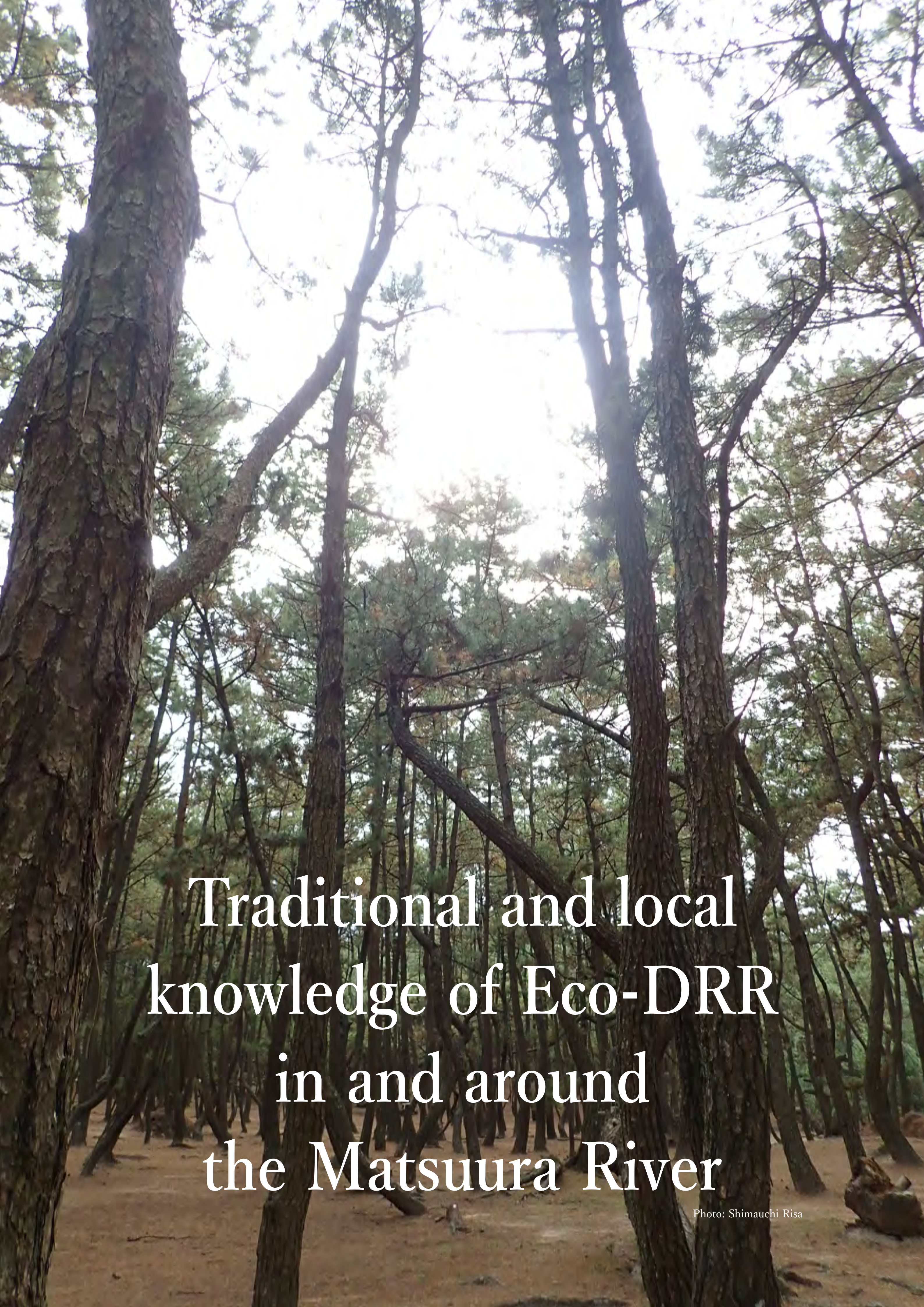
Eco-DRR as Learned from Local History

Traditional and local knowledge of Eco-DRR in and around the Matsuura River

Cover photo: Kitamura Keita



Traditional and local knowledge of Eco-DRR in and around the Matsuura River

Photo: Shimauchi Risa

Foreword

When I visited the Matsuura River for the first time, the hot summer had ended and fall had begun. Atsushi Teramura from Kyushu University showed me the river and numerous traditional flood control and irrigation facilities. Their usage of stones left the greatest impression on me. Stones cut from nearby mountains were used to control the river flow, create weirs that lead water toward rice paddies, and build the city of Karatsu on the sandbanks of the river mouth. The masonry techniques that were claimed to have originated from ancient practices in Korea and China can be credited for the river scenery and streetscapes that have survived until the present day. By simply observing the masonry all around, one can experience a close connection with the distant, far off continent beyond the Genkai Sea that the river flows into. The traditional knowledge and technology of the local people used to obtain stones is still relied on to harvest the blessings of the river and avoid disasters. The Matsuura River thus conveys a sense of connection between people across space and time.

