WATER CONTROLS IN A JAPANESE IRRIGATION SYSTEM*

JOHN D. EYRE

IN JAPAN, as in other rice-growing countries, successful paddy cultivation depends on the amount and seasonality of the agricultural water supply. Rice, unmatched by other cereals in its thirst for moisture, demands water continuously from the time the seeds are sown in the spring until the fall harvest. Lack of sufficient water in the paddies through neglect or drought results in reduced, low-quality yields, and, in extreme cases, in crop failure.

Unfortunately, the Japanese paddy farmer is unable to depend on rainfall for the large amounts of water needed between April and October. Although statistics seem to indicate that the total rainfall is sufficient for agricultural needs, rains are sporadic and ill-timed for maximum benefit, and they fall short of meeting paddy requirements. The drizzly monsoon rains of June and early July, even though they fluctuate markedly in time of appearance and reliability of volume and duration, are best suited to the Japanese agricultural cycle, since they normally fall when rice seedlings are being transplanted in the sodden paddies. During the other rainfall peak, in the fall, rains commonly appear in the company of violent typhoon winds that leave damaged and flattened rice in their wake. The rice plants and their heavy heads of grain become saturated, so that farmers must hang the sheaves until they are dry enough for threshing. Between the early-summer and fall rainfall extremes, during a critical part of the growing season, rains often do not fall for long periods.

To offset the poor timing and undependability of the rains, the Japanese have made impressive advances in irrigation based on surface and groundwater resources. The islands are liberally endowed with surface water, especially in the form of streams and rivers rushing seaward from the interior highlands. That the Japanese have been quick to recognize the irrigation

*Data for this article were collected in Japan during two periods of field research: 1950–1951, with a fellowship granted by the Social Science Research Council; and 1953, with funds awarded by the Ford Foundation. Thanks are due Dr. Richard K. Beardsley of the University of Michigan Center for Japanese Studies in Okayama City for his company on bicycle trips through the Twelve Village irrigation system and neighboring areas and for assistance in collecting and evaluating irrigation data. All photographs were taken in August-September, 1953.

➤DR. EYRE is assistant professor of geography in the University of Washington, Seattle.

potential of these bodies of running water is shown in a government survey of agricultural water use.[1] Of the more than seven million acres of paddy[2] in Japan, 65 per cent are dependent on river water. Dependence on rivers for irrigation is greatest in central and northern Honshu and Hokkaido, a reflection of the excellence of surface water resources and the lack of attention paid alternative sources.

The government report also indicates that ponds, springs, and lakes are less important, though still significant, in the national irrigation picture. Steep stream gradients that hasten silting, the high value of cultivated land, and the location of good damsites far from the productive plains have ruled out any large-scale erection of big reservoirs strictly for irrigation. Yet, through the centuries, the Japanese have concentrated on small ponds dug in slopes with such success that pond water now serves 21 per cent of the paddies. Ponds assume special importance in the plains bordering the Inland Sea, in western Japan, where rainfall is scanty and agricultural lands are among the oldest in the country. In mountain villages springs feed many paddies and altogether supply 5 or 6 per cent of the agricultural water. Lakes are little used for irrigation in Japan because of their relative scarcity and the difficulty and expense of lifting water to neighboring paddies.

Although most of the surface water supply is at least partly utilized, abundant ground-water bodies known to exist in many of the alluvial lowlands have hardly been tapped. Little more than 1 per cent of the irrigation water is drawn from wells, and they are usually pressed into service only in paddies adjacent to stream beds or are used as supplementary sources in times of drought.

In view of the universal dominance of rice in the Japanese rural economy and land-use pattern, it is not surprising that irrigation controls are of primary concern in village economic, political, and social life. To ensure the uninterrupted availability and equitable distribution of irrigation water, an unusual degree of cooperation is essential among individuals, groups, and the administrative agencies charged with water management. Dams, canals, diversion devices, and the like must be kept in satisfactory operation through

[1] The last systematic national survey of irrigation sources was made by the Japanese government in 1907. Despite the age of the report, it is felt that the irrigation pattern there outlined is in keeping with present reality. Findings of the 1907 report are summarized in an outstanding work: Toshio Kitamura: Nihon kangai suiri kanko no shi-teki kenkyu [A Historical Study of Japanese Irrigation Customs], Tokyo, 1950, pp. 476–477 (in Japanese).

[2] Paddy acreage in Japan totaled 2,875,925 *cho* (one cho equals 2.45 acres) in 1950. Quoted in "Japanese Crop and Livestock Statistics, 1876–1950," *General Headquarters Supreme Commander for the Allied Powers, Natural Resources Section Rept. No. 143*, Tokyo, 1951, p. 115.

their combined efforts. Water laws must be passed, taxes levied, and water disputes arbitrated. Cooperation of this degree certainly is not unique to Japan, but there is no doubt that water controls there are of uncommon complexity. For the most part, the complexity stems from the extreme fragmentation of irrigation systems and the cooperatives that control them, and from the force of tradition that permeates most irrigation arrangements.

The total number of irrigation cooperatives in Japan, both formal and informal, is well over one hundred thousand. The large number is due in part to the many, diverse water sources utilized and the dispersion of the paddies irrigated. Another explanation is found in the historical process of land occupance in Japan. The conversion of wild lands into paddy has been a long, sporadic process that has necessitated the fixing of separate irrigation facilities for each reclamation project. In recent times, the fragmentation of irrigation systems has proved a hindrance to attempts at scientific water management, though in some instances unified control has been achieved in conjunction with large-scale land improvement works.

In turn, the manifold irrigation systems help explain the persistence of traditional water controls despite governmental attempts to institute more efficient operating methods. As is true of most other phases of Japanese society, controls exercised in irrigation are a compound of the old and the new, the traditional and the scientific. Under the urging of government specialists and with allocation of government funds, better engineering methods are gradually appearing in many long-established irrigation systems. Likewise, many large irrigation cooperatives are now operated in accordance with formal laws. However, the pace of change is slow, and throughout Japan the rule still is informal physical and human controls that originated in the distant past.

There is no specific body of water law. To some degree, this lack is attributable to habitual Japanese reluctance to resort to the law for settlement of disagreements. But more directly, it is the result of the fact that each irrigation cooperative has its own set of traditional procedures. If contested, traditions involved must be weighed with the merits of the demand for their alteration or abolition, and a compromise reached through discussion. Only rarely does a water dispute reach the law courts. The uniqueness of each irrigation cooperative means that both its water traditions and its relationships with other irrigation-control organs must be considered separately, rather than as components of a uniform water law. Individuality of this degree adds variety to the study of Japanese water controls and is an important consideration in analysis of the structure of rural society.

