

DEVELOPMENT AND MANAGEMENT OF RIVER FLOOD CONTROLS AND WATER UTILIZATION FACILITIES IN THE MIDDLE AND LOWER REACHES OF THE ISHIKARI RIVER OVER 100 YEARS

- TRANSFORMATION OF COLD REGION PEATLANDS INTO ONE OF JAPAN'S TOP RICE CULTIVATION AREAS, LEADING TO THE FORMATION OF A MAJOR ECONOMIC ZONE -

HIDETO KON

Hokkaido University, Faculty of Engineering, Sapporo, Japan, hkon@eng.hokudai.ac.jp

TAKASHI INOUE

Hokkaido University, Research Faculty of Agriculture, Hokkaido University, Sapporo, Japan, tino@env.agr.hokudai.ac.jp

YASUYUKI HIRAI

Civil Engineering Research Institute for Cold Region, Sapporo, Japan, hirai-y2xp@ceri.go.jp

KAZUMASA NAKAMURA

Civil Engineering Research Institute for Cold Region, Sapporo, Japan, chuson@ceri.go.jp

SATOMI KAWAMURA

Civil Engineering Research Institute for Cold Region, Sapporo, Japan, kawamura-s@ceri.go.jp

ABSTRACT

In Hokkaido, a cold region in northern Japan, full-scale land reclamation started when the local headquarters of the Hokkaido Development Commission was established in Sapporo in 1871. The center of land reclamation in Hokkaido was the Ishikari River Basin, the second largest river in Japan, where the city of Sapporo is now located. In particular, the middle and lower reaches of the Ishikari River basin downstream from Kamuikotan was a primeval swamp and peatland at that time, which hindered its reclamation. However, the development and appropriate management of river flood control and water utilization facilities in the middle and lower reaches resulted in changes. The peatland in this cold region were transformed into one of Japan's leading rice cultivation areas. The transformation of this region into a major economic zone was realized in a relatively short period of one hundred-odd years.

Cut-off works were selected as the principal improvement method in the beginning of flood control of the middle and lower reaches of the Ishikari River. The construction of 29 cut-off works has provided a dramatic improvement of the safety level of flood control in the basin. In addition, the water level of the mainstream and tributaries in normal period decreased, making the improvement of trunk and branch water channels possible. As a result, an area of peatland was transformed into the present-day vast rice cultivation areas in a short period of time. The development of this region would not have been possible without the improvement of the mainstream of the Ishikari River.

This paper describes the development and management of river flood controls and water utilization facilities in the middle and lower reaches of the Ishikari River as well as the important roles they played in contributing to the development of the basin.

Keywords: Development of Hokkaido, cutoff works, Ishikari River, peat swamp, flood control, paddy field

1. INTRODUCTION

The Ishikari River originates at Mt. Ishikari (1,967m above sea level) in the Daisetsu Mountains, flows through the narrow gorge at Kamuikotan and enters the Ishikari Plain. Many tributaries join the Ishikari River, which drains into the Sea of Japan at Ishikari City. The basin of the Ishikari, a first-class river with a main channel of 268km in length (the third-longest in Japan), measures 14,330km² (the second-largest basin Japan) (Hokkaido Regional Development Bureau, 2007). The river basin is home to roughly 3 million people, including citizens of Sapporo, the prefectural capital. This accounts for more than half the population of Hokkaido. The basin forms the social, economic, and cultural base of Hokkaido (River Bureau, Ministry of Land, Infrastructure and Transport, 2004). "Ishikari" is said to originate from *i shikara pet* (a very winding river), the description used by the indigenous Ainu people of Hokkaido. As the name suggests, it used to meander over wide areas of vast,



Figure 1. Location of the Ishikari River Basin



Figure 2. Map of the Ishikari River in Hokkaido (Wasson 1875, Hokkaido University Library)

low, peaty wetlands, and it repeatedly flooded (Ministry of Land, Infrastructure, Transport and Tourism and Ishikari City). Figure 1 shows the location of the Ishikari River Basin.

The Meiji New Government was established in 1868 (the first year of the Meiji Era; hereinafter, years of this era will be noted as M1, M2 and so on), and it focused on utilizing the natural resources of Hokkaido, such as land, minerals, and fishery produces to enrich the nation. The new government established the Hokkaido Development Commission in 1869 (M2). In 1871 (M4), the local headquarters of the Commission was established in Sapporo, and the full-scale development of Hokkaido began. Hokkaido's development centered around the Ishikari River basin, which includes the city of Sapporo. The Ishikari River flowed through a primeval swamp, and the soils in the area, which were wetland and peat soils, hindered development efforts. This study examines the history of development of the areas at the middle and lower reaches of the Ishikari River.

