

## A HISTORY OF WATER IN THE KINGDOM OF WATER, TOYAMA, JAPAN

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### ABSTRACT

Toyama Prefecture has a unique history, worthy of the name, “Kingdom of Water”. It receives abundant rainfall and snowfall and has high-quality groundwater supported by alluvial deposits throughout the prefecture. Although the abundance of rainfall and gravel provides natural beauty, it is also associated with flood damage to human society. This paper introduces Toyama's hydrogeology, the birth of the prefecture, the reconciliation of fighting flood damage and urban planning, the culture of spring water, and the latest water business ventures. In particular, the history of flood control at the Joganji River is directly related to the development of Toyama and is described in detail. This paper illustrates the relationship between classical heritage and recent developments throughout the history of water in Toyama.

*Keywords:* Flashy stream, cylindrical diversion, artesian well, river improvement, Toyama

### 1. HYDROGEOLOGY IN TOYAMA

Toyama Prefecture has a well-developed historical water management system that has been nurtured by people who contribute to the coexistence of human society and the environment. The purpose of this study is to determine how the wisdom of our predecessors in Toyama Prefecture relates to current water use and society, and how water-related hazard risks have been mitigated.

Toyama Prefecture is located on the Sea of Japan side of central Honshu (mainland), east of Niigata and Nagano Prefectures, south of Gifu Prefecture, and west of Ishikawa Prefecture. The area of Toyama Prefecture is 4,248 km<sup>2</sup> (33rd out of 47 prefectures nationwide), 90 km east–west, and 76 km north–south. Toyama Prefecture is surrounded by the Hida Mountains (Northern Alps) with the 3,000-m-class Tateyama Mountains in the east, the Hida Highland in the south, and the Ryohaku Mountains in the west. Large rivers, such as the Kurobe River, the Joganji River, the Jinzu River, the Shogawa River, and the Oyabe River, originating from each mountain area flow northward and empty into Toyama Bay (Figure 1).

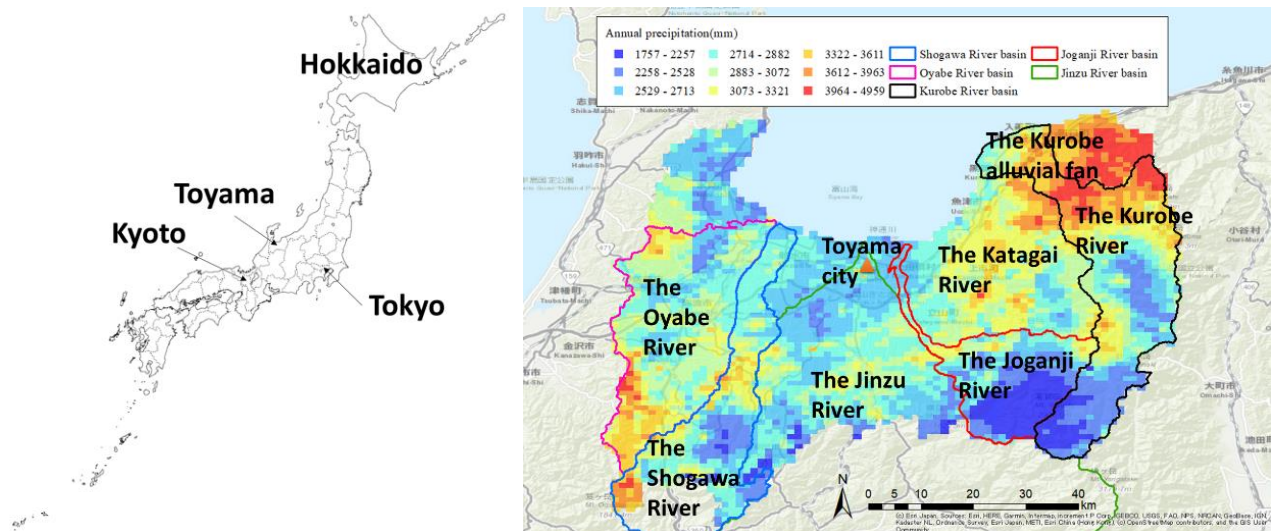


Figure 1. Map of Toyama and five major rivers in Toyama Prefecture, overlain with the distribution of mean annual precipitation.

The climate in Toyama Prefecture is classified as a typical Japanese coastal climate zone and is affected by the relatively warm Tsushima Current. Rainfall from early summer to autumn and snowfall caused by cold winter winds blowing over the warm sea result in a large amount of precipitation in this area. For example, on April 16, 2015, there was snow, 19 m high, on the Tateyama Kurobe Alpine Route, which usually receives snow in excess of 10 m (Photo 1).

