

LAND IMPROVEMENT IN RELATION TO LAND FORMS

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Preface

This paper is written in connection with my three papers which have been published in the Series of Human Geography of this Proceedings.^{1~3)} The purpose of these papers is to prove the following facts, that is, complexity and variety of nature in Japan, the appropriate landuse to the above mentioned feature, the land improvement for the more intensive landuse and the change in the ecosystem of the concerned area.

In this paper the following problems will be examined: (1) the origin of the readjustment of rice fields and its spread, (2) the nature of the lands where rice fields need to be readjusted, (3) the connection between irrigation canals of a large scale and land forms.

The author wishes heartly to dedicate this article to Emeritus Professor Shinzo Kiuchi

for the commemoration of his retirement from the University of Tokyo in 1971.

I Distribution and Location of the Readjusted Paddy Fields

1. The Progress of the Arable Land Readjustment

It is hardly possible to collect basic data for making up a nation-wide distribution map by absolute location which will show the works carried out by the Arable Land Readjustment (Replotment) Association, i. e., the expansion of arable land and the sort and size of individual district improved. For, such valuable materials (i.e. Application for establishment of the association, Plans of the works, Reports on completion of the works and on the disposition of the substitute lots) were destroyed by fire or abandoned in most of the prefectures at the end of the war.

So, I examined the topographical maps (1 : 50,000), covering Honshu, Shikoku and Kyushu, which were temporarily amended during the period of 1948-50 by the process of aerophotogrammetry. The readjusted districts of the farmland which appeared on the maps I recorded on transparent blank map put over the land utilization map (1 : 800,000). Hereby, the absolute distribution of the readjusted arable land in a narrow sense, which was hardly grasped by statistics, was made clear. However, reshaped fields in the districts too minute to appear on a topographical map (1 : 50,000) such as the paddy fields on the bottom of small valleys are excluded. On the other hand, this distribution map includes not only the readjusted fields but also the new reclaimed rectangular parcels: it is justifiable, as most of these reclamation works have been carried out by the Arable Land Readjustment Association.

Now, the first thing we notice on this map is large concentration of the readjusted paddy fields on both Niigata and Sendai Plains where the ratio of tenant farmers was high during the period of 1900-30. Some of these paddy fields were resulted from the reclamation of either lagoons, lakes or idle back marshes reserved for overflow. Secondly, the readjusted paddy fields are distributed mainly in the northeastern part of Honshu, and they form a remarkable contrast to the paddy fields of Jôri-system in the western part. This means that the size of a Jôri-parcel is 60×6 ken or 30×12 ken which has been suitable for ox-plowing, and as compared with the standard size of rearranged parcel of 30×10 ken, Jôri-system remains comparatively advantageous even

today for use of motor tillers (hand tractors). It also means that those fields had irrigation and drainage system in good order, and scarcely needed readjustment. Some of these, however, which were located on marshy land were readjusted along the basic lines of Jôri for the purpose of underdrainage or construction of agricultural roads. The works including improvement of farm roads, irrigation and drainage facilities and levees carried out over 33 ha area at Hikoshima, Tawara, Iwata-gun in Shizuoka Prefecture between 1872-75 were one of the examples of the readjustment of the old Jôri paddy fields. It is reported that there was almost the same case in Kanazawa Plain.⁴⁾

The paddy fields of Jôri-system are mainly distributed on the alluvial plains, which can easily conduct water from the smaller rivers, especially on the terminal and peripheral area of alluvial fan and on the upper part of delta. Among these there are very few marshy fields, and it is due to the fact the efforts toward double cropping began in early days and irrigation and drainage facilities has been gradually arranged in a long run, but to a greater extent, it is attributable to their topographically better situation, i.e., neither damp nor high and dry. On the damp delta and lagoons, reclamation of paddy fields had been in progress since the Shoen (manor) Age, and on some parts of alluvial fans and terraces higher and drier, reclamation of either ordinary fields or paddy fields by means of large scale reservoir was carried out. These reclaimed fields were no longer allotted on a grid pattern and they often had confused system of irrigation and drainage.⁵⁾

In the Edo Era, embankment works of big rivers, reclamation works by drainage, and development of paddy fields on damp ground were advanced on a large scale. Among those areas we can see tracts of paddy with rectangular system, but the ones voluntarily reclaimed by the farmers were still irregularly shaped. In those days, there was every tendency toward the improvement of levees between paddy fields, but formally it was necessary for the farmers to get permission by the Shogunate or the feudal lords, and in case they could raise production per unit area, they were compelled to pay the land tax of higher rate, and these restrictions checked the progress of works. However, in the last days of the Tokugawa Government, land improvements such works as exchange, consolidation of farm lands, rearrangement connected with check-row transplanting system and introduction of horse plowing, drainage by culvert, soil adding in paddy field were promoted chiefly by the wealthy landowners. This tendency

gradually grew stronger after the Land Tax Revision Ordinance in 1873. Hereby the private landownership system was established and the land tax was settled, but on the other hand, the profit of landowners was increased by jump in rice price. This fact encouraged land improvement works with a view to raise production per unit land. There also occurred the necessity for execution of such works as improvement of irrigation and drainage facilities and readjustment of land for the purpose of free cultivation.