The middle and lower reaches of the Ishikari River were mainly improved by channel cutoffs (i.e., the construction of shortcut channels). The completion of 29 cutoffs dramatically improved the flood safety of the basin (areas at the middle and lower reaches of the Ishikari River). In addition, the water level of the mainstream and tributaries at normal times decreased, enabling the improvement of networks of trunk and branch drainage channels. As a result, swampland was transformed into vast rice cultivation areas, and the area has developed into an important economic zone in only about 150 years. This paper describes the development and management of river flood control and water utilization facilities at the middle and lower reaches of the Ishikari River, as well as the important roles they have played in contributing to the basin's development.

2. DEVELOPMENT OF THE ISHIKARI RIVER BASIN IN THE EARLY PERIOD OF HOKKAIDO'S DEVELOPMENT (1870-1900)

Hokkaido was called Ezo-chi before the Meiji Era, and indigenous Ainu lived in the area. The people of Honshu and Hokkaido are said to have had interactions since the end of the 14th century. In 1868 (M1), the Meiji Restoration was completed. The new Meiji Government completely changed national policy. To defend Japan's northern areas from Russian incursions and to catch up with Western military and economic powers, the new government, under the motto of developing Japan as a wealthy country with an able military, decided to promote the development of the land and natural resources of Hokkaido, including minerals and marine products. In 1869 (M2), the Meiji Government established the Development Commission for these purposes and decided to develop Ezo as a special area. It renamed Ezo as Hokkaido. The government established the Sapporo Headquarters of the Development Commission in 1871 (M4) as an institution dedicated to the management of Hokkaido and started the full-fledged development of Hokkaido (Hokkaido Development Bureau, Ishikari River Development and Construction Department, 1980a).

The center of development in Hokkaido was the Ishikari River basin, where Sapporo was located and where the Sapporo Headquarters of the Hokkaido Development Commission was established. James R. Wasson, an army

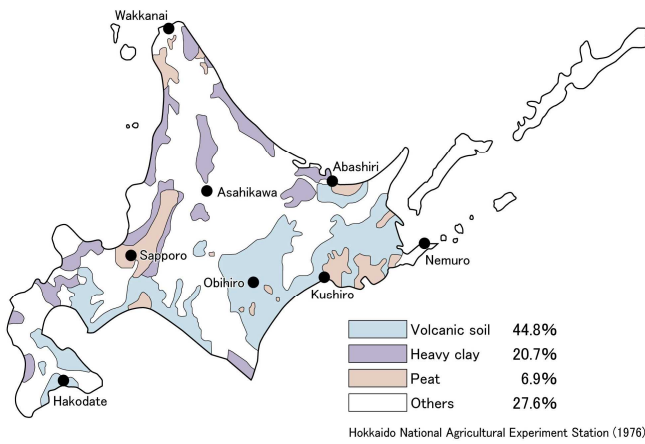


Figure 3. Distribution of problematic soils in Hokkaido

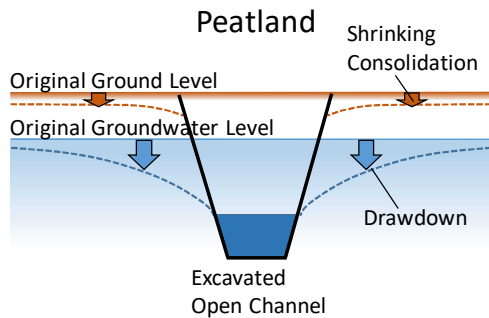


Figure 4. Peatland groundwater level lowered by channel excavation



Figure 5. Channel excavation at a peatland (Tsuishikari, Hokkaido University Library)

excavation of channel is shown in Fig. 4, and channel excavation in progress at peatland in Tsuishikari is shown in Figure 5.

After 1887 (M20), the developed areas along the Ishikari River expanded upstream. Similar to the development around Sapporo at the lower reaches of the Ishikari River, improvements to the drainage system were essential for the conversion of peatland to arable land. For the development of areas at the upper reaches of the Ishikari River, it was necessary to construct drainage channel networks and to implement projects for lowering the water level at the lower reaches of the Ishikari River. The local residents, driven by their strong desire to eat rice daily, strove to cultivate rice, and the Hokkaido Government changed its policy from banning rice cultivation to promoting it. Rice cultivation was actively attempted in areas where the water supply had become abundant after the construction of irrigation facilities. Thus, the main industry gradually shifted from fishing to agriculture (Hokkaido Development Bureau, Ishikari River Development and Construction Department, 2011).