The spatial distribution of normal annual rainfall from 1980 to 2010 illustrates the considerable precipitation received throughout the prefecture (Figure 1). In particular, the Kurobe River basin had a very large amount of precipitation.

The mean precipitation from 1939 to 2019 was 2,338 mm, 1.4 times the mean precipitation in Japan, while the mean air temperature was 13.7 °C and has been increasing over time (Figure 2). In winter (December-February) from 1980 to 2010, the mean temperature did not fall below freezing but was often snowy (Figure 3).



Photo 1. Tateyama Kurobe Alpine Route (April 16, 2015).

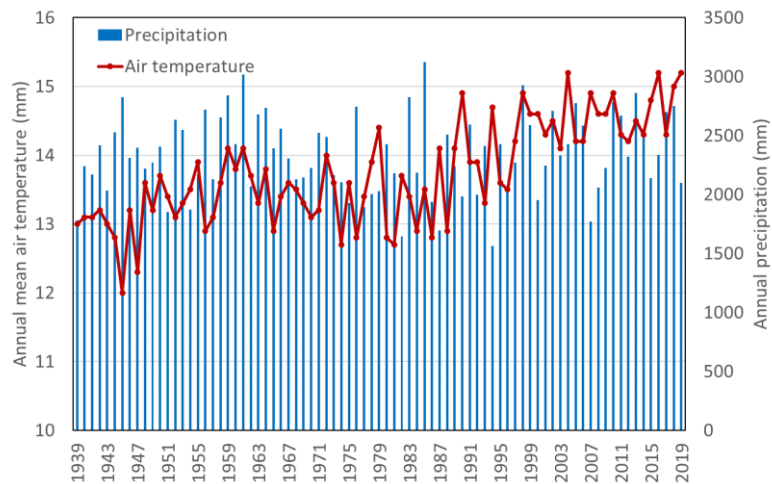


Figure 2. Annual mean precipitation and mean air temperature during the period 1939–2019.

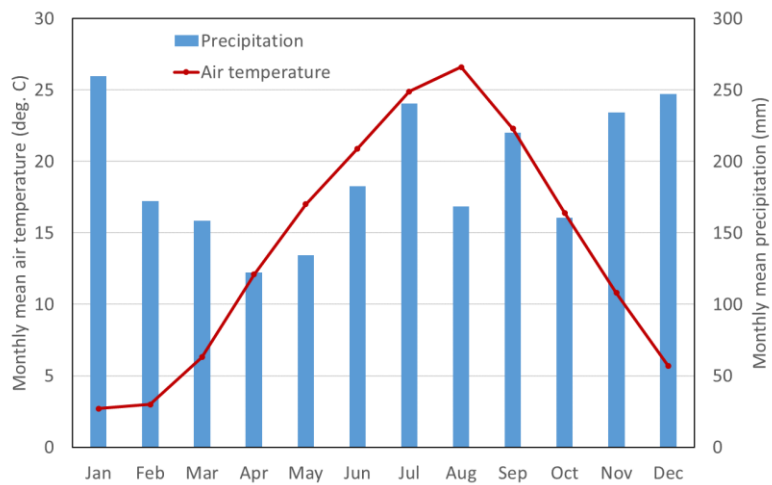


Figure 3. Monthly mean air temperature and precipitation (1981–2010).

## 2. A HISTORY OF TOYAMA PREFECTURE

Since its foundation, the people of Toyama Prefecture have had an interest in history. Following the Meiji Restoration in 1871 (Meiji 4-year), the feudal domain was replaced with the Prefecture of Toyama, which covered the area of the present-day Toyama city. In 1872 (Meiji 5-year) the first Toyama Prefecture was merged with Niikawa Prefecture, and in 1876 Niikawa Prefecture was merged with Ishikawa Prefecture. However, there was a turbulent civil engineering budgetary conflict within the Ishikawa Prefecture assembly, between the people of Kaga and those of Ecchu. Kaga required the construction of roads and communication systems, whereas Ecchu needed flood and sediment control measures. The conflict developed into a prefectural movement from which it was established in 1883 (Meiji 16-year) that Toyama Prefecture would protect the region from water-related disasters.

## 3. FLOOD CONTROL PROJECTS IN THE JOGANJI RIVER

As mentioned above, Toyama Prefecture has a large number of rapid-flowing rivers and considerable precipitation. One of these rivers, the Joganji River, the most rapid-flowing river in Japan, has been involved in a number of disasters that have had large socioeconomic impacts.