Thus, in 1887, following the examples of what is called Shizuoka system, the rearrangement of levees between paddies on a grid pattern, and Ishikawa system, the readjustment of paddies, farmers executed improvement of cultivated land in various areas. It was then prefectural governor Takatoshi Iwamura who promoted Ishikawa Prefecture to be the pioneer of modern rearrangement works. In 1887, he heard Roichi Hida's talk on agricultural circumstances in Luxembourg after his inspection tour there, and recognized the necessity of readjustment of fields as the basic step for the improvement of farming. On returning home, to the prefectural government office, he persuaded execution of arable land readjustment at the conference of county heads. Then he appointed the Paddy Fields Readjustment Committee in 1888, with their duty regulated as follows: 1) Marshy fields shall be reclaimed into dry fields; double cropping shall be aimed and Chinese milk vetch be grown there. 2) Improve the water facilities. 3) Horse plowing shall be aimed. 4) Properly straighten the foot-path between paddy fields. 5) Increase the area of cultivated land.⁶⁾

The area where readjustment with such aims was enforced was about 60 hectares of marshy fields, about 6 km west to Kanazawa city, which was often visited by the overflow of the Yasuhara River. They had the fields oriented from north to south, the standard length and size of a parcel being either 30×8 ken or 12×20 ken, 8 ares. The details are not mentioned here, but this system was widely adopted in Ishikawa Prefecture and taken for model of arable land readjustment works in various districts. Rearrangement at Minamishitahaba (1901-06), which made a pioneer in Iwate Prefecture, also followed the readjustment works in Ishikawa Prefecture.

Though there might be backgrounds of all kinds for the advanced execution of readjustment works in Shizuoka and Ishikawa Prefectures in the former half of the Meiji Era, I would like to mention that, they are both located access of agricultural forefront district of Kansai, though the former is on the Pacific side, the latter in the

districts bordering the Sea of Japan, and there was also much room left for diffusion of double cropping, and animal plowing.

Now, readjustment works in their early stage were limited to those carried out in a small scale by single or small group of wealthy landowners or cultivators. But the larger the enforcement area expanded, the more the number of persons concerned increased and there arose pros and cons between landowners.

In order to adjust conflicting interests legally, the old Arable Land Readjustment Law was enacted in 1899 and enforced the following year. The original purpose of this law was to elevate cultivating efficiency by readjusting plot and shape of fields and by promoting exchange and consolidation of farm-land. However, the influence of wealthy landlords who had played a leading part in agricultural improvement in the former half of Meiji Era gradually declined; in the meantime, absentee landlords who had rapidly grown since the latter half of 1880's began to get the farming villages under their control. They began to carry out readjustment works on their own initiative in order to enlarge their holdings, and to raise tenant rent resulting from increased yield per unit area by means of irrigation, drainage by culvert, etc. As previously stated, a series of revisions of the Arable Land Readjustment Law accelerated this tendency. And the works such as replotment, exchange and consolidation of farmland aiming at the elevation of labor productivity became less valued.

Only after the reformation of farmland previously stated, arable land rearrangement in its proper sense began to be demanded by the farmers, and at the time of enactment of the Land Improvement Law in 1949, regulations for exchange and consolidation of farmland were laid in Chapter III. Next, these works were projected to be operated over the land of 1,710,000 hectares during 5 years after 1950. In 1956, among the new measures for the promotion of farming, mountainous and fishing villages, the comprehensive rearrangement works including arable land consolidation and land improvement were considered as special subsidiary works.⁷⁾

Now let us investigate the distribution of the corporation which executed rearrangement of paddy fields alone or together with other works, among those corporations established for the purpose of land improvement established by the end of March 1956. We notice that the rearrangement works were carried out most largely in Chûbu and eastward, the progress rather declining in the Sendai and Akita Plains, going active

steps in the Kitakami Plains and the district covering the Koriyama and Fukushima basins. On the other hand, in the southwestern Japan, there are not so much to be noticed even on the delta near the coast, with scattering lots in a small scale on the bottom plains of smaller valleys.

As for the Plains of Kanto, rearranged lots of some hundred hectares are distributed along the mid-stream and up of main rivers, with scattering lots lying along the smaller branch valleys. In Wajû like polder in the Plains of Nôbi, the rearrangement is making rather rapid progress lately than prewar days. This is resulted from the use of a power draining pump, which simplified regulation of water use, conversion of marshy fields into dry ones, and reclamation of many ditches between paddy parcels, and has some relation to the introduction of a power cultivator.

2. Topographic Location of the Readjusted Paddy Fields

The readjustment works of paddy fields are rarely operated apart from other works, but usually executed in relation to such works as drainage of deep paddy fields, soil adding, improvement of water facilities and construction of farm roads. When we examine the localities of rearranged fields, in nine cases out of ten, they were naturally ill-drained and were easy to turn into paddies with primitive agricultural technique. For example, the fields readjusted comparatively in early days with drain or culvert had been either the deep paddy fields on the back marsh of the delta, wide bottom of a drowned valley, the one-time lagoon, the terminal and peripheral area of alluvial fan, the zone adjacent to the precipice of a terrace where cold water oozed out, or the area which was turned into deep paddies by such obstacles as dikes, roads or railroads. These cases are easily found in the topographical maps of 1:50,000 or 1:25,000.