3. FLOOD CONTROL PLAN FOR THE ISHIKARI RIVER

3.1 Major floods, and flood control plans

In 1898 (M31), the Ishikari River Basin had heavy rainfall from September 6 to 8. The crops, which were on the verge of being harvested, were almost completely lost. Bridges and railroads that had finally been completed

advisor employed by the Meiji Government, surveyed the topography and river channels of the Ishikari River from 1873 to 1874 (M6-M7). The map of the Ishikari River in Figure 2 (Wasson 1875 (M8)) is considered to be the oldest record of the channel's shape (Hokkaido Development Bureau, Ishikari River Development and Construction Department, 2002).

One purpose of Hokkaido's development was the development of agricultural fields on vast tracts of land that would achieve increases in agricultural production. During the early years of development, rice cultivation was considered impossible because of the cold climate. It was officially banned. The primeval land of Hokkaido had problem soils that were not suitable for the growth of agricultural crops. As shown in Figure 3, problem soils, such as peat, heavy clay, and volcanic ash distribute in vast areas of Hokkaido. The Ishikari River basin had vast peatlands at its middle and lower reaches.

In 1886 (M19), the Hokkaido Government of the Ministry of Interior was established. The Hokkaido Government emphasized basic projects that would support agricultural development. Such projects included the construction of drainage and irrigation canals and facilities for flood control. The construction of drainage canals was a project that required urgent implementation. The Hokkaido Government started construction of the Sapporo Plain Drainage System in 1886 (M19) and decided to implement projects of the same type in many areas of Hokkaido. The Hokkaido Government prioritized the improvement of rivers in order to increase the flood control capacity of areas with wetlands and promoted improvements to swamp soil by constructing drainage systems. Effective flood control and drainage promoted the conversion of swampland into dry arable land. This series of steps in a land development project became the prototype for Hokkaido's flood control projects for agricultural land development. A schematic of how the groundwater in peatland was lowered by the



Figure 6. Areas inundated by the 1904 flood

shortly before the flood were washed away. Residents of inundated areas left their villages, and farmers abandoned their farms one after another. The leaders of the communities along the Ishikari River established the Ishikari Flood Control League. The League petitioned the House of Lord and the House of Representatives to start flood control on the Ishikari River. The Hokkaido Government decided to strongly promote flood control projects, established the Hokkaido Flood Control Investigation Council, designated Dr. Bunkichi Okazaki as Chairman, and started surveys toward formulating a drastic flood control plan (Hokkaido Development Bureau, Ishikari River Development and Construction Department, 2002).

In 1904 (M37), two floods occurred during the period from June to July. Bunkichi Okazaki analyzed the discharge in the river channel and the floodwater discharge measured by simultaneous discharge observation and estimated the amount of water that would flow back into the Ishikari River (the flood return discharge) if certain flood countermeasures were taken. He estimated the flood return discharge at the control point at Tsuishikari, which was the location of the Ishikari Ohashi Bridge, under the assumption that the planned countermeasures had been completed. The estimated return discharge was 8,350m³/s, which was more than four times the measured discharge. The discharge estimated by Okazaki was used as the design discharge for the Ishikari River (at Tsuishikari) for the more than half-century until the Basic Plan for the Implementation of Construction Works was formulated in 1964 (the 39th year of Showa era; hereinafter, years of this era will be noted as S1, S2 and so on.) (Website of the Hokkaido Regional Development Bureau (HRDB); Hokkaido Development Bureau, Ishikari River Development and Construction Department, 2002; Suzuki and Kawamura, 2012). Figure 6 shows areas inundated by the 1904 flood.

In 1909 (M42), Okazaki presented to the Hokkaido Government the Survey Report for Flood Control on the Ishikari River, which was compiled based on calculations of the design discharge (flood return discharge) obtained from discharge observations during the 1904 flood (M37) (Website of the HRDB).