The Joganji River has a basin of 368 km<sup>2</sup> and is 56 km long, making it a first-class river (national river). The source of the Joganji River is Kitanomatamadake, at an altitude of 2,662 m, where water and gravel flow down a short path. The riverbed gradient is about 1/30 in the mountains, and about 1/100 in the plains. The deep snow in Tateyama often remains until June–July when rainy season fronts and typhoons hit, which can result in a large amount of melt water.

Although approximately 28,000 people live in the basin, the estimated flood area covers 145.1 km<sup>2</sup>, affecting a population of around 272,000. In short, the floodwaters cross the basin boundary and into the next river basin. Collapsed sediments caused by the Ansei Earthquake (1858) remain in the Tateyama caldera at the headwater and can flow into the river; thus, debris flows are likely to occur. Estimated landslides caused by the Ansei Earthquake have ranged from 270 to 410 million m<sup>3</sup>. In addition, nearby forests have a low water retention capacity because more than 40% of the basin area is covered by forests that exceed the forest limit.

In July 1891, an unprecedented flood occurred throughout the entire Toyama Prefecture, with 16 people drowning, 7,596 homes flooded, and 4,755 ha of paddy fields flooded. The Joganji River also suffered 21 days of inundation and damage to 6.7 km of dykes. Thereafter, Dutch civil engineer Johannis de Rijke was invited to advise on flood control, thus ushering in the beginning of modern civil engineering in Japan. He planned major changes to the river channel plan, embankment, and service water. Specifically, he advised relocating the ceiling river section to the west side, widening and straightening the channel, and diverging the river. He also planned optimal placement of the embankment, upgrades to the structure, regeneration of the open levee (Kasumitei), and amalgamation of service water.



Photo 2. Shiraiwa Sabo Dam

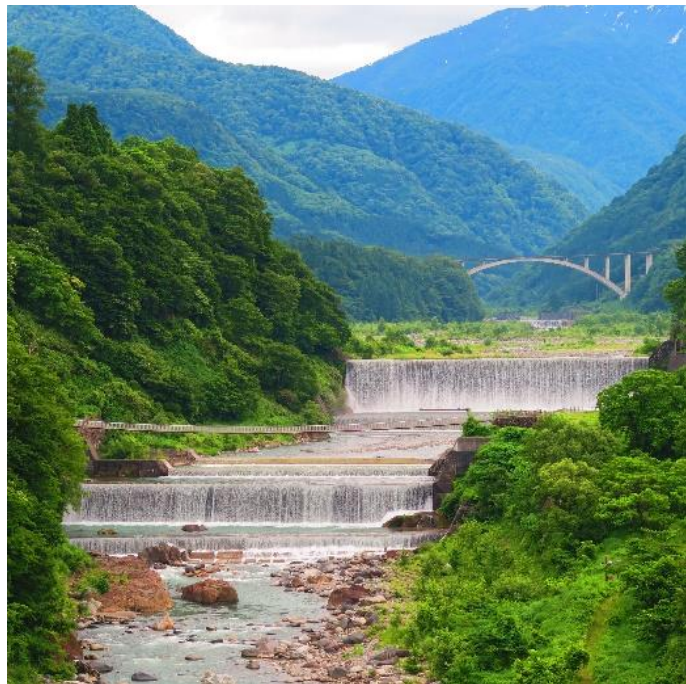


Photo 3. Hongu Sabo Dam

After that, Japanese engineers carried out various modern flood-control measures. One representative example is the Shiraiwa Sabo Dam (Photo 2). In 1926, government-directed Sabo works began at the Joganji River. The father of Sabo, Masao Akagi, the first director of the Tateyama Sabo Office, stated that, "The most



important problem in the Sabo works at the Joganji River is the construction site of the Shiraiwa Sabo Dam." Shiraiwa, as the name implies, is a place where white bedrock (granite, granodiorite) is greatly exposed, and Akagi chose it as the base point for the Sabo works. For that reason, Akagi surveyed the construction site of the Shiraiwa Sabo Dam almost every day for a month, and then made a Sabo plan for the entire Joganji River. After a lot of time and money were spent, the Shiraiwa Sabo Dam was completed in 1939, and the sub-dams were built in sequence thereafter. The Shiraiwa Sabo Dam has a height of 63 m and a total height of 108 m including the seven sub-dams, all of which are still the highest in Japan. However, the construction was extremely difficult, as the construction period was limited due to the snowfall and severe environmental conditions in the mountains. The Shiraiwa Sabo Dam, which stores a large amount of sand and considerable sediment control, was effective even during the 1969 flooding events. The work of the Shiraiwa Sabo Dam is key to controlling the large amounts of unstable sediment upstream of the Joganji River. In addition, the Hongu Sabo Dam (Photo 3), which was completed in 1937 and boasts the largest amount of stored sand in Japan, is also an indispensable structure for flood control of the Joganji River. Both structures were designated national Important Cultural Properties.