Let's take Yokote basin, Akita Prefecture as an example. One of the fields readjusted earliest is situated to the west of Iwasakicho, at the southern end of the basin. The deep paddy fields of about 400 hectares are surrounded by the Minase River on the north, by the Tertiary hills on the southeastern side, and by an independent hill on the southwestern side. They were readjusted about 1910. During the period from the Taisho to the Showa era, arable land readjustment works were carried out in several places along the area 35~25 meters above sea level, which extends over the periphery of Rokugo alluvial fan and the flood plain, and also at some spots lower than

Land Improvement

the zone where cold water oozes out on the alluvial fan of the Sainai River. The area readjusted up to 1939 was less than 10% of paddy fields in the whole basin, and far smaller when compared with that of Akita Plains. But the airphoto (1 : 10,000) taken by the US Forces in 1948 shows that the readjustment works have been executed in most of the area covering the vicinities of Yokote city and Rokugo alluvial fan.^{8,9)} Among the paddy fields where these modern rearrangement works have not been operated, there are a tract of Jôri paddy fields covering 700~800 hectares, about 5.5 km long from northwest to southeast and about 1.8 km at the widest, on both the low land and the high plain on the left bank of the Asahi River, to the northeast of Yokote city. In this area, the paddies do not always need readjustment, as they are from the beginning regularly arranged (60×60 ken), though the subdivision of Tsubo of Jôri system is not so regular, and they are densely provided with water-facilities. In the southern part of the basin, there are many new settlements along the road reclaimed according to the plan by which homesteads would face the road, and the farms would be cultivated at the back. These settlements seem to have come to existence in the early period of the Edo era, whose paddy fields are also regularly divided. On the other hand, in the northern part of the basin, dispersed settlements have developed, and it is likely that the cultivating land of each family conglomerates around each homestead. These subjects will be further investigated hereafter.

Now, let's take another example around the terrace of Isawa upland (diluvial fan), Iwate Prefecture.^{10,11)} On the topographical map of Mizusawa (1 : 50,000) surveyed in 1913, there already marked a trace of arable land readjustment in the tract of about 1.5 km square, at Minamishitahaba, of former Natsudamura, about 3 km west to the city of Mizusawa. This area stretches over the lowest gravel terrace and another terrace 1 m higher than the former, on the right bank of the Isawa River, 65~75m above sea level. Both terraces were formed in the alluvial epoch, and they are not covered with volcanic ashes but with top soil of dark brown loam with about 30 cm depth. When the ground was leveled for the purpose of rearrangement gravel sometimes came out or underground water oozed out. There were deep paddy fields on the lower terrace and shallow indented places, and the villagers had then hard time in drainage. It was in Feb. 1901, the following year of the enactment of the Arable Land Readjustment Law that the first Association for Land Improvement in this prefecture was established

in this district. It is said that the leader was a landowner-farmer whose holding was about 4 hectares of land, who, returning home from the Sino-Japanese war (1894-1895,) observed the early readjustment works in Ishikawa Prefecture. Since then he took it into his mind to improve paddy fields in his own native land. The aims were to raise cultivating efficiency, to introduce horse plowing, to improve deep paddies where cold water would ooze out, and the exclusion of "from parcel to parcel" irrigation system. The tract where the works were carried out had an area of 314 hectares, of which 211 hectares were paddy fields. The system of the readjustment was as follows. Main roads 1.5 ken (about 2.7 m) in width were laid at intervals of 120 ken on a grid pattern. Irrigation and drainage ditches 1 ken wide were provided, crossing at intervals of 30 ken and 120 ken; Unglazed drainpipes were used for underdrainage. The size of a parcel was 10×30 ken (about 10 are) and both shorter sides abutted on the irrigation and drainage ditches so as to meet the convenience of passing. It is said that the technician who took the lead in those works had taken a short course of rearrangement of cultivating land at an agricultural college in Tokyo. This system was more improved than the Ishikawa system, and similar to the one executed at Kōnosucho, Saitama Prefecture in 1902. Now, the readjustment works at Minamishitahaba were quite successful, but they failed in the financial aspect since the works were carried out ahead of the times without any subsidy, and to make the matter worse, they were cursed by successive poor crops. Please refer to the treatise¹²⁾ about the details of the above problem as well as those concerning the distribution of the increased cultivating land (the difference between the area which had been registered on cadastral map and the area accurately measured after the readjustment).

To return to the subject, the reason that no readjustment works of paddy fields had been noticed in Isawa-gun until the outbreak of World War II might be that the experience had discouraged the people from another trial. But after about 1940, aiming the food production increase and the elevation of cultivating efficiency in order to cover the labor shortage, readjustment works of cultivated land were carried out in many districts. For example, several plots of paddy about 10~20 hectares underwent those works at a time in succession on the Vth terrace adjacent to the land below the high terrace of the eastern margin of the Isawa upland. Those works were extended in the same way to the land covering 88 hectares situated to the north of

Minamishitahaba (the VIth terrace). But the performance of the works was limited in small districts when compared with the whole acreage. After the Isawa Plain Land Improvement Corporation was established in December, 1950, the readjustment works were carried out on the land covering some hundred hectares every year till they were completed over 6,646 hectares by 1960. The performance was due to the government subsidization, the strong driving force of the Corporation, and the owner-farmers' active participation toward the branch works of the 'state and prefecture-managed' irrigation and drainage works.^{12,13)}