3.2 Cutoff works on the Ishikari River

In 1910 (M43), Okazaki became director of the Ishikari River Control Office and started the 1st Phase Ishikari River Flood Control Works. However, the progress of this construction was slow due to financial constraints. In 1917 (the 6th year of the Taisho era), Tadao Okino, vice-minister for Engineering Affairs of the Ministry

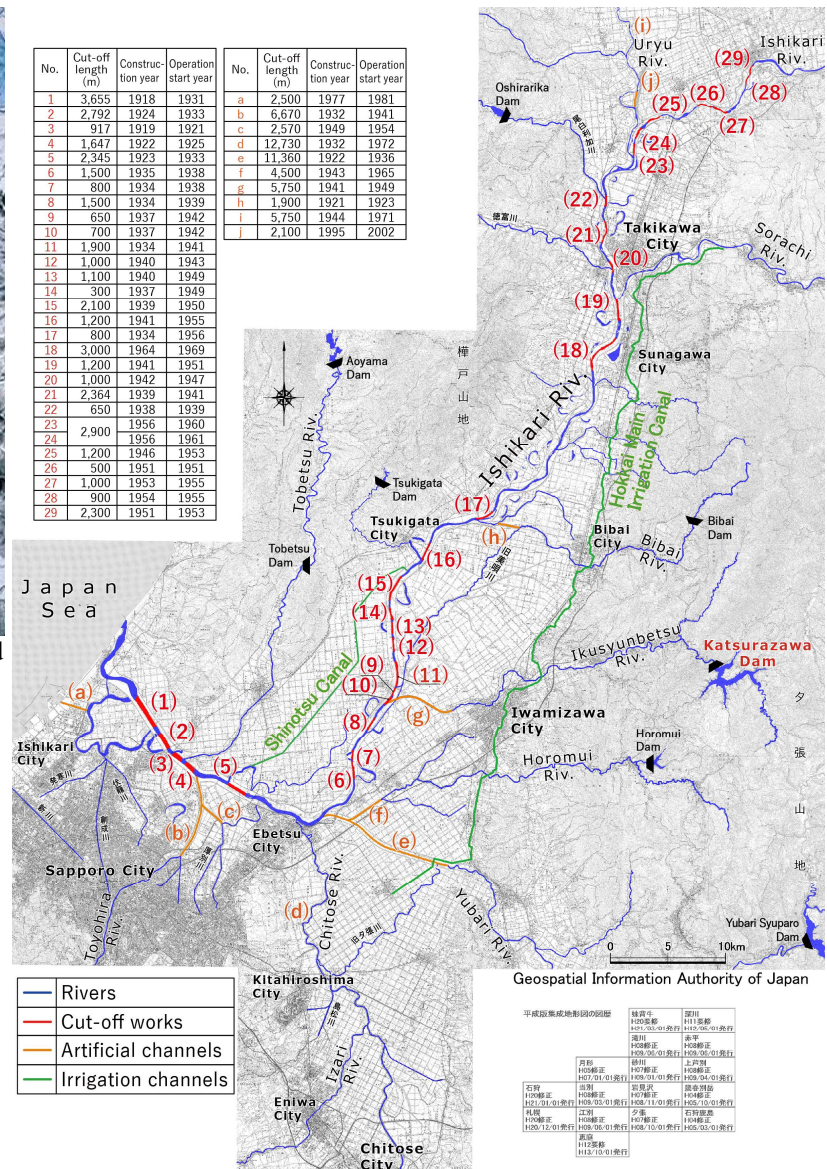


Figure 7. Cutoff works on the Ishikari River and Hokkai Main Irrigation Canal



Figure 8. The Oyafuru cutoff channel



Figure 9. Cutoff works in middle reach of the Ishikari River (Hokkaido Development Bureau)