#### **4. URBAN PLANNING IN CENTRAL TOYAMA CITY AND FLOOD CONTROL OF THE JINZU RIVER**

The Jinzu River flows through the center of Toyama city and was navigated using a bridge supported by boats called Funahashi. Temporary bridges such as this were used because floods were so severe that bridges were regularly damaged. However, in response to socioeconomic improvements, there was a desire to stabilize the river; therefore, improvements to stabilize the Jinzu River commenced in 1896 (Meiji 29-year). The project was a combination of urban and river development, and the Hasekoshisen river improvement project was started in 1901 (Meiji 34-year). Naturally, the river meandered near the prefectural government office and city hall and the project aimed to straighten its course. During the straightening process, excavations were made at the start of the meander, which initiated the straightening using natural flow. The residual excavated soil was used for the reclamation of meandering areas and other urban development projects. This was a unique river project of global significance.

Recently, sightseeing boat trips (the Matsukawa River; Photo 4) and park development (Kansui Park; Photo 5) using the old river have been carried out, contributing to overall river traffic.

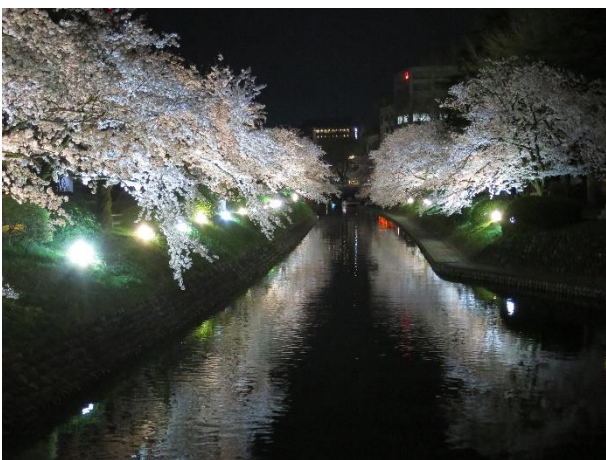


Photo 4. The Matsukawa River and cherry blossoms at night in April



Photo 5. Kansui Park in Toyama City

#### **5. SPRING WATER AND CULTURE**

“The Best 100 Waters” are 100 springs, rivers (including irrigation water), and groundwaters that were designated as “great waters” across the country by the Environment Agency (currently the Ministry of the Environment) in March 1985. “Great water” in this context means that “the conservation status was good” and “there were conservation activities by local residents”. It did not mean “delicious water that can be drunk as it is”, as some water sources required boiling prior to drinking. In Toyama Prefecture, the largest four locations were selected for “Great water”(the Kurobe River alluvial springs, Anantan-no-reisui, Tateyama Tamadono Spring, and Uriwari Shozu). Later, in 2008 in the Heisei era, the Best 100 Waters were chosen again; as before, the largest four locations were selected for “Great water in the Heisei era” (the waterside of the Itachi River and Shozu, Yumi-no-Shozu, Gyoden-no-sawashimizu, and Fudodaki-no-reisui). All eight selected locations were spring waters.

The Kurobe River alluvial springs, one of the 1985 great waters, are famous across Japan. They are located at the edge of the Kurobe River alluvial fan and refer to the area that extends between Nyuzen Town and Kurobe

City. In Kurobe City, in particular, artesian wells are called “Shozu” . Nationwide, spring water is described as "清水" in Chinese characters, but it is characterized by different names, such as "Shimizu", "Kiyomizu", "Seisui", and "Shozu", depending on the region. Also, the Chinese character notation may be different.

There are 20 artesian wells in each street in the Ikuji district, Kurobe City. Each well has a historical name and is rooted in the local culture. "Shimizuan-no Shozu" is especially famous among the 20 artesian wells mentioned above (Figure 4). Many artesian wells also have water tanks with steps (Figure 4), and their use is determined upstream. The water in the uppermost tank is used for drinking, then for cooking, washing, and finally for cooling canned beer, juices, and fruits in subsequent tanks.