Lastly, when we turn our eyes to the southwestern Japan, we find that most of the readjusted paddies that are distributed along the coastline are the ones reclaimed systematically in recent years. And, most of the regular paddy fields which intermittently lie along the big rivers in the districts where Jôri-system is prominent were also reclaimed recently. This is the result that the old course of the river, the ox-bow lake, and the natural levees were reclaimed successively with the progress of the river improvement works after the Meiji era. Especially, about the time when the old low dike works turned into high dike works after the enactment of the River Law in 1896, the paddy fields extended to the idle back marshes reserved for overflow and to the natural levees, approaching the river. The popularization of power pumps still more furthered this tendency. For instance, the riparian works of the Chikugo River in kyushu started with the low dike works in 1887, underwent the high dike works according to the River Law of 1896, (chiefly downstreams from Kurume city), developed into the project of 1921. It was not until 1921 that the zone between Kurume and Haki upstreams was given priority in the high dike works, whose aim is considered to have been the protection of reclaimed paddy fields about 1,000 hectares along both banks of the Chikugo River. According to Jôgyo Takeuchi,¹⁴⁾ the zone benefited by the pumps set on the riverside of the Chikugo during the period between the end of the Meiji era and 1940 was 3,889 hectares, of which 1,140 hectares were reclaimed paddies, which proves that the utilization of pumps has promoted the reclamation of the natural levees. I should like to add that the transition of the utilization of land along the Chikugo River, east to Kurume, is clearly recognized when we compare the topographical map (1 : 20,000) surveyed in 1900 with the one (1 : 25,000) surveyed in 1938 and amended according to the data of 1954.

The natural levees along the mid-stream of the Kitakami River, Iwate Prefecture were utilized mainly as mulberry field from Meiji era to the beginning of Showa era. After the world panic in 1929, the mulberry fields were converted into paddy fields, which was extensively carried on especially during World War II, though we can find quite many cases that the paddies were re-buried by a flood. They were futile works before the construction of a dam serving for multi-purposes in addition to adjustment of floods.

Along the Watarase, the Tone and the Arakawa River in Kanto district, there are lots of paddies which were cultivated after the construction of the continuous dike, or reclaimed by means of exclusion of water between the inside and outside dikes, most of which are regularly formed, There is an interesting case of reclaimed paddy field on the natural levees on the right side of the Tone River, west to Fukaya-shi. There is a German-style brickyard which was established in the middle of Meiji era. They had dug the material of the brick mostly out of the natural levee. The site was reclaimed into paddy fields of 300-400 hectares through the efforts of the local committee.

II Land Improvement and Land Association

1. Changes in Landscape Caused by an Artificial Water System.

An investigation is in progress as to how the erosion and transportation caused by an water system, the landform, land use, traffic, and the settlements in that drainage area are transformed as the figure of a river is changed by the construction of a dam and that of an embankment. For example, as the flood control works have been advanced through three steps,—the low dike step, the high dike step and the control system of flux or the high dam step—, the development and the improvement of agricultural land have made a characteristic progress in proportion to the three steps mentioned above. The thought to construct a high dam for flood control and multiple water use was supported since the end of the Taisho era, but it was after the enforcement of the Comprehensive Land Development Law 1949 that it was on a full scale realized, though the plan of constructing such a dam had been made for the Sagami River¹⁵⁾ and Nojiri lake¹⁶⁾ before World War II. Because the construction of a high dam costs too much, it is necessary for the plant to cooperate with the agricultural development in order to

reduce his own allotment in the investment. Then it becomes also possible that a high river terrace which has been utilized only extensively is transformed into a rice field on a large scale. For example, rice fields of about 7,000 ha in the Isawa Plain, Iwate Prefecture, gained a lot of benefit by the Ishibuchi dam across the Isawa River. In addition, the highest terrace of the Isawa upland was changed into a rice field by the Government enterprise.

The construction of canals and ditches for the reclamation of a rice field means the creation of an artificial water system in that plain. In such case, if some different landforms ranged together are united by an artificial water system, causal relation of many phenomena which were latent or nonexistent by nature sometimes comes into view. The most frequent is the breaking of an irrigation canal, the collapse of a hill side and a cliff of a terrace caused by a flood affected by the human works, and as a result the fields suffer damage. As these accidents are usually small in scale and do not bring about a great disaster such as happened by a break on the embankment of a large river or a collapse of a dam, people do not pay much attention to them. But the accidents are so frequent that the whole extent of damage cannot be overlooked. In fact, there is a section of countermeasures against calamities in the Ministry of Agriculture and Forestry. The cause of this damage is natural power such as a heavy rain and an earthquake, but the extent of the damage is often enlarged by the interposition of the construction which does not well match with natural environment.

There are many long irrigation canals of which upper part is situated along the foot of a mountain, therefore it is apt to be broken in the following case. For example, the Tazawa-sosui (irrigation canal), Akita Prefecture was broken in two places on the lower reaches of the Mikaeri gorge through which the Tamagawa flows. That is because the small remnant of a terrace which was hung over the steep valley fell down. Also in the neighborhood of Yuzawa situated at the west foot of the Tengu tertiary hill, the irrigation canal made of concrete which is 2.6 meters in width and 1.72 meters in height was broken extending over 20 meters by the heavy rainfall in July of 1970. The site was the part of a very shallow valley thickly covered with decomposition and drained ill owing to the canal crossing this site. Moreover, the rainwater was concentrated upon the place; it flew over upon the canal, at last the rainwater broke the canalwall and joined with the water in it to destroy the hillside. Along the west side

of this hill the Senya dislocation which occurred with the Rikuu Earthquake of 1896 stretches from north-northeast to south-southwest.¹⁷⁾ In the small valley near the broken place mentioned above, debris of landslide caused by the earthquake at that time from a terrace of a few hectares. In setting to work, however, no researches were given about the results of that earthquake in this locality.