A refreshing sea breeze passes through Niji-no-matsubara stretching at the river mouth. Beyond the beautiful pine forest forming an arc like a wing, the Karatsu Castle (also called the Maizuru Castle) stands on a small hill as if it were floating on the wing. If you climb up to the castle while observing the stone walls arranged in an orderly fashion, the vast Genkai Sea spreads out before you, and below you the river flows as if nestled close to the streets of the Karatsu city. If you walk down to the city and stand on the long bridge crossing the river, you can observe the Karatsu Castle reflected in the surface of the slowly flowing river. On calm days, the Matsuura River lends its peaceful presence to the local people.

If you put the city of Karatsu behind you and travel upriver, you can see places where the river is enclosed on both sides by mountains as well as areas where it flows by rice paddies and small

Photo 1. In the middle of the city of Karatsu

Photo 2. Morning on the Matsuura River

villages.

These old villages seem to avoid the river by clinging to the skirts of the mountains, and the rice paddies receive water from the open levees during floods. On the river, masonry weirs deliver water to the rice paddies and villages, many of them being so old that their construction date is unknown.

The Matsuura River has a long history of deep connections with the local people. The history of how the local people have avoided disasters while receiving the blessings of the river is overflowing in and around the river. It serves as a valuable space that facilitates learning about the traditional relationship between people and the river. During spring, Japanese dace (ida) move upstream to breed. On my first visit to the Matsuura River, I once again learned about the importance of yearly rhythms of the river that repeat over and over again.

This river is featured in the second edition of the series "Eco-DRR as Learned from Local History" . If this series can contribute to building improved relationships between human and nature amidst the current climate and socioeconomic changes by considering the history of the relationship woven in the Matsuura River, then the hard work of all those involved in its publication will be rewarded. Although we have a long way to go, steady progress is being made in this endeavor.

Yoshida Takehito

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Photo 3. The Matsuura River and Niji-no-matsubara, as seen from the Karatsu Castle

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Photo: Shimauchi Risa

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Kyoto University Fukamachi Katsue

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Photo 2. Civil engineering heritage Umankashira (Matsuuracho, Imari City)

Photo 3. Haginoo Weir (Matsuuracho, Imari City)

Water from the Matsuura River, which flows through the northern part of Saga Prefecture, has been used to sustain the daily life and farming needs of the local people. Moreover, the river has also been used for Japanese dace fishing and transportation. The river's floodplain has a history of disasters, such as floods caused by heavy rains, and the locals have cleverly used its waters, stones, and flora and fauna to devise methods to reduce damage from these natural disasters. For example, Umankashira is Japan's oldest facility to enable rice paddy cultivation using the siphoning principle to deliver water in a channel that is higher than the surface of a river (the Matsuura River) to an opposite riverbank. Moreover, this facility has continued to function along with the nearby Haginoo Weir. Umankashira has been recognized by the Japan Society of Civil Engineers as a Public Works Heritage, which serves as the core of the local heritage focusing on nature, history, and culture. On the Matsuura River, there are a great deal of examples of flood control and local irrigation heritage, which reflect the local characteristics along the river.

Moreover, the Matsuura River is surrounded by three prefectural natural parks, including Kurokamiyama, Genkai Quasi-National Park, and Nijinomatsubara (designated as a place of scenic beauty). It is a location rich in natural and cultural heritage. The riverside features stone monuments, places of worship, nature (such as large trees), and various land features that tell the history of natural and other disasters that have occurred there.

Photo 4. A stone monument restored after a large flood (Matsuuracho, Imari City)

Photo 5. Large trees and a religious spot near the cross-levee (Ochicho, Karatsu City)

Photo 6. Discussion during a Matsuura River Eco-DDR

Through investigations and discussions focusing on the traditional and local knowledge from the Matsuura River basin, this booklet introduces various applications of local wisdom and technologies for facing both nature's blessings and troubles that connect the past, present, and future. This booklet is composed of four sections: The History of the Matsuura River, Remaining Traditional and Regional Knowledge, Future Traditional and Local Knowledge of Azamenose, and Traditional and Local Knowledge of the Matsuura River. This work attempts to comprehensively explore methods of coping with natural disasters that have been learned through past experiences as well as methods of using resources provided by nature. Along with scientifically validating the meansof disaster prevention and mitigation through geographical features, such as floodplain embankments and ecosystems, this booklet introduces efforts to link local and traditional knowledge to town planning as well as actual examples showing the techniques and potential of public works, such as river improvements.