The Twelve Village System

A well-known irrigation system, that of the Twelve Village Irrigation Cooperative (*Junikago Yosui Kumiai*) in Okayama Prefecture (Fig. 3), has been selected as a case study. Besides having an unusually long and well-documented history, replete with a formidable set of rigid water traditions, the system is located in one of the most prosperous and scientifically managed agricultural areas in Japan.

The Twelve Village system has the distinction of being the oldest and the second-largest irrigation network in Okayama. Located in the western Okayama Plain, it derives its waters from the Takahashi River, at the point where the river debouches on the lowlands, and thence it flows in a gentle arc toward Kojima Bay. Along its 20-mile course water is diverted into branch canals that feed an average 10,000 acres of paddy, an acreage increased by one-third when surplus water is available for paddies at its southern terminus.

The present system is the culmination of centuries of effort on the part of farmers and rulers of the western plain to lead river water to interior paddies suffering from periodic water shortages. Exactly when the system was initiated is not known, since its origins predate written accounts. The very name savors of the distant past, based as it is on the *go*, a political subdivision that was established in the seventh century and disappeared in the nineteenth century when the feudal order was abolished. According to local tradition, the general lines of the present canal network were laid out by an Okayama savant, Senotaro Kageyasu, in 1182 upon orders from the ruling lord to improve rice production. The existence at that early date of a large expanse of productive paddy and the rudiments of an extensive irrigation system suggests that procedures were evolved in an even earlier period, and the probability is supported by the antiquity of human settlement in the parts of the plain through which the system passes.

Modern engineers may well marvel at the technique attributed to Kageyasu in laying out main sections of the canal. He is said to have had such an accurate eye for elevation that he had assistants mark his selected path as he rode horseback across the plain, and along this course waterways were subsequently constructed. Since that time, many refinements have been made, but except for newly reclaimed paddies added to the southern end, the general layout of eight centuries ago still persists.

Paddies served by the Twelve Village system are noted for their intensive cultivation and high productivity. Summer and fall find the countryside blanketed with rice (Fig. 1), and during the following two seasons paddies

FIG. 1—Small irrigation ditches serve paddies in Oishi Village. The paddies are outlined by rows of soybeans.

FIG. 2—Hollow log used to transport water from paddy to paddy across the main canal, here (Oishi Village) only a few feet wide. The old woman has just finished doing her laundry in the canal.

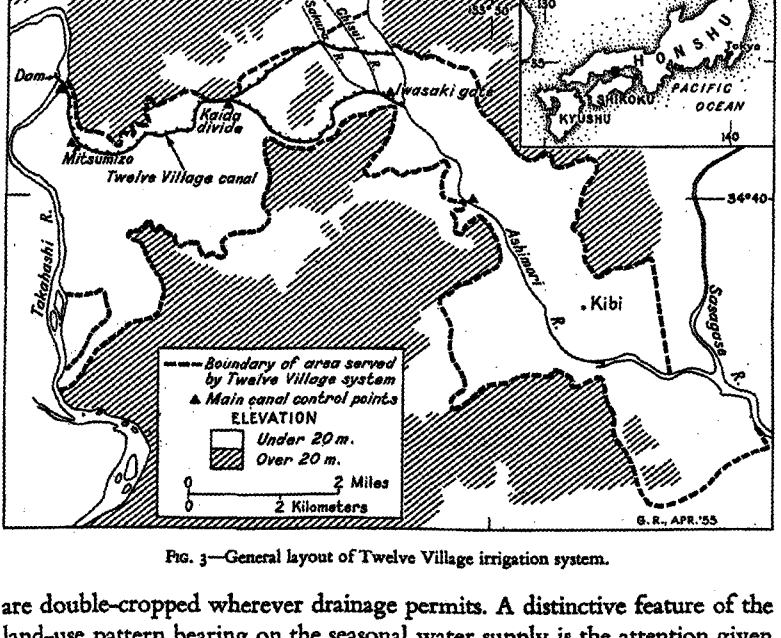

FIG. 3—General layout of Twelve Village irrigation system.

are double-cropped wherever drainage permits. A distinctive feature of the land-use pattern bearing on the seasonal water supply is the attention given *i-gusa*, a reed used in the manufacture of the matting that covers the floors of most Japanese homes. Like rice, the reed has a high moisture requirement, so that its cultivation following rice, from December to July, in many paddies requires a small amount of irrigation at a time when paddies are normally fallow or support a dry crop. Paddies differ in their water demands and in the ease with which they can be irrigated, because of critical variations in elevation, soil composition, field construction, and depth of the water table. These differences often result in waste of water and give rise to an unending chorus of farmer complaints.

LAYOUT OF THE SYSTEM

In its broad outlines, the layout of the Twelve Village system is fairly simple (Fig. 3). Water diverted from the Takahashi River moves eastward in a main canal, which later divides into two sections and merges into the small Ashimori River flowing south into Kojima Bay. Thus the system has two distinct personalities. The canal section is ancient, its operation is permeated with tradition, and its water is put to many nonirrigation uses. The

Ashimori River section is relatively modern in construction and equipment and plays a more impersonal role in the life of the countryside.

Water is drawn from the Takahashi River by means of a long diversion dam built diagonally across the stream bed (Fig. 4). Formerly made entirely of local materials, the dam now boasts solid-concrete terminal sections, each 148 feet long, and a 738-foot central section of loosely piled river rock (Fig. 5). Every fall during high water some part of the central section is washed away, which must be replaced by spring. Sturdier construction capable of withstanding floodwaters has been ruled out by the strenuous objections of downstream irrigation cooperatives fearful of water shortages during the growing season. Further recognition of downstream interests is shown by a small spillway set in the eastern terminal section of the dam, over which pours water in excess of Twelve Village needs.

Water diverted by the dam enters the main canal through a large pipe that penetrates the river dike. As with the river flow, little attention has been given to measurement of the volume of water drawn off into the system. It is known that the intake pipe permits the entry of a maximum seven tons of water a second, but the frequency of the maximum, the volume of average flow, and the degree of seasonal fluctuation have never been ascertained. Water supplies are either enough or not enough. If enough, operations continue serenely, but shortages are soon revealed by the farmers' protests and, if serious, result in the imposition of allocation measures.

The initial section of the main canal, about 20 feet wide and six feet deep, has a recently installed concrete lining as far as Mitsumizo (Three Canals), where branch canals draw off water for neighboring paddies. The efficient concrete dam at the water divide, like a few other modern engineering refinements made recently, reflects increased cooperative awareness of the need for maximum use of irrigation water. But the retarding force of tradition remains strong enough to have compelled dimensions to conform with those of the ancient wooden barrier formerly used and not with more recent estimates of water requirements. Local and downstream interests permitted erection of the concrete structure only after conferences and investigations had proved to their satisfaction that tradition was not being broken and that their rights were not in jeopardy.

Beyond this point the main canal continues eastward toward the Ashimori River, gradually decreasing in size as it is tapped by more than two dozen secondary canals. Gravity alone forces water through the narrow mouths of some of the secondary canals, but a variety of old devices still in operation

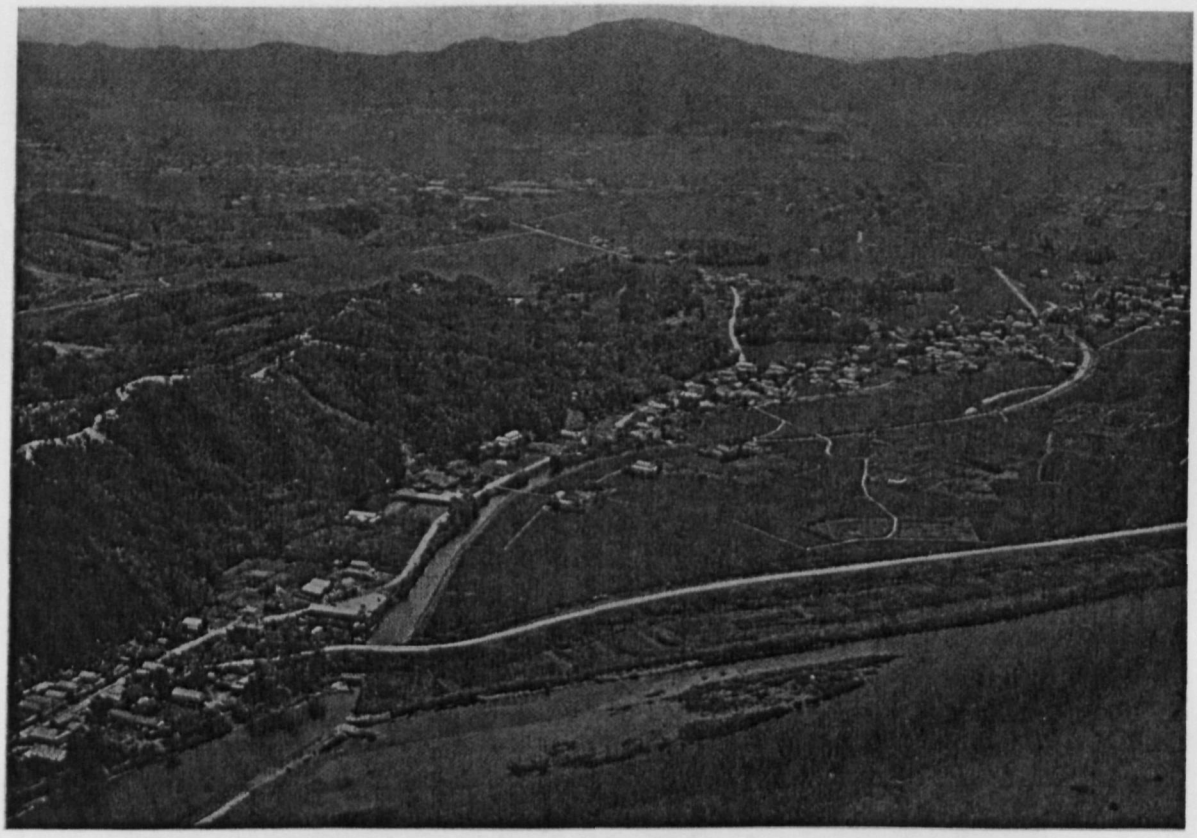

FIG. 4—Aerial view of beginning of Twelve Village system, showing diversion dam across the Takahashi River (left foreground). The main canal bears to the left across the densely settled plain. (Photograph courtesy of University of Michigan Center for Japanese Studies.)

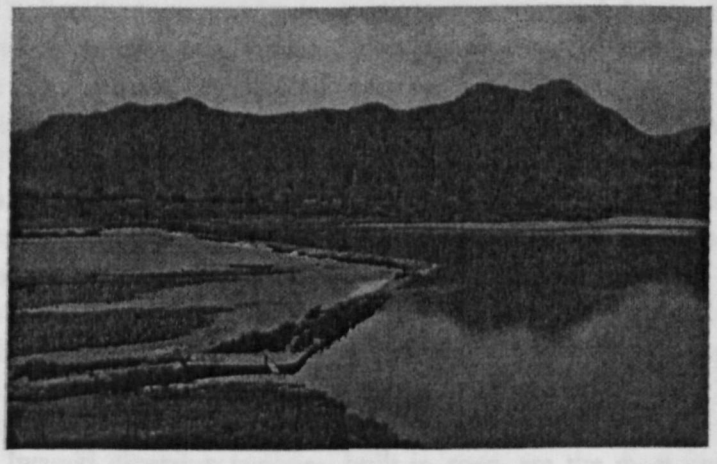

FIG. 5—Ground view of diversion dam. Note spillway in concrete section in foreground and loosely constructed central section.

(Fig. 6) show how much of the diversion from the main canal was once effected. Simple devices, commonly of rocks, logs, or both, at convenient places in the canal back up water until it flows in satisfactory amounts into a secondary canal. When logs are used, their girth and the depth they are submerged are closely scrutinized, since deviation from long-established usage would be reflected in the amount of water diverted. With the passage of time a few of the old devices have deteriorated and are remembered more as place names and for their historical associations than for their function. There is no doubt that minor engineering changes could eliminate the need for the remaining diversion devices, but water rights and control procedures worked out by their ancestors are still jealously guarded by many Twelve Village households.