On the left bank of the Uono river in Niigata Prefecture we find a long irrigation canal constructed by the Ministry of Agriculture and Forestry to make paddy fields of about 570 ha on the confluent fans extending from Muikamachi to Kokonokamachi. By the heavy rainfall in July of 1970 this canal was broken about 2 meters in width at the site where it lies on the cutting and banking of 4 to 5 meters in height at the foot of a hill, and the flood washed away the soils of the banking. The hill made of the strata of gravel and clay are inclined to make a landslide, which may cause further the collapse of the canal in the future. The parts of the canal running across near the apex of the fans are constructed with an iron siphon under the ground so that it can be saved from destruction by flood and/or mud and rock stream. In the same places, however the both sides of the slope near the exit of the valleys are attached by the deposits of terrace or talus. For that reason the structure of the canal which runs partly along those slopes should have been also specially devised.

One more example of the breaking of the irrigation canal constructed by the Ministry of Agriculture and Forestry was seen on the upper stream of the Kama River which is the left branch of the Kiyotsu flowing into the Shinano River in Niigata Pref. This canal was constructed to make paddy fields on the highest and secondary terraces, about 350~500 meters above sea level, of the right bank of the Nakatsu River. The intake is set in the gorge near the valley head of the Kama which is about 700 meters above sea level. On the 500 meters downstream where the canal runs across the branch valley, the canal was broken about 70 meters in length owing to the heavy rains on May 3 to 6 and 25 of 1960. This is because the works against the flood of a branch brooklet was not perfect and because the compositions of lava and sandy soils fell from a high small terrace and attacked the canal. To the west above this Kama valley the high plateau made of the lavaflows from Naeba volcano makes the prominent cliffs of about 200 meters in height. To say in addition, this place belongs to the area where the snow lies about 4 meters deep and is far from being suitable for such public works. (Fig. 1)

2. Irrigation Water and Gross Land Association

In a case of a gross land association¹⁸⁾ composed of a high and low land surface, the change taken in the uses of the higher land surface is likely to have some influences on the physical nature and the landscape of the lower land. For example, when the forest which covers the higher terrace is cleared, it may result in soil erosion or change in the condition of underground water. Of course, the degree of the changes depends on the geomorphological nature, the former vegetation, the climate, and landuse.

In our country, we can find many examples that the rice fields have been made on the upland with the several terraces, from the lower level gradually to the higher level, to meet the demands for increase of rice production in each period with the development of technology. A good example of this can be seen in the Isawa diluvial fan and the highly elevated terraces along the Nakatsu River¹⁹⁾ (Fig.1). When rice fields are made on the higher land surfaces, we may observe various results described below.

First of all, at the time of irrigation, the water stayed a few centimeters in the plats of the rice field, and the soil is also saturated by the water. Therefore, with the