The keyword of this booklet is Ecosystem-based Disaster Risk Reduction (Eco-DDR), an approach that emerged from international disaster prevention and mitigation efforts. Healthy, rich ecosystems play the role of directly reducing disaster risk and indirectly alleviating disaster impact. Let us all consider how to respond to natural disasters while emphasizing the importance of such ecosystems and the local cultures that arise from them.

【The History of the Matsuura River】

Photo: Shimauchi Risa

The History of the Matsuura River

Kyushu University Teramura Jun

Overview of the Matsuura River

The Matsuura River is a Class A river that runs through the cities of Karatsu, Imari, and Takeo in the northern part of Saga Prefecture. With a river basin area of 446 km^2, a river channel length of 47 km, and headwaters originating in the Kurokami mountain system, its river mouth flows into Karatsu Bay, and its main tributaries are the Kyuragi River and the Tokusue River.

There are plains in the downstream area and the Niji-no-matsubara pine forest on the coast, located on its left bank near the river mouth. As well, on the left bank of the Matsuura River are Karatsu Castle and the streets of Karatsu City.

Aside from the downstream area, there are no large plains, and in the mountains, there is a repeating pattern of valleys and lowlands. The riverbed of the main channeland its tributaries is gentle, similar to the current upstream.

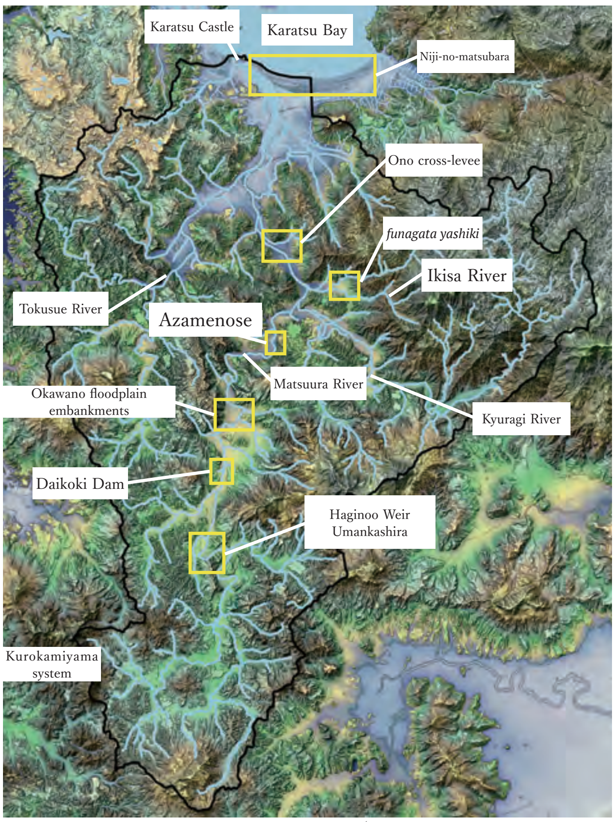


Image 1. Matsuura River basin overview (created based on a Kashmir 3D super topographical map)

As a result, up until the Meiji and Taisho eras, transport by riverboat from the river mouth to the middle reaches of the river was common on the Matsuura, Kyuragi, and Tokusue rivers.

The river basin has a population of approximately 100,000 people, with the only urban area being Karatsu, which is located at the river mouth and occupies only 1 % of the basin area. The most common types of land use in this area are rural areas and agriculture production, at approximately 84 % and 15 %, respectively.

(1) Fauna of the Matsuura River

Many types of animals and insects inhabit the Matsuura River basin. There is a rich variety of freshwater fish, beginning with *ayu* and freshwater minnows. Among these fish is the Japanese dace, which is locally called the *ida* and appears in legends throughout the region.

Cicadas are one insect commonly seen in the mountain valleys. In recent years, damage caused by wild boars and deer has increased; therefore, fences have begun to appear on farmland in rural areas between fields and forests.

The Azamenose in the Matsuura River basin is a wetland created under a national nature restoration project, and in the richly restored natural environment, bitterlings and shellfish abound in the ponds and channels created.