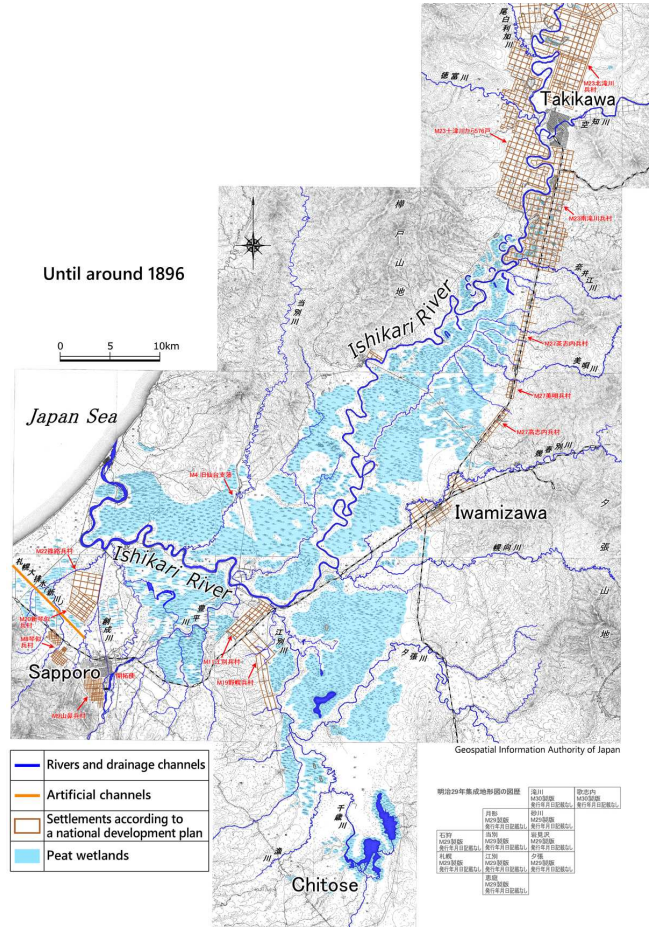


Figure 10. Flood control and water utilization facilities, and land use status (1896)

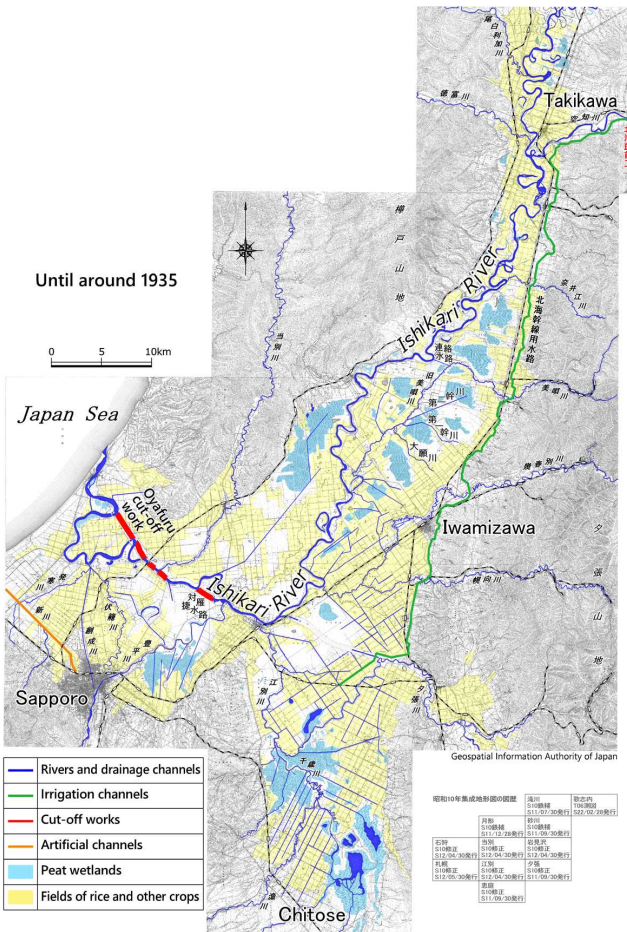


Figure 11. Flood control and water utilization facilities, and land use status (1935)