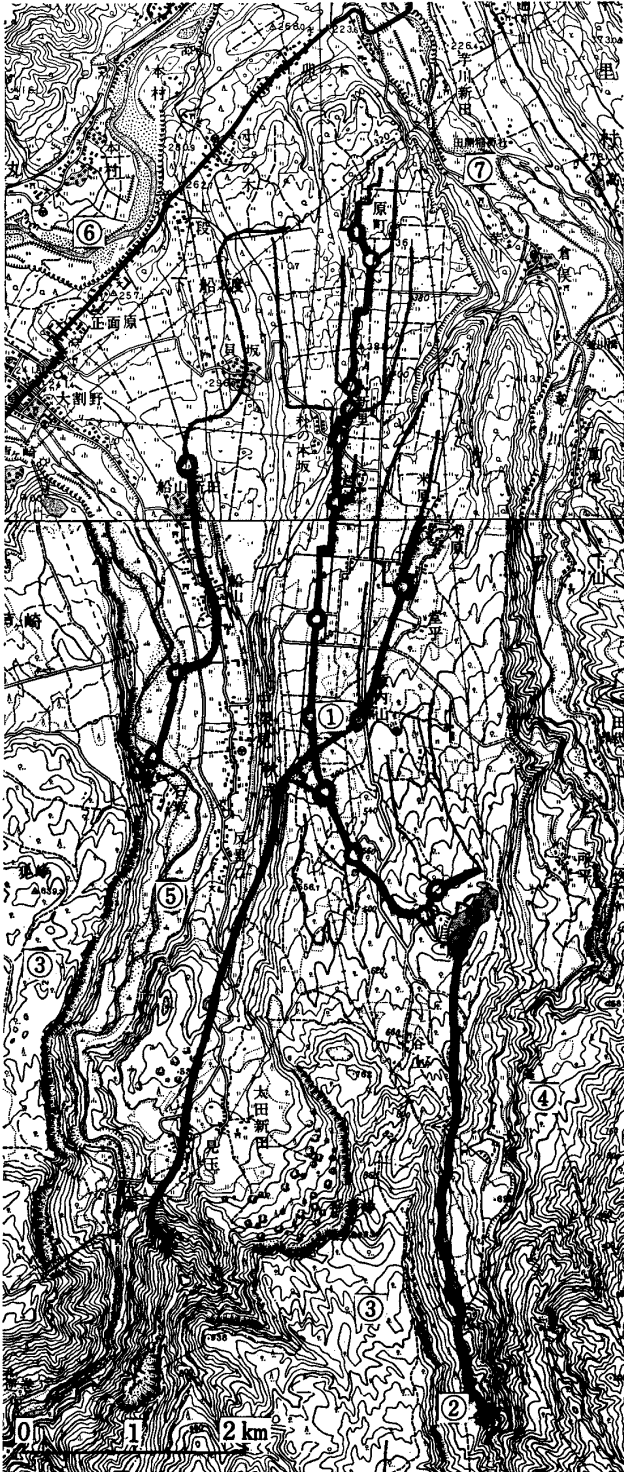


Fig. 1 Making of rice fields with irrigation canals on the terraces between the Nakatsugawa, and the Kamagawa, Niigata prefecture. ①Main canals, ②Site of headwork, ③Lava plateaus, ④The Kamagawa, ⑤The Nakatsugawa, ⑥The Shinanogawa, ⑦The Kiyotsugawa

intensive rainfall, the water rushes into the drains and tends to cause erosion at the edge of the higher terrace, or increases the lateral erosion of the water ways. We may take the case of the Ryusei upland in Kamiina of Nagano Prefecture. It has been dissected deeply by the branches of the upper Tenryu River such as the Fukazawa, the Obinashi, and the Ozawa, and as a result, *tagiri* landform is developed. This vertical cliff of the *tagiri* is of about 20 to 30 meters in height, and at the time of heavy rainfall, the overflow from the canals and drains or that which comes directly from the rice fields is likely to cause an erosion at the edge of the escarpment.²⁰⁾

Compared to this, the problem of erosion in the *shirasu* plateau which spread widely in southern Kyushu is much more serious. That is, the upper layer of several meters of the recent volcanic ashes covering the *shirasu* of several tens meters is less permeable, and thus, at the time of heavy rainfall, the water which flowed over the surface falls over at the cliff and causes erosion in the lower *shirasu* layer, because the *shirasu* saturated with water becomes very loose.

In cases where the rice fields are formed on a plateau, as in the Iwakawa plateau, the erosive power is increased by the overflowing water and the water that leaks out of the cliff. From 1950 to 1958, the Government has been on *shirasu* controlling measures, and has spent over eight hundred million yen of the national budget for preventive constructions in thirty districts which mount up to 6,464 ha.

The next discussion will be focused on the effects brought on the lower land and the land use by the irrigation water which permeates into the subsoil of the fan or the higher terrace.

The Ryusei upland, which was mentioned formerly, is an elevated confluent fans covered with several meters of loam originated in volcanic ash. In the eastern part of this plateau, a rice field of 1,170 ha, shaped like a belt, ranging about one kilometer in width and twelve kilometers in direct length has been made during 1927 to 1928, along the canal which runs from north to south. The water supply of the canal to this rice field is 4.32 tons per second, and the amount of water which is absorbed into the ground under the rice field totals to 1 to 2 tons per 100 square meters. Because of this, the amount of water which is permeated from the cliff-gouged valley and the cliffs of the first and the second terrace has increased remarkably. As a result, many rice fields under these cliffs have been saved from drought, while some have been too wet

and required readjustment of rice field with drainage works. Owing to the increase of spring water, horseradish fields have been made on the bottom of the valleys, which have developed through headwards erosion from the cliffs of terraces and on the third terrace, trout nursery has been established. Moreover, the settlements on the second terrace use water which springs out from the cliff, or dig horizontal wells from the cliff into terrace and pipe out water. Today, the amount of water which permeates the ground has been decreased compared to that at the time of reclamation. This is because some clayey substance has been accumulated in the B layer soil under the rice field, that prevents water from permeating.²⁰⁾

Previous to the usage of concrete, the loss from canal by permeation was great, and it was difficult to carry water down to the fans which were made of sand and gravel even to the surface. The Ozeki canal with the upper width of 5.4 meters which had been constructed by the feudal lord of Satake during 1825 to 1834 on the confluent fans in the northern part of Yokote basin is an example of the difficulty mentioned above. This Ozeki was located at higher place than the other older canals, Shimozeki and Kamizeki, approximately along the 82 meter contour line. It was dug out in order to track water from the Tama River, but it proved to be a futile effort since the ground of the canal was made of sand and gravel. The Tazawa-sosui construction which had been started as a part of the Tōhoku District Promotion Project in 1937 finally finished its 31.3 kilometers of main waterway (upper width of 2.1 meter) by the spring of 1951, and in the same year started supplying water to the 16.6 ha of the cultivated area.

In the following year they tried to flow eleven tons of water per second as planned for the land of 155 ha. However, as some parts of the canal were not yet made of concrete, and no mechanical power like bulldozer was used for clearing, the water permeating in the soil sprung out in the settlement and cultivated fields near the margin of fans, which caused a damage from inundation. For example, in the fan of the Sainai River, ordinary spring water belt exists between 50 and 57 meters contour line, but after the construction of the Tazawa-sosui it was elevated up to around 70 meters. (Fig. 2). Since 1956 machines have been brought in for the clearings, and the subsoil of the rice fields were hardened by the machine's weight. This, along with the use of bentonites, decreased the leakage of water from the rice fields. However, the depth of surface soil

of the fans is only about 30 centimeters, and the layer below this surface consists of gravel. If the surface layer is less than 30 centimeters deep, the bentonite does not function effectively to prevent the water from leaking, and thus the water in the rice fields has not enough time to become warmer. Such defective rice fields were seen in the Rokugo fan at the south end of the irrigated area in the Yokote basin. In order to make a good use of these defective fields, clayey and loamy soil must be brought in from some other places, or better yet, they could be used as irrigated meadows.