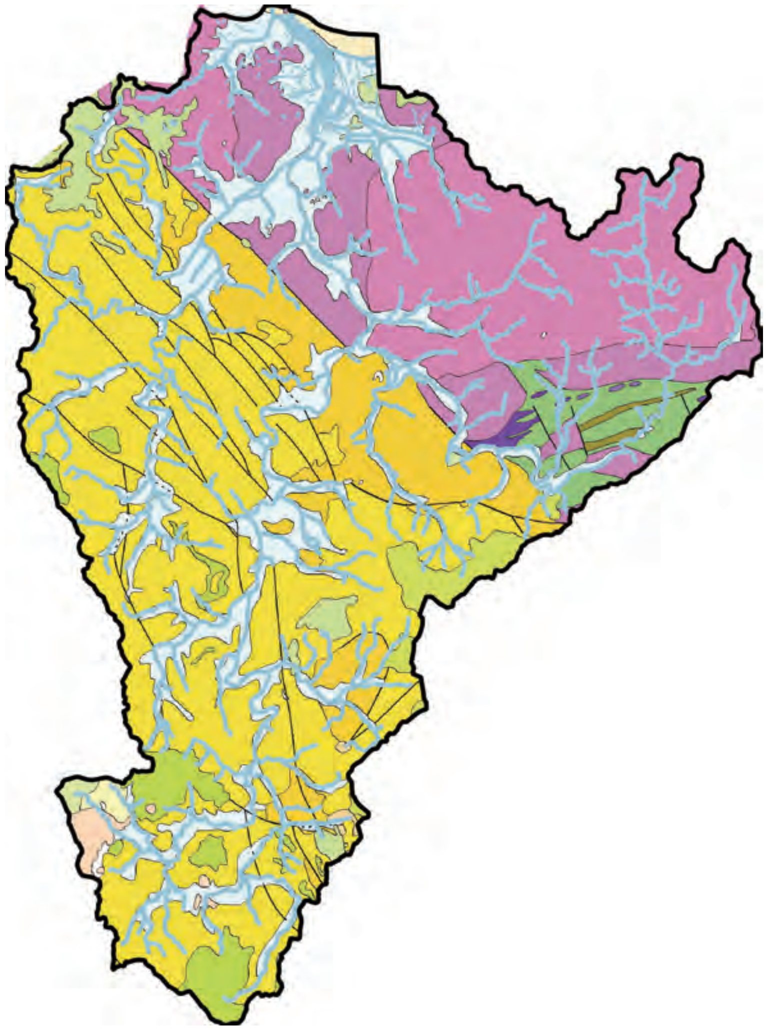
(2) Geology of the Matsuura River Basin

The geology of the Matsuura River basin can be broadly divided into two areas; east from the Kyuragi River and the downstream portion of the Matsuura River itself are composed of granite and granodiorite in the granite series, while most of the remainder is made up of sandstone, mudstone, and shale zones of the Tertiary system.

When granite-series rocks are weathered, they become decomposed granite (sandy sediment), facilitating sediment disasters. This type of geology produces a great volume of sand, thus leading the rivers to become sandy, though they do maintain some relative clarity throughout the water column.

Tertiary-system mudstone and sandstone are comparatively soft, weather rapidly, and are prone to landslides. There are, therefore, many landslide zones in mountainous areas. Moreover, areas with this geology and terrain frequently have terraced rice fields. The Matsuura River basin also has such landscapes, including the Terraced Rice Field of Warabino, which has been designated as an important cultural landscape.

Furthermore, sandstone is a soft type of stone, thus making it easy to quarry and process. There are several quarries in the river basin that produce stone for use in walls and other such purposes.