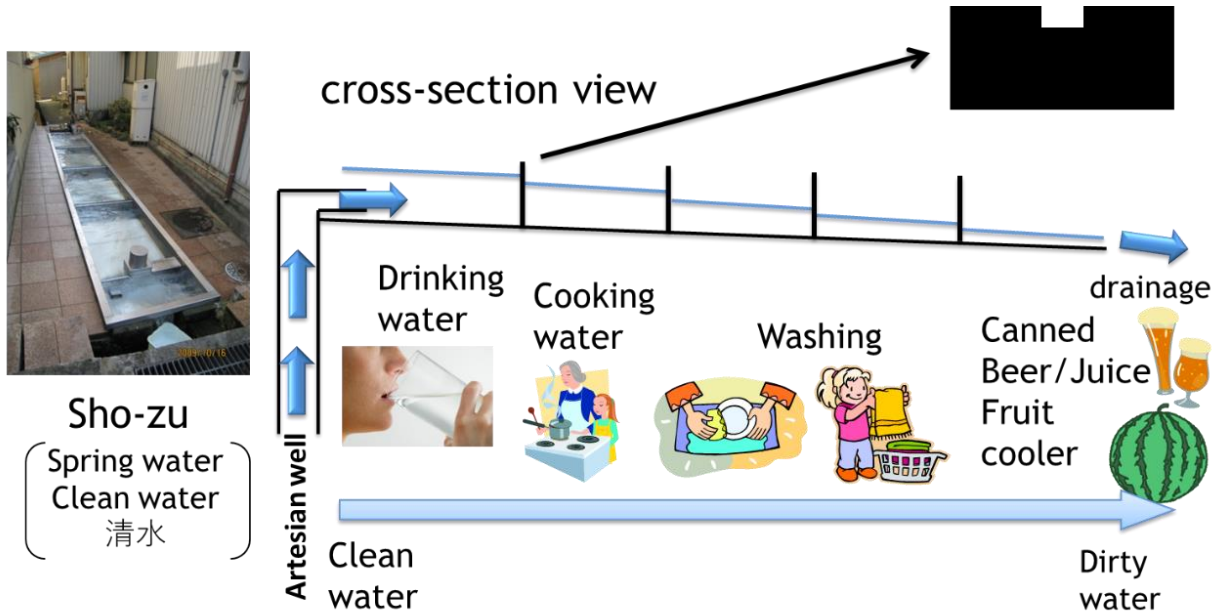


Figure 4. Water usage schematic at an artesian well in Kurobe City.

## 6. IRRIGATION WATER

Here, I introduce the cylindrical diversion that is considered to be one of the most attractive and beautiful in Japan. The Higashiyama cylindrical water tank (Photo 6) was constructed in 1955 and crosses the Katagai River from the Kaita water tank on the opposite bank using a siphon, and draws water from a tunnel that connects to the waterway. Cylindrical diversion is used to distribute agricultural water accurately at a specific rate. Water that is pumped from the center of the cylindrical facility overflows and falls from the cylinder perimeter. The system visibly divides the water equally owing to the careful design of its architects.



Photo 6. Higashiyama cylindrical water tank

## 7. BUSINESS

Finally, water business ventures have recently been introduced. Coca-Cola (Japan) Co. Ltd. collects water from seven water sources in Japan and sells plastic bottled water. One of them is located along the Shogawa River in Tonami City, Toyama Prefecture, and is being shipped nationwide.

In addition, various businesses are being developed using the deep-sea water of Toyama Bay. Toyama Bay is one of the deepest bays in Japan and contains deep-sea, low-temperature water endemic to the Sea of Japan, which is abundant at a depth of 300 m or less and accounts for about 60% of Toyama Bay. The stable low temperature, cleanliness, and eutrophication of deep ocean water mean that this water has many uses, including in fisheries, food, medicine, and health promotion, applications that are expanding every year.

## 8. SUMMARY

Toyama Prefecture has a unique history worthy of the name of “Kingdom of Water”. It receives abundant rainfall and snowfall and has high-quality groundwater supported by alluvial deposits throughout the prefecture. Although the abundance of rainfall and gravel provides natural beauty, it is also associated with flood damage to human society. The struggle is ongoing and many rapid-river control projects are underway in Toyama Prefecture.

Toyama City has grown to be one of the leading cities on the Sea of Japan side with 410,000 people, thanks to the integrated project of river improvement and urban development on the Jinzu River. There have been 11 major floods in the Jinzu River since 1912, but no death have occurred in the seven floods since 1954. The Joganji River has been flooded seven times since 1926, but no one had been killed. According to contribute the wisdom of our predecessors, the safety and security of Toyama Prefecture has been maintained today. In addition, a new water culture that fits the modern socioeconomic environment has been cultivated, one that includes small-scale hydroelectric power generation using agricultural irrigation canals, companies using the abundant high-quality groundwater, and geothermal heat pump systems using the stable temperature of groundwater.

## ACKNOWLEDGMENTS

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