Starting from August 15, 1953, the changes in the underground water level caused by the water leakage in the rice fields have been observed every ten days in the experimental wells with the total of four observations. From these observations, the underground water level was found to rise about five meters in the middle part of the fan and about one meter in the lowest part (the margin of the fan) during the time of irrigation.

Lastly, the map indicating the source of the irrigation water used in the area surrounded by the Tazawa irrigating area (about 2,000 ha), the Tama river, and the Omono River, is given. From this map, the relationship between the gross land association and the artificial water system is made clear. The confluent fans which lie the Saito River and the Mariko River was changed into rice fields from the lower part in the order of Shimozeki (lower dam, constructed in 1699, 16 kilometers from the Tama River irrigated area 496 ha, 526 ha at present) and then Kamizeki (upper dam, constructed in 1694, 296 ha cultivated for rice fields by the 16 kilometers of water way from the Tama River, 365 ha at present). The further effort to build Ozeki on higher land ended in failure, but at last, the vast uncultivated area in the highest belt of the fans turned into a rich field by the construction of modern water ways which lead the water from Lake Tazawa through the power plant. This irrigating water springs on the lower reaches than the end of the confluent fans or rises the underground water level. It is quite natural for us to find the zone where drainage water from the upper rice fields are reused, and the district irrigated by the underground water in this area. (Fig.3).

Conclusion

In this paper I have explained two or three facts that agricultural public works of a large scale such as the construction of long irrigation canals, reclamation of land and irrigation over a wide area have influence on not only the concerned land but also the

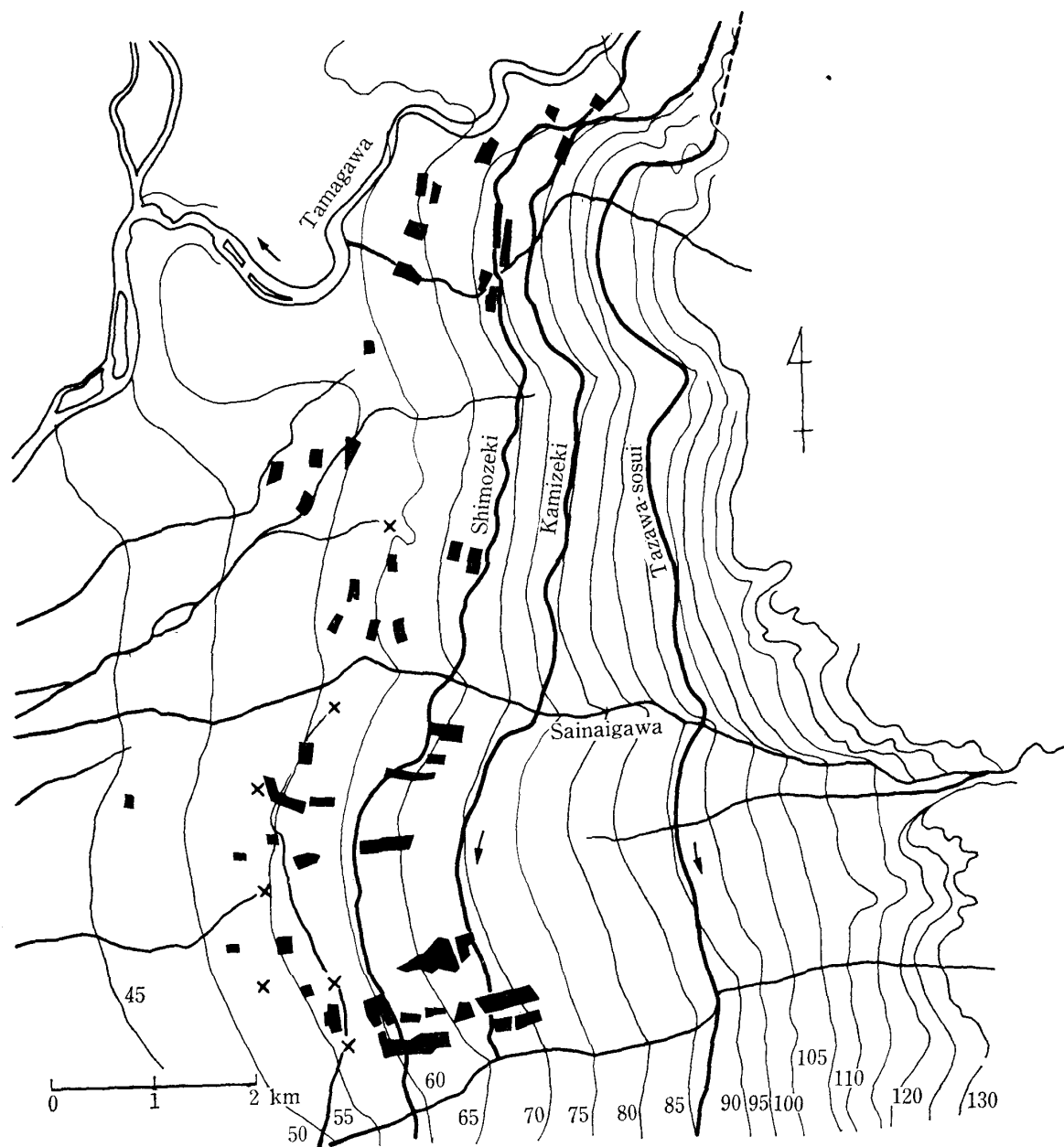


Fig. 2 Original springs and the plots (black spots) where the underground water supplied by the Tazawa-sosui (irrigation canal) before the flooring with concrete gushed out temporarily. (by courtesy of the Ministry of Agriculture and Forestry)

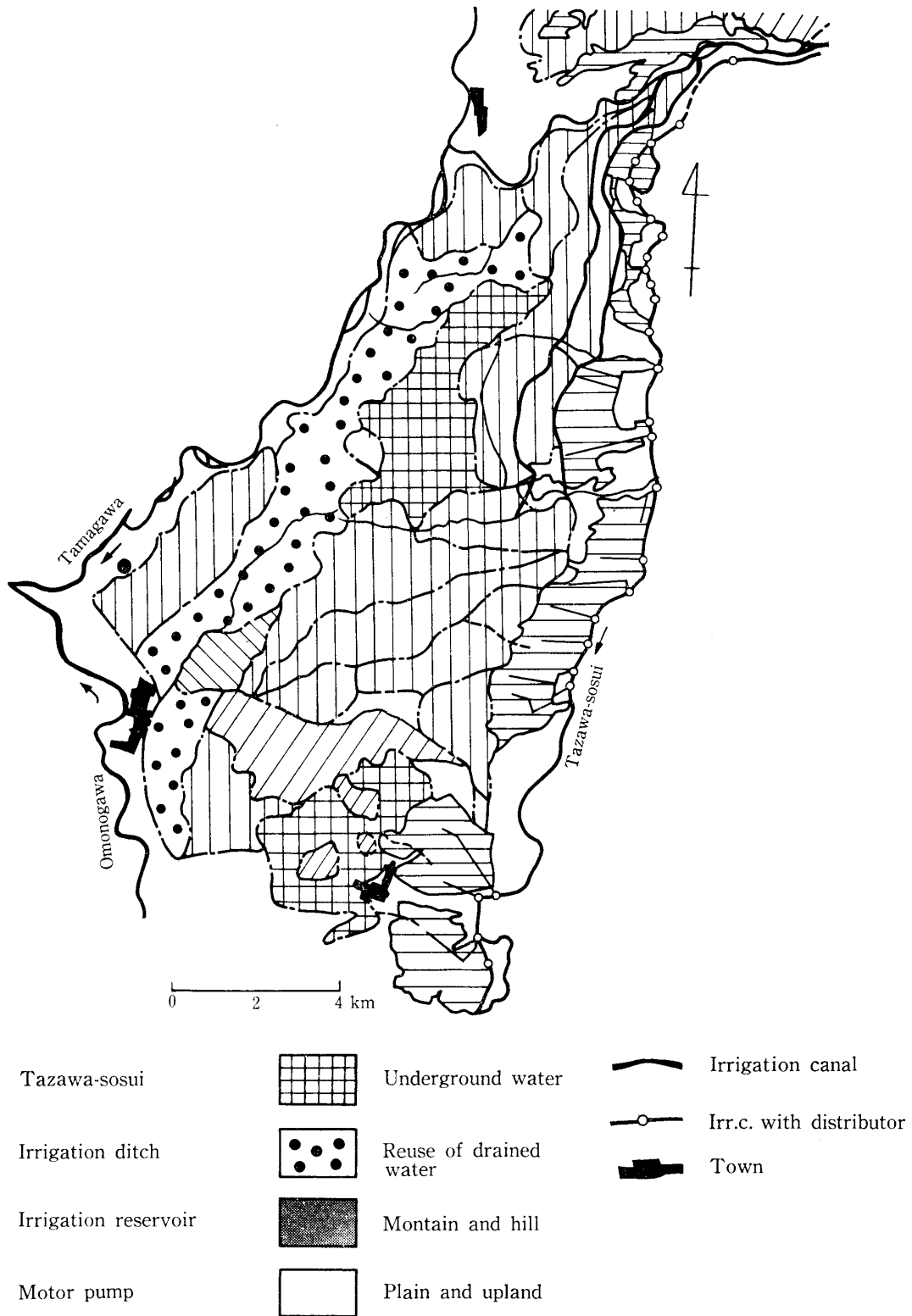


Fig. 3 Irrigation districts distinguished by the sources of irrigation water in the northern part of Yokote basin, Akita Prefecture. (by courtesy of Minist. Agri. Forest.)

neighbour land in the physical aspect and land use, and in a various way according to their original topographical nature. Such a dynamic study is an effective measure to comprehend the structure of the regional human ecosystem. Moreover it helps us to anticipate chain reaction extending over the wide land and the far-reaching influence which must be caused by the drastic human action to nature, and to consider a counterplan such as the precatation for a disaster and the compensation for inhabitants who are suffered.

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- (J) means written in Japanese.