No		Legend symbols	Classifications	Formation	Formation period
692		K12_pim_a	Igneous	Granodiorite, tonalite, mass, island arc / continental	Mesozoic, early Cretaceous, Aptian, Albian
728		K12_pam_a	Igneous	Granite mass island arc / continental	Mesozoic, early Cretaceous, Aptian, Albian
101		Pg2_sbs	Sedimentary	Brackish water strata and marine and non-marine mixed strata sandstone, sandstone and mudstone interlayered and sandstone and mudstone	Mesozoic, Paleogene, Eocene, Lutetian to Priabonian
100		Pg3_sbs	Sedimentary	Brackish water strata and marine and non-marine mixed strata sandstone, sandstone and mudstone interlayered, and sandstone and mudstone	Mesozoic, Paleogene, Eocene, Lutetian
167		Pg3_soss	Sedimentary	Marine strata sandstone	Mesozoic, Paleogene, Eocene, Lutetian
8		H_sad	Sedimentary	Valley plain, intermountain basin, river and coastal plain alluvium	Mesozoic, Quaternary, Holocene
10		H_ssd	Sedimentary	Coastal and dune deposits	Mesozoic, Quaternary, Holocene
14		Q32-33_std	Sedimentary	Dune deposits	Mesozoic, Quaternary, Mid-late late Pleistocene, late Pleistocene
488		N3-vba_ai	Igneous	Alkali basalt and trachybasalt, intrusive rock	Mesozoic, Neogene, Miocene, Messinian to Pliocene
886		D3-P1_mscma_hg	Igneous	Mafic schist, high P / T type wide area metamorphic rock, garnet zone	Paleozoic, Upper Devonian to Permian age Cisuralian period
790		D3-P1_msp_hc	Metamorphic	Serpentinite, high P / T type wide area metamorphic rock, marginal mud belt	Paleozoic, Upper Devonian to Permian age Cisuralian period
549		N3_vis_ai	Igneous	Andesite and basaltic andesite, intrusive rock	Mesozoic, Neogene, Miocene, Messinian to Pliocene

Image 2. Matsuura River basin geological map (Geological Survey of Japan, AIST, created from seamless Digital Geological Map of Japan, scale 200,000:1)

Koshidake in the Kurokami mountain system, where the headwaters of the Matsuura River was a local source of obsidian production. This stone has been found in far-off locations, including the Korean peninsula and the burial mounds of Okinawa. This provides clues to the activities of the people living in the Matsuura River basin during ancient times as well as their exchanges with distant regions.

The Matsuura River basin also contains the Karatsu coal fields, which contributed to the modernization of Japan by yielding a great amount of coal, spanning from the last days of the Tokugawa shogunate to modern-day Japan.

(3) The Matsuura River its History

Numerous burial mounds and ruins containing obsidian stone tools have been found around Koshidake, which serves as the source of the Matsuura and was formerly also a major source of obsidian. Moreover, with the presence of many such burial mounds discovered in the river basin area, we can see that people have inhabited the region since the ancient periods. In the medieval period, the powerful Matsuura Clan controlled a wide area, from the Matsuura River basin to Hirado.

In the early modern period, a complicated variety of domain (*han*) administrative divisions existed in the area, including lands directly controlled by the Shogunate—such as Karatsu-han and the Shogunate territories and the Saga, Ogi and Hasunoike-han of Hizen Province. Although Hizen Province was controlled by the Saga Domain, it was further divided into the Ogi and Hasunoike Domains, thus the political division of this area was extremely complex. However, the smaller domains of the Hizen Province were closely connected to the main Saga Domain. Broadly speaking, the lower reaches of the Matsuura River belonged to the Karatsu Domain (directly controlled by the Shogunate), whereas the upper reaches were Saga Domain territory.

Through out modern history, the river has been increasingly used and altered. The first Karatsu daimyo—Shimanokami Terasawa—joined the Matsuura and Tokusue rivers into one river. They were once separate rivers which flowed downstream into the plains. He also planted a pine forest along the coast, where he strictly controlled logging, in order for the forest to serve as a windbreak.

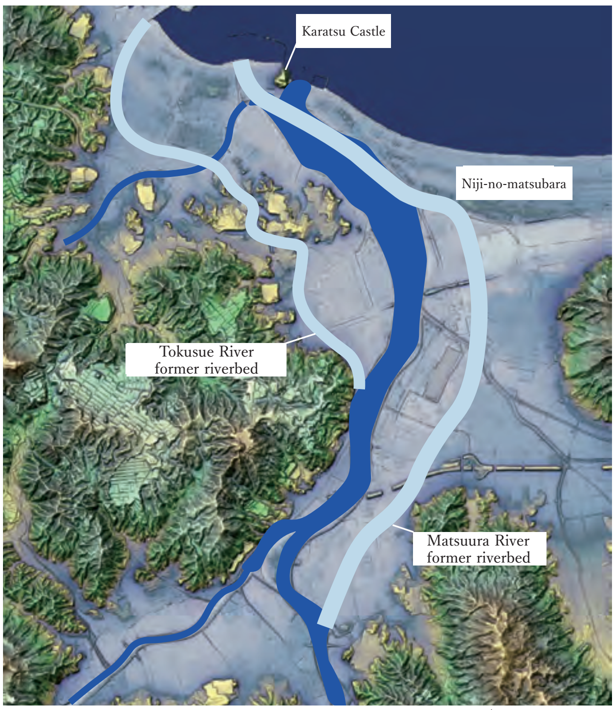


Image 3. Matsuura River downstream riverbed changes (created based on a Kashmir 3D super topographical map)