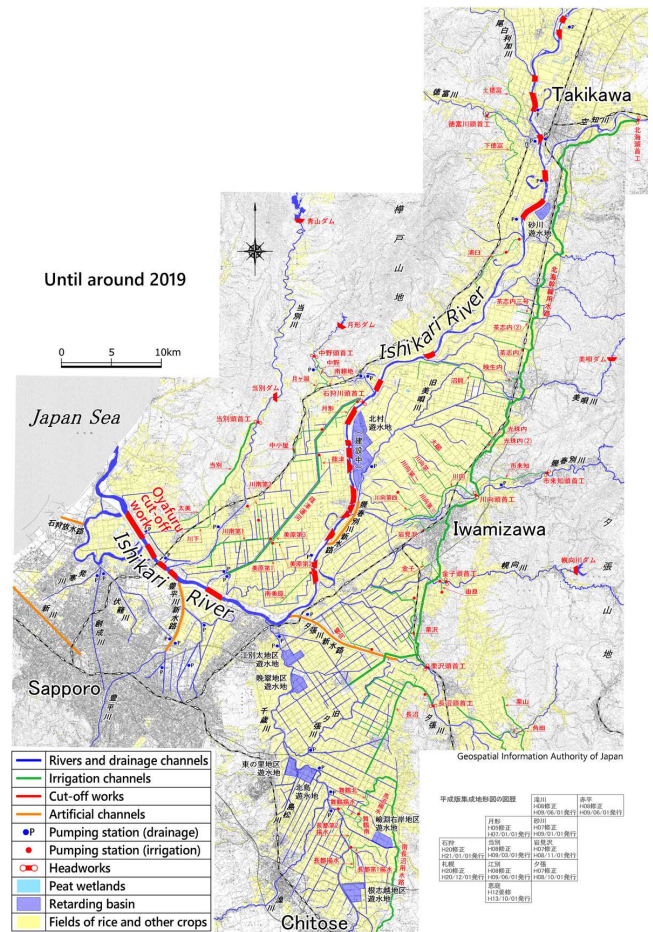


Figure 12. Flood control and water utilization facilities, and land use status (2018)

Home Affairs visited Hokkaido and had discussions with Bunkichi Okazaki on improvement works for the Ishikari River. As a result, they decided to implement cutoffs for river improvement. Thereafter, the improvement of the Ishikari River was to be carried out basically through cutoffs for the half-century from 1918 (T7) to 1969 (S44). While these cutoffs were being implemented, there were many floods; however, the 29 cutoffs shortened the Ishikari River by about 58km, and the river was eventually shortened by about 100km, including natural short circuits. The water level gradually fell, the flow capacity increased, and flood damage was gradually reduced. Figure 7 shows cutoff channels completed on the Ishikari River, and Figure 8 shows the Oyafuru cutoff channel, a typical cutoff. Figure 9 shows the middle reach of the Ishikari River where the cutoff works was implemented. The original river channels are shown in the photographs.

The main channel of the Ishikari River was improved by implementing cutoffs. The water level fell and the flow capacity increased. Improvements in peripheral areas on the Ishikari River, including areas along tributaries and at the upper reaches, had become possible. The ends of agricultural drainage networks in areas on relatively small-scale tributaries were connected to such small rivers. The improvement in small tributaries lowered river water levels and groundwater levels in land on the tributaries, greatly contributing to the development of agricultural land.

3.3 Development of agricultural drainage networks

The Hokkaido Government reversed its policy and began to promote rice cultivation. In 1900 (M33), agriculture became the top industry in Hokkaido, and from 1903 (M36), agricultural production accounted for 40% of all production (Hokkaido Development Bureau, Sapporo Development and Construction Department, 2011; Agricultural and Rural Development Information Center). The paddy field area increased even in lowlands in northern areas at the middle and lower reaches of the Ishikari River. The paddy fields spread to lowlands at the upper reaches of the Ishikari River in the Kamikawa Basin, Biei, and the Furano Basin.

The central and southern areas of the Ishikari River basin had widely scattered peatlands whose soil was unsuitable for rice production. The paddy fields in these areas, which had been developed only in small, scattered arable areas with good water supply, were small-scale and similarly scattered. In 1922 (T11), the Hokkai Earth Work Union was established in response to the national government's policy of increasing food production, and in 1924 (T13), construction started on the Hokkai Irrigation Canal. This large-scale irrigation channel stretched the roughly 80km between present-day Akabira City and Namporo Town. This project was based on a national vision for building a strong country and developing the entire area along the left bank of the Ishikari River into Japan's largest granary. Figure 9 shows the Hokkai Main Irrigation Canal (the former Hokkai Irrigation Canal).

In this way, in areas at the middle and lower reaches of the Ishikari River that had been barren wetlands (peatlands), facilities for drainage and irrigation, and cutoffs for flood control had been constructed since the early period of settlement and development under the management of the Development Commission. The prototype for irrigation-drainage systems that support the current vast rice cultivation area was developed during this period. Thanks to these facilities, the wetlands were converted to paddy fields in a short period of time. Figures 10, 11, and 12 show flood control and water utilization facilities and land use status in 1896 (M29), 1935 (S10), and 2018 (the 30th year of the Heisei era).

4. DEVELOPMENT OF THE ISHIKARI RIVER IN RECENT YEARS (1945 - PRESENT)

4.1 Development of flood control and water utilization facilities after WW2

Japan passed through the age of "building a wealthy country" that started in the Meiji Era, the wars of the Taisho Era, and the Greater East Asia War (WW2) from 1937 (1941) - 1945), and suffered great social and economic destruction. The development of Hokkaido had become increasingly important, and the Comprehensive Development Project for the Ishikari River System was initiated to promote the utilization of water in the Ishikari River System for industry and daily life through the use of the water of the Ishikari River to supply food and water and energy resources for the basin. In addition to the need for flood control, water for industry and residents was called for. In responding to these demands, multipurpose dams were the central facilities. Katsurazawa Dam (1947-1957) (Figure 13) was constructed on the Ikushunbetsu River, a tributary of the Ishikari River, as a pillar of the first comprehensive river development project in Hokkaido. The objectives of this dam were flood control, power generation, irrigation, and water supply.

In 1956 (S31), as a measure to address serious food shortages after WW2, the Shinotsu Area Peatland Development Project was initiated with a loan from the World Bank. This project planned to introduce water into the Shinotsu Canal (Shinotsu Main Irrigation Canal) in order to convert the barren peatland of the southern Ishikari area to arable land. Under this project, the Ishikari Headwork was constructed to take water from the Ishikari River. This facility was completed in 1963. The Shinotsu Main Irrigation Canal (Figure 14), a 23.1km-long irrigation and drainage canal, was completed in 1970 (S45) (Hokkaido Development Bureau, Sapporo Development and Construction Department, 2011).



Figure 13. Katsurazawa Dam (under construction)



Figure 14. Shinotsu Canal (Shinotsu Main Irrigation Canal)

Table 1. Changes in population, arable land area, and urban area

	1900 (approx. 110y before)	1955 (approx. 60y before)	2015 present
Population of the Basin (10 thousand)	44	184	312
Cultivated Lowland Area (ha)	15,500	97,900	111,100
Urban Lowland Area (ha)	400	2,800	17,100

Note: “Lowland” excludes the upper reaches of the Ishikari River (Kamikawa).
Adapted from the Hokkaido Development Bureau, MLIT (2015),
Overview of agricultural and rural development in Hokkaido

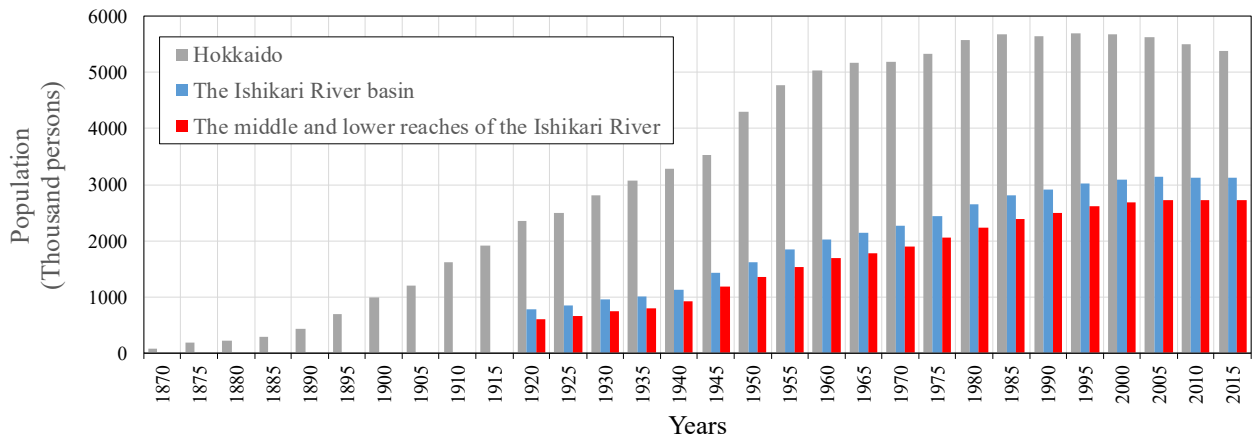


Figure 15. Population changes in the Ishikari River basin

4.2 Future issues

From the initiation of land development after the establishment of the Development Commission, rice productivity and quality had greatly improved from the construction of flood control, drainage, and irrigation facilities during the early period of development, and from subsequent soil dressing and improvements of rice plant varieties. Currently, fields where paddy rice is cultivated account for about 110,000ha, and the area has developed into one of Japan’s leading rice-growing areas (Table 1 and Figure 15). The areas at the middle and lower reaches of the Ishikari River had been developed to convert peat swamps into agricultural fields by lowering the groundwater level and drying the wetlands. When peat soil is rapidly drained and the groundwater level drops, the peat changes from saturated and anaerobic to unsaturated. The following problems occur. 1) The peat layer becomes thinner due to groundwater lowering, and land subsidence occurs. 2) The acceleration of peat decomposition increases carbon dioxide (CO₂) emissions. 3) The drying of peat swamps affects precious wetland ecosystems. Paddy fields are closely related to water circulation and groundwater circulation, and the groundwater recharge function is one of the many functions of paddy fields. Groundwater recharge from paddy fields can prevent excessive lowering of the groundwater level, which in turn can contribute to controlling land subsidence and carbon dioxide emissions and to the preservation of valuable wetland ecosystems.

Japanese society has entered an age of severe depopulation, which poses a serious problem in maintaining the current status of paddy fields, in addition to the government's policy of reducing the area of paddy field. The number of workers employed in Hokkaido is projected to be 65% of the 2010 figure in 2040, in 30 years, and 45% of the 2010 figure in 2060, in 50 years. These estimates project disastrous conditions from the viewpoint of the sustainability of regional industries (Hokkaido government, 2015). With declines in food production and the workforce due to depopulation, an issue to be addressed is how to maintain the water system in the Ishikari River Basin, including the maintenance of paddy fields, the groundwater recharge function, and the ability to moderate groundwater decreases. Policies, research, and technological developments that addressing these issues are future tasks for the administration.

5. CONCLUSION

Since the establishment of the Development Commission in 1869 (M2), Hokkaido's development has been promoted. In areas at the middle and lower reaches of the Ishikari River, which was the center of land development, peat and other soils were problematic and unsuitable for agriculture. Such soils were improved by the construction of flood control facilities that lowered river water levels, the construction of drainage canal networks that lowered groundwater levels and dried the swamps, and the construction of irrigation systems that supplied water to the area. Hokkaido's development was promoted as Japan's policy of building a wealthy country in the early period of development and as a national restoration policy after WW2. Hokkaido has played an essential role as a food supply base of the country.

Since then, the productivity of rice farming and the quality of the rice have greatly improved as a result of improvements in soil management, including the implementation of soil dressing and improvements in rice plant varieties. The current population of the Ishikari River Basin, which has grown to about 3 million in only 150 years since the start of development, accounts for more than half of the population of Hokkaido. The Ishikari River Basin, with 110,000ha of paddy fields in areas at the middle and lower reaches, has been transformed into one of Japan's largest economic zones and granaries. The conversion of such peatland into vast paddy fields is rare anywhere in the world, and it can be said that Hokkaido's development is a successful example of the comprehensive development of a river basin.

As a future issue, it is vital to maintain the flood control and water use systems in areas at the middle and lower reaches of the Ishikari River from the viewpoint of global environmental protection in response to climate change and global warming. Toward that end, the further promotion of policies, research, and technological development in terms of river management is desired.

REFERENCES

- Agricultural and Rural Development Information Center. Basis of Water and Soil, <https://suido-ishizue.jp/index.html>.
- Hokkaido Development Bureau (2007). River Development Plan for Ishikari River (Downstream).
- Hokkaido Development Bureau, Ishikari River Development and Construction Department (1980 a). History of Flood Control Works in the Ishikari River.
- Hokkaido Development Bureau, Ishikari River Development and Construction Department (1980 b). Report on Comprehensive Flood Management Plan in Special Soft Ground Area in the Ishikari River basin.
- Hokkaido Development Bureau, Ishikari River Development and Construction Department (2002). Ishikari River - Flood Control - Basis of Regional Development.
- Hokkaido Development Bureau, MLIT (2015). Overview of agricultural and rural development in Hokkaido.
- Hokkaido Development Bureau, Sapporo Development and Construction Department (2011). Ishikari River Basin Journal.
- Hokkaido Development Bureau website, History of Flood Control Works in the Ishikari River, <https://www.hkd.mlit.go.jp/ky/index.html>.
- Hokkaido government (2015). Hokkaido Population Vision.
- Ishikari City website. Outline of Ishikari City, <http://www.city.ishikari.hokkaido.jp>.
- Ministry of Land, Infrastructure, Transport and Tourism, River Bureau (2004). Basic Policy for River Management of the Ishikari River System.
- Ministry of Land, Infrastructure, Transport and Tourism. Rivers in Japan - Hokkaido - Ishikari River, www.mlit.go.jp.
- Suzuki, E. and Kawamura, S. (2012). Flood Management in the Ishikari River over 100 years.