The construction of the canal varies as it moves across the plain, from neatly lined concrete or rock retaining walls (Fig. 8) to earthen banks in need of repair. Banks are sometimes reinforced with rows of stakes, often strengthened with interwoven bamboo strips. The canal bottom is for the most part unlined and supports a rich growth of aquatic plants, though not enough to impede the swiftly moving water. Few obstructions are encountered: elevated streams are pierced by pipes, and a small trestle carries the track of a rail line above the canal.

As one follows the canal through the many small, clustered rural settlements (*buraku*) that dot the plain, it is an unending fascination to see the uses to which the water is put. Stone steps lead down from houses facing the canal in order that laundry and vegetables can be washed and scraps disposed of (Fig. 10). Fish nets, traps, and lines are in constant use, and during the hot, humid days of summer the cool water attracts swarms of young swimmers. The banks are also pressed into service as the main route for foot and bicycle traffic between settlements. Strips of granite quarried in the mountains are laid across the canal at frequent intervals and make crossing easy (Fig. 11).

Midway along its course, at the Kaida divide, the main canal loses more than half its remaining volume to a major branch that runs along the southern edge of the area serviced by the main canal. This is a concession to downstream parts of the system: instead of serving the paddies along its short course, it is designed to guarantee plentiful water to those along the middle and lower Ashimori River. Just before it joins the Ashimori, the branch canal is tapped by the Iwasaki water gate for paddies east and west of the river. The Iwasaki diversion facilities, built in 1949, are the most imposing in the entire system. Until their construction, water diversion at that point was determined for centuries by a huge boulder, "Turtle Rock," set in the

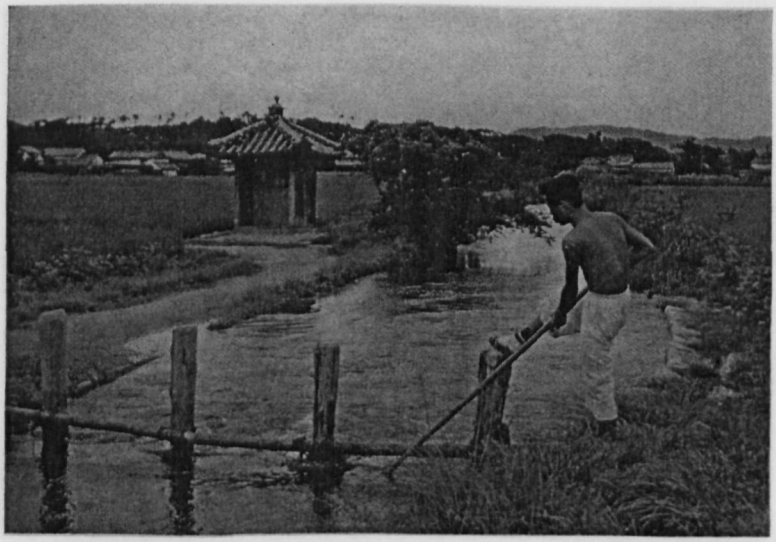

FIG. 6—Primitive diversion device, Soja Town. The water guard's son is clearing away debris caught around the logs. Buddhist wayside shrine in middle ground.

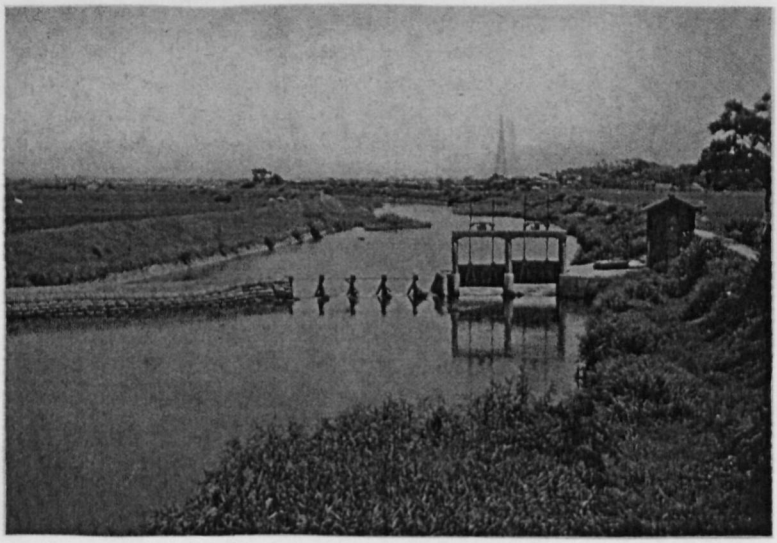

FIG. 7—Modern diversion device on the Ashimori River, Kibi Town.

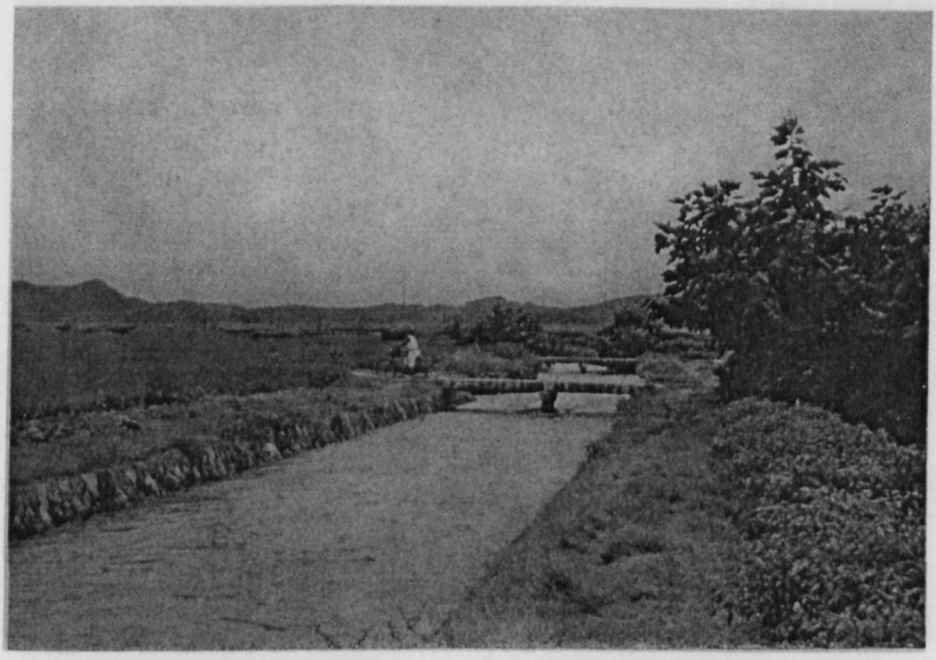

FIG. 8—Main canal downstream from Mitsumizo, with figs and peppers growing on right bank. Note rock retaining walls.

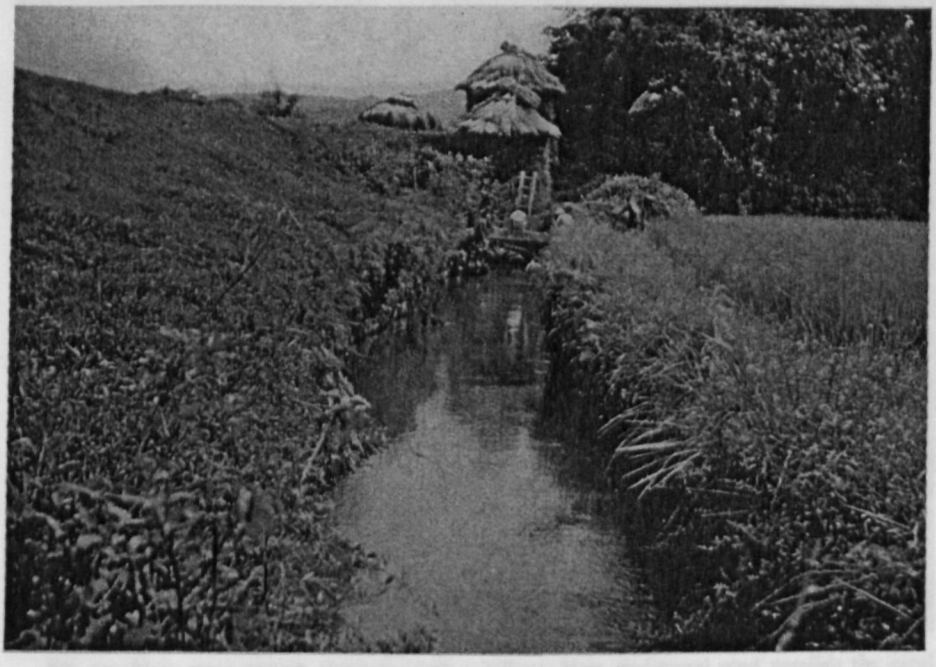

FIG. 9—Main canal passing under an elevated stream, the Chisui, in Oishi Village.

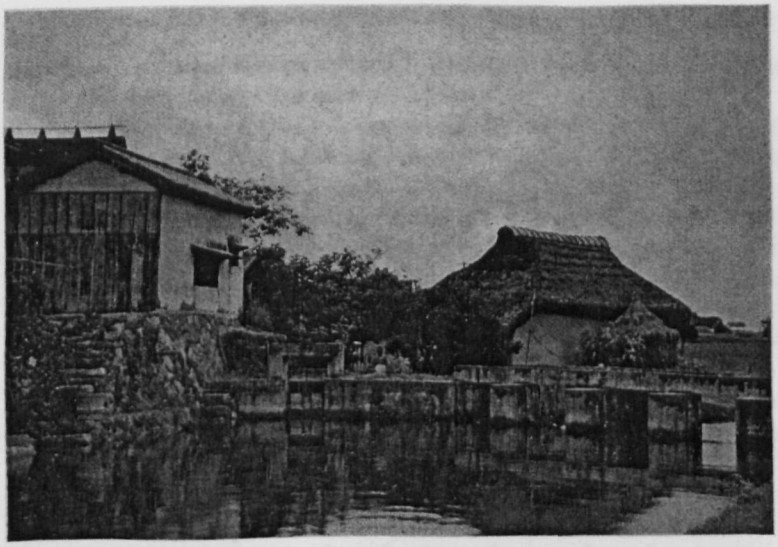

FIG. 10—Water divide at Mitsumizo. Steps and landing enable householders to use the backed-up water for laundry and other purposes.

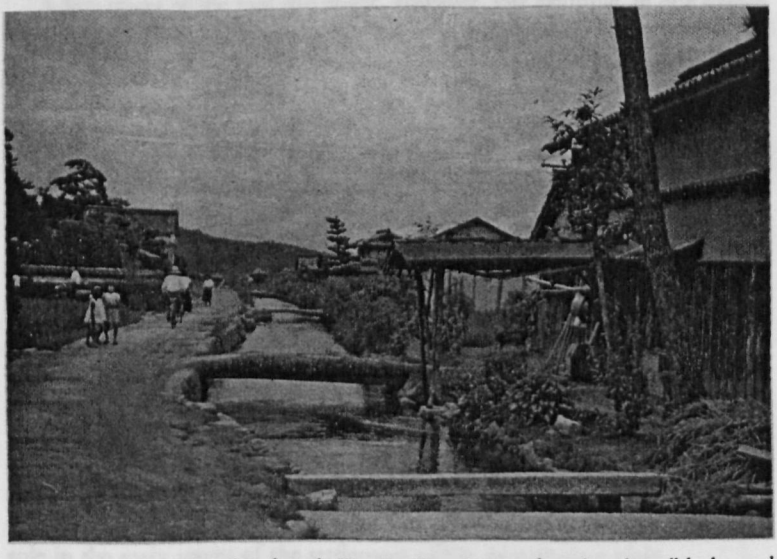

FIG. 11—Main canal passing through Hattori Village. Here prefectural road parallels the canal. Granite slabs serve as bridges.

canal bed. The inflexibility of tradition kept the rock in use long after silting and minor bank changes had made its measurements highly erratic.

Both the main canal and its principal branch merge into the Ashimori River and flow south. The Ashimori, whose irregular flow emerges from the interior mountains, does not have enough water throughout the year to be dependable for extensive irrigation but has a bed wide enough to accommodate its own and the added supplies of Takahashi River water. Instead of a narrow canal flowing placidly through paddies and settlements, the main Twelve Village water artery now becomes a rushing river enclosed by high dikes, with only a few large diversion devices that draw off water for irrigation in the southern part of the system. Irrigation works along the river are modern (Fig. 7), owing to the relative newness of the paddies served and to the fact that river maintenance is the responsibility of the prefecture and not of the cooperatives supervising Twelve Village affairs. Thus divorced from the strong traditional controls that dominate irrigation procedures along the main canal, the river portion of the system has been transformed in recent times into an efficiently operated unit by the application of sound engineering and rational management.

A few traces of the past still linger, however. For example, in one stretch below the Iwasaki water gate a handful of creaking water wheels lift water from the river to tiny paddies cultivated within the dikes. As with the main canal, a vantage point on the river is an excellent spot to view a cross section of rural life in the continuous flow of human traffic its dike roads attract.

Finally, below Niwase Town, the Ashimori broadens, joins the short Sasagase River, and, having completed its mission in the Twelve Village system, spills its remaining waters into Kojima Bay.

Elevated Streams

Just before reaching the Ashimori River, the main Twelve Village canal passes under two elevated streams, the Sakura and Chisui Rivers (Fig. 3). Both streams, which emerge from nearby mountain slopes of crumbly granite, have built up elevated beds with their heavy loads of sediments (Fig. 9). During much of the year the beds are bone-dry; only after heavy rains does water make a brief, though often violent, appearance. The meager, undependable amounts thus available have little effect on the Twelve Village system. But it is likely that these elevated streams played a more significant role in the early stages of the settlement of the surrounding plain.

Together with the many ponds among the fringing hills, they were probably principal sources of water; for not until irrigation techniques were

perfected could the rulers of the Bitchu fief, in which most of the Twelve Village paddies were located, carry out the great undertaking of making Takahashi River water available to distant paddies. Both streams are contained by high dikes anchored with pine and bamboo to keep flash floods in check, and labor gangs are dispatched by the prefecture to remove excessive accumulations of sand and gravel in the stream beds. The small flow of water that appears from time to time is now directed into one of the Twelve Village canals.[3]

Administrative Controls

The most striking feature of water administration in the Twelve Village system is the confusing number of irrigation cooperatives, with specific, and often overlapping, functions and administrative areas. In general, the existence of so many water-control organs is explained by the practice that irrigation water drawn from any part of the system automatically charges individuals and groups using it with the upkeep of the canals and associated control devices.

Most irrigation cooperatives are traditional in form and operation, many are informal, and all are primarily concerned with the smooth supply of irrigation water. The Twelve Village Irrigation Cooperative, which lends its name to the entire system, cannot be considered a higher-level body with unlimited control over all parts. Instead, it is the only cooperative among the many managing Twelve Village water supplies that is composed of representatives from all the 14 political subdivisions, towns, and villages through which the system passes. Although it does handle the external affairs for the entire system, meeting with prefectural, national, and other cooperative representatives when occasion demands, its jurisdiction within the system is limited to maintaining a few key facilities: the Takahashi dam; the intake pipe drawing water from the river into the main canal; the main canal as far as Mitsumizo; and the main branch canal between the Kaida divide and its junction with the Ashimori River.

All other cooperatives administer canals and irrigation control devices supplying water to specific sections of the system. Thus one large cooperative

[3] The Chisui (Blood Running) River has inspired a colorful myth. Twenty centuries ago a famous general, Kibitsu Hiko, charged by the Emperor with the subjugation of this district, had as his chief rival a devil named Ura. From their positions north and south of the present Twelve Village system, Ura atop a mountain (still known as Mt. Oni-ga-shiro, "Devil's Fortress") and the general at Kibitsu Shrine, the two directed a stream of arrows at each other. Bested in the struggle, Ura transformed himself into a pheasant, then a carp, only to have the general turn into a hawk and catch him. Blood from the concluding moments of the fight flowed down nearby slopes, giving birth to the Chisui River.

is responsible for the upkeep of the Iwasaki water gate (Fig. 12) and draws its membership from the areas served by water passing through the gate; similarly another maintains the large inlet along the west bank of the Ashimori River where water is drawn off for the southern parts of the system. Seven other large, formal cooperatives are charged with the maintenance of the main canals where they pass through their respective administrative areas. Finally, each secondary canal is supervised by one of about 90 informal cooperatives, whose main function is to keep the branch canals and irrigation devices serving their paddies in good working condition. Participating farmers are charged with the upkeep of the small irrigation ditches and in return have the right to use as much water as they desire of the amounts provided through cooperative action.

Water allotment is not left to the whim of the individual farmer. Every major inlet drawing water from the main canal or the Ashimori River is operated by a water guard in accordance with traditional procedures or special orders from the cooperative concerned. The guards also prove a worth-while investment when strict water-rationing regulations are put into effect. In the informal cooperatives, the position of water guard is honorary and unpaid. In many cases it has been filled by members of one family for generations as a form of public service; for example, members of the same family have served as Twelve Village water guards at the Takahashi River inlet since 1703.

In the formal cooperatives agricultural water taxes are assessed by the member village and town offices and not by the cooperative directly. Because of the overlapping cooperative structure, a Twelve Village farmer must pay at least two, and possibly four, water taxes, according to the number of cooperatives handling the water he uses, but in 1951 he paid an average of 500 yen per *tan* (0.245 acre) as his annual water tax. Labor and money must also be given to his informal cooperative to maintain feeder canals. Water taxes are collected in a lump sum by the village and town office in conjunction with other taxes in two installments each year. The proportion of the total irrigation costs borne by each village and town is fixed, having been determined at the beginning of the modern period on the basis of paddy acreage served, which replaced the feudal basis of paddy productivity. Cooperative budgets, set in April, fluctuate in accordance with the amount of repairs and improvements to be made during the following year.

The Twelve Village and other formal cooperatives operate under uniform procedures and regulations set up by the central government. This action was taken in part to increase irrigation efficiency, in part to create responsible

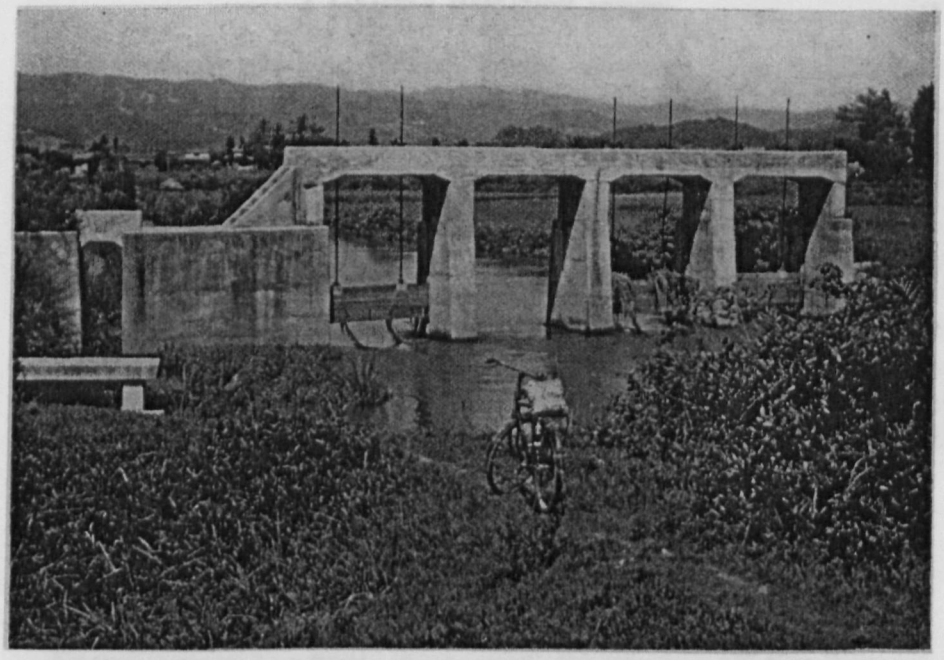

FIG. 12—Iwasaki water gate, 200 yards upstream from the junction of the branch canal and the Ashimori River.

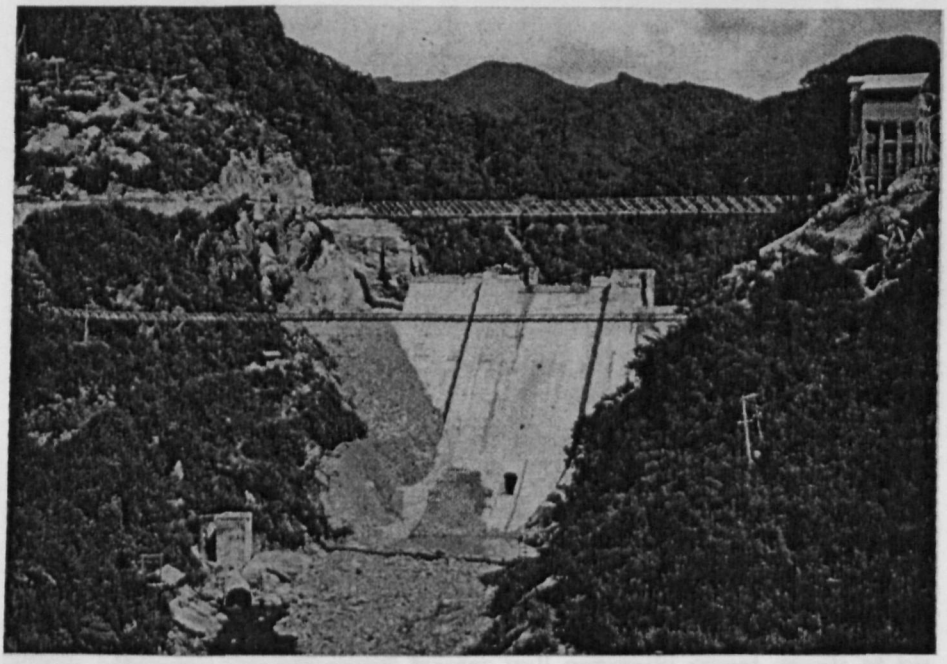

FIG. 13—Dam under construction on the Osakabe River, a main tributary of the Takahashi.

organs through which to channel federal assistance funds. Standardized cooperatives are also thought to be better suited to handling their own internal and external affairs. The efforts of federal and prefectural agencies have had a visible impact on only the legal structure of irrigation cooperatives, and irrigation practices in general remain little changed.

Intracooperative Water Disputes

Despite the complexity of administrative controls and the set character of water rights, disputes are not at all uncommon. They are naturally most frequent during periods of low water, when everyone is concerned about possible reduction of allotments. Heated appeals to authority are the usual means of expressing discontent, but that the best solution is provided by nature is indicated by an old Twelve Village saying: *Ame de mizu no kenka ga awa to naru,* "When rain falls, water disputes turn to bubbles." Yet even when rain does fall, there is no guarantee against the probability of similar arguments when supplies again dwindle.

Disputes are of two kinds: those within the system, and those between the Twelve Village and other cooperatives along the lower course of the Takahashi River. The former are small-scale, temporary, and fairly easy to solve. But the latter have become more intense during the past century with the increase in irrigation needs and the gradual strengthening of the political influence of rival systems.

Within the Twelve Village system, paddies differing in size and quality are freely intermingled and depend on the same irrigation source. Whether a farmer's paddies are higher or lower than those of his neighbor, whether they retain water or lose it easily, is not reflected in his water demands. When the thousands of households participating in the system are multiplied by the number of land inequities that do exist, it is not surprising that discord over water allocation is a permanent feature of Twelve Village irrigation management.

Most intrasystem disputes arise from demands for better distribution of water from plentiful supplies in the upper and central parts of the system; the remainder relate to water shortages in the lower part of the system. Both kinds are apparently frequent, yet they are difficult to observe and even harder to document. Village and town officials are reluctant to discuss such administrative shortcomings, except for the few disputes that leak into the newspapers. Likewise, the individual farmer will generally reveal details of his irrigation problems only after long acquaintanceship with the field investigator.

Serious water shortages sometimes occur throughout the entire system, as in 1925, 1944, and 1946, because of a general drought. At such times water rationing helps alleviate distress, but it also gives rise to discontent over the allotment. Few years, even those when water is plentiful, pass without demands from the southern parts of the system that upstream diversion devices be left open longer so that more water can pass downstream. In 1949 farmers in the Seno district were so hard pressed that they marched in a body to one of the responsible upstream village offices to demand more water, and their demonstration became so violent that police had to be called to restore order. The reclaimed lands around the western fringe of Kojima Bay are also unrelenting in their search for more water. They do not, however, have membership in the Twelve Village cooperative but depend, rather, on an agreement awarding them its surplus water, in return for which they make token payments for the upkeep of upstream irrigation facilities. Within the next five years the reclaimed lands will be supplied with water from a huge lake now under construction, and a constant source of friction in Twelve Village affairs will thus be removed.

Disputes with Downstream Cooperatives

Two other main cooperatives share Takahashi River water (Fig. 14), both downstream from the Twelve Village diversion dam: the Kambarai system (1530 acres) and the East-West system (15,580 acres). The latter, the largest in the prefecture, was created in 1923 by the consolidation of the many scattered and inefficient systems around the lower reaches of the river.[4] It has openly opposed the historical upstream rights of the Twelve Village system and insisted that tradition be replaced with a more equitable water allocation all along the river.

Disputes usually center on the size, construction, and management of the Twelve Village dam. Discord on this point can be traced far back into the feudal era, but it was not until 1940 that it was submitted to the law courts. After two years no decision had been reached, so an out-of-court settlement was made, which reduced the width of the dam by one-third and thus allowed more water to move downstream.

The most recent development bearing on the allocation of river water among the competing systems is the construction of a multipurpose dam on the Osakabe River (Fig. 13), one of the Takahashi's main upstream tribu-

[4] For a general description of these and other irrigation cooperatives in southern Okayama, see Ryushu Kasaishi: Okayama heiya ni okeru kangai ni tsuite [Irrigation in the Okayama Plain], *Jimbun Chiri* (*Human Geography*), Vol. 3, No. 2, 1951, pp. 65–73.

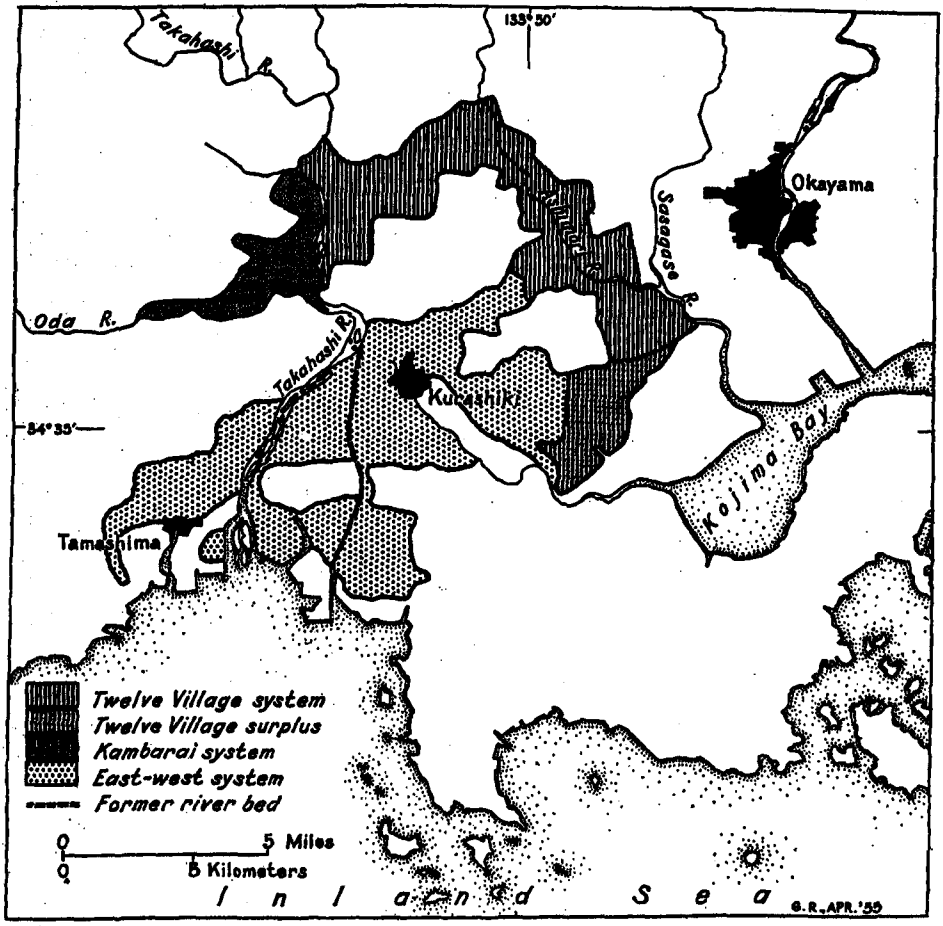

FIG. 14—Irrigation systems along the lower Takahashi River.

taries. Although capable of producing 3000 kilowatts of electricity, the dam is designed primarily for flood control and storage of water for agricultural use. In average years, half its capacity of 10 million cubic yards can be periodically released to stabilize the river flow. Originally planned by the three large cooperatives, the project finally ended up in the hands of the central government. Another dam proposed for the Takahashi River shortly before it enters the Okayama Plain could eventually become the main storage reservoir controlling river flow and thus release the Osakabe dam for flood control, but it is still only in the planning stage.

Prefectural interest in dam construction on the Takahashi has not been stimulated by irrigation needs alone. The areas around the two cities in the lowlands along the lower course of the river, Kurashiki and Tamashima,

have been designated as industrial zones and are attracting a growing number of textile and other manufacturing concerns. In both areas the unreliable river water supply has forced partial dependence on ground-water bodies, which are satisfactory in quality but too few in number for the amount of industrial expansion visualized. Successful harnessing and management of the river water are therefore essential for prefectural industrial growth as well as for the improvement of irrigation.

Among the many problems in regularizing the Takahashi River flow and distributing it equitably is the lack of detailed statistics on the seasonal volume. Present irrigation arrangements, based on upstream rights and historical precedents, make more accurate and detailed data of flow characteristics unessential. Also, prefectural and national agencies working in the field of water resources, which normally could be regarded as interested in river development and use, have given flow measurement scant attention. Measurement was finally begun during the Allied occupation, but statistics have been assembled from only one station along the Takahashi.

Although there are hopes for a reasonable solution of irrigation problems, no acceptable proposal has yet been made. The main difficulty is that water from the new Osakabe dam will reach the plain mixed with other river water, thus giving the Twelve Village cooperative reason to argue for continuation of present practices, in which its interests are dominant, and the East-West cooperative an opening for demands for a complete reallocation of water.

The most sensible suggestion made so far is that a solid dam be constructed at the site of the Twelve Village dam and all the irrigation water used by the three systems be distributed from it. This would permit a rational water allotment based on paddy acreage. In opposition, the Twelve Village cooperative feels that its historical rights will be lost and its water supply decreased. It is apparent that any satisfactory solution will have to revolutionize present irrigation arrangements, and will in the long run prove detrimental to the Twelve Village cause.