Along with Karatsu Bay, the mouth of the Matsuura River (which was unified by Shimanokami Terasawa) served well as a port, and the industries based there developed under the Karatsu Domain. The *Hizenshusanbutsuzuko* (Illustrations of Hizen Products) depicts products, such as coal, ceramics (e.g., jars) and Japanese paper, being delivered by riverboat on the Matsuura River to Karatsu and then shipped around Japan.

Karatsu was also a major whaling center. The *Hizenshusanbutsuzuko* depicts fishing with cormorants (*ukai*) as well as freshwater clam fishing. In addition, in terms of fish, the river is well-known for *ayu* and *ida*. *Ida* is the Japanese term for Japanese dace, and at the beginning of spring, these fish move upstream to breed. The first storm of spring was, therefore, called the "Ida Storm," and the Matsuura River was called the "Ida River." Although there are many depictions of the river's *ayu* in the Manyoshu, it is generally believed that this may actually depict the nearby Tamashima River.

During the Edo Period, Weirs were built on rivers to increase agricultural land, and technology was developed to create long waterways that can carry water to rice paddies. Many river structures were built using various methods; these include the stone Daikoku Weir on the main Matsuura River and Umankashira, with a waterway under the river made by Narutomi Hyogo Shigeyasu, which is revered as the "god" of flood control in Saga and elsewhere even now. There are also many Weirs and waterways that currently take water from the river and transport it over great distances, operating the same way they did when they were built long ago.

Moreover, rice paddies, which are the primary reason for building irrigation facilities, are a common sight along the Matsuura River. Due to the many villages lining its banks, we can see how the river provided the foundation for human activity. However, because the riverbanks are situated on a floodplain that has experienced frequent flooding, it was necessary to devise methods for reducing flood damage.

In many villages, houses were built on natural levees or mountainsides much higher than the elevation of the floodplain. As seen in the Okawano village, several methods such as ring levees, were built surrounding villages on low-lying land. In addition, because riverbank rice paddies were on floodplains, floodplain open levees were formed to construct rice paddies thereby reducing potential flood damage to the land.

Traditional flood control and irrigation facilities, including embankments (e.g., open levees), were not just built as we see them in their current form. Successively higher embankments were constructed over many years, thus providing a mechanism to limit damage to fields for farming and houses. This "try and see" method is an approach to traditional river technology that gradually improves functioning based on the years of experience gained through repeated disasters. In the "try and see" method, the accumulated methods of interacting with the river are not merely old technology but are linked to the present and continue to be applied.

Azamenose is a wetland with rich natural resources and flood control functions created through a nature restoration project in the Matsuura River middle basin, where traditional flood control technology was applied to create a natural environment.

Since ancient times, the local people living near the Matsuura River have maintained a constant relationship with it. Although this relationship has transformed over time, these transformations are not delineated by periods. They are always connected and build upon one another.

By examining the region through the perspective of the river, we can understand how humans and nature are connected and that the accumulated experience of the past leads us to the present day.

Works cited

Encyclopaedia of Rivers, p. 605

Matsuura River System Development Plan, Ministry of Land, Infrastructure, Transport and Tourism, Kyushu Regional Development Office, Takeo River Office (July 2009)

Geological Survey of Japan, AIST, Seamless Digital Geological Map of Japan, scale 200,000:1 (detailed version, data updated on: June 14, 2020), https://gbank.gsj.jp/seamless/

Sugihara, Shigeo. *Estimating the Origin of Obsidian Relics Excavated at Koshidake, and the Ryo Hirasawa and Suzuoke Ruins of Kyushu* (2011)

Ide, Isei. *A History of Coal Mining in Saga* Kinkado (February 1972)

Karatsu History Compilation Committee. *History of Karatsu* (reprinted version), p. 17 (1991)

Kizaki, Seihyo, *Hizenshusanbutsuzuko, Coal and Ceramics Overview*, copy National Archives digital archives

Painting 1. *Hizenshusanbutsuzuko*, fishing with cormorants (National Archives digital archives)

Activities of the Local People in the Matsuura River Basin During the Ancient and Medieval Periods Naoyuki Ichimