was very low. However, during the 20 years from 1955 to 1975, consolidation advanced rapidly.

First, to supply irrigation water to paddy field areas in drought, water resources development, mainly via reservoir construction, was carried out over a wide area, from Hokkaido to Kyushu. By this means, the areas of annual drought rapidly decreased.

At the same time, the Goguchi project, which involved making one headworks out of many, was carried out throughout Japan. Before this project, many headworks of the old type, which were constructed on each river, were frequently destroyed by flooding, and subsequent stable intake of irrigation water was not possible. With the progress of this project, stable intake of water could be achieved by just one modern, strong headworks, constructed upstream on a given river.

With the establishment of such headworks, irrigation facilities inside project areas were completed; water could then be supplied to each paddy field plot. The consolidation of these facilities remarkably widened the breadth of irrigation.

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Paddy field drainage projects were also vigorously carried out. Downstream on large rivers, representative paddy field areas were developed; these areas had poor drainage before World War II. The farmers in such areas had trouble cultivating their paddies, even at low efficiency. After World War II, drainage conditions were remarkably improved by drainage system consolidation, short-cuts, and pumping station construction.

2. Development of Land Consolidation

Paddy field lots in Japan before World War II, as in Southeast Asian countries nowadays, were very small and irregular. In such paddies, mechanization and work efficiency was very low. Beginning in the mid-Meiji Era, land consolidation (denku-kaisei) was carried out. In this consolidation the paddy fields were made rectangular, 18×54 m, and 10 a in area. In 1963, a new land consolidation project was established, which increased the area to 30 a (30×100 m), with separate
irrigation and drainage canals, the former being located along farm roads and the latter along the opposite sides of lots. Because both the irrigation canal and the drainage canal are located along the short side of the lot, they are spaced 200 m apart. The density of these canals is very high compared with those of Southeast Asian countries and the U.S.A.

As indicated above, each paddy field lot is linked to irrigation and drainage canals, thus making available free water management and leaving the choice of crop kind and species to the farmer.

In Southeast Asian countries, such land consolidation has not yet been carried out; therefore, irrigation and drainage canal density is very low. For this reason, even if water resources are developed, the water will not reach each plot and cannot be used for irrigation. By contrast, in a representative rice area in Sacramento, California, the counter-plotting of paddy fields is well-known: land consolidation projects began there about 10 years ago, and the rectangular plots have gradually increased.

3. Development of Pipeline System

About 20 years ago, irrigation canals were made of earth and operated on the gravitational system. With the development of land consolidation, however, the pipeline system is coming into use for irrigation canals. The pipeline system has the following advantages: irrigation water can be freely used, as the farmer wishes; the conveyance of water is independent of topography; the land used for a canal can be reclaimed; there is no problem with dirt clogging the canal.

Under the pipeline system, farmers can supply irrigation water simply by opening the valve of the pipeline system. However, adequate water cannot be supplied if the design and operation of the pipeline system is not adequate. Because pipeline system capacity is determined by the water requirement for puddling (shirokaki), which is usually the maximum water requirement, the pipeline capacity must be several times the ordinary water requirement. For this reason, if one farmer supplies irrigation water at a high level, another farmer will be unable to supply his fields because of the pressure deficit. Therefore, in employing pipeline system, equal allocation of water and adequate operation of the system should be considered.

II. Water Requirement Planning

1. Basic Concept of Irrigation Planning

There are many variations in the basic concept of irrigation planning. In the irrigation planning flow chart shown in Figure 3, the sum of evapotranspiration and seepage from a paddy field is called "gensuishin" (water requirement in depth); this is the basic quantity for irrigation planning. The net water requirement consists of gensuishin plus management water requirements in lot, minus effective rainfall for that lot. This net requirement is the water needed for lot irrigation.
The gross water requirement consists of the net water requirement plus management water (conveyance loss + management water for facilities) minus supplementary reserve water in the planning region. If return flow is used in this area, it is subtracted from the gross water requirement and added to the regional water requirement for purposes other than irrigation; the total amount of intake water from the headworks is determined in Japan in this way.

2. Differences Among Countries in Irrigation Water Planning

The differences among countries fall into two major categories. First, in Japan, the fundamental factors in irrigation are evapotranspiration (ET) and percolation, while in other countries only ET is a factor, and percolation is loss. For this reason, there is quite a difference in net water requirements between other countries and Japan. The irrigation water requirement in the Southeast Asian countries, for example, seems to be insufficient, owing to the lack of land consolidation and the above differences in the concept of factors.

Second, in Japan, management water is counted at each level: main, lateral and tertiary canal. In other countries, however, this management water is considered to be loss. This leads to quite different concepts of allocation efficiency. This concept is the same in adding total excess water for net water requirements, but there is quite a difference in the sense that excess water is necessary as management water only vis-a-vis loss in conveyance.

3. Water Requirement Due to Land Use

With changes in paddy field land use and land consolidation, the water requirement changes. Water planning should take this fact into full consideration.
The causes of water requirement changes are drainage, land consolidation, rotation of upland and paddy, direct seeding system instead of transplanting, etc. If the drainage canal is consolidated and subsurface drainage is carried out, the quantity of percolation is increased by the lowering of this groundwater level and the increasing soil permeability. If drainage and irrigation canals are separated by land consolidation, the return flow comes to zero and, therefore, water use to one chance. If a paddy field is used for upland crops and then returned to paddy use again, the quantity of percolation is usually increased owing to the increased permeability of the soil. The water requirement for puddling in particular is remarkably increased. In the direct seeding system, puddling water is not needed, but initial ponding water is needed.

The changes in water requirement due to land use changes are generally mentioned above. The extent of change depends on soil characteristics, groundwater level, type of land consolidation, level of drainage, etc. Therefore, basic investigations should be conducted to gather fundamental data.

III. Water Management System

1. Practice of Water Management

In Japan, to increase rice production and quality, very precise water management is usually carried out. Representative water management is shown in Figure 4.

Rice culture in Japan is fundamentally based on the transplanting system in ponded paddy fields. This is quite different from the system in the U.S.A. where rice culture is based on direct seeding in ponded paddies. It is quite similar to those of the Southeast Asian countries, but nurseries are small since transplanting machinery is used.

As shown in Figure 4, first soil puddling (shirokaki) is carried out, followed by transplanting to the paddy, with growth beginning in a few days. The maximum

![Figure 4 Growing stage, works and water management](image)

**Figure 4** Growing stage, works and water management

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tilling is 30—40 days after transplantation; heading is at 70—90 days. The rice can be harvested about 40—50 days after that. During this period there are several other tasks, such as disease and pest control and spraying of fertilizer. Otherwise, ponding is continued from transplantation to maximum tilling, with intermittent irrigation usually applied after mid-summer drainage.

Outlined above is the standard pattern of rice cultivation scheduling and water management in Japan. However, there are several regional variations, depending on the variety of rice plant, paddy conditions and climate. For example, in Tohoku and Hokkaido, in the northern part of Japan, mid-summer drainage and intermittent irrigation are usually not employed and deep ponding irrigation is used when the weather is rather cool.

2. Organization of Water Management

Water districts, called "tochikairyoku," are the basic organization of water management. A tochikairyoku, a corporation organized by the farmers who benefit from the irrigation, is established when the land improvement project has begun, in return for the benefits received.

Each corporation is administered with the fees incoming from the farmers involved. This charge is usually proportional to the irrigating paddy field area. The money is spent on the water management and maintenance of the irrigation facilities according to determination by meetings of representative farmers. In addition, governmental subsidies are applied to land improvement projects, though not to water management and maintenance.

The duty of the corporation is major facility maintenance. Small facilities are usually managed by the farmers involved. The facilities managed by the corporation include main reservoirs, headworks and diversion weirs in the main canal, etc. Such main facilities are operated in accordance with established rules, with some allowances made for the conditions in a given area.

When very severe drought conditions exceed the planning conditions, irrigation
water is saved at several levels. Apart from this, the farmer can use the water freely within the rules determined by the corporation. In this case there are two systems. In one, the valves for each paddy plot are operated by farmers themselves. In the other, the valves are operated by a technician nominated by the group of farmers. In the latter case the allocation of irrigation water is more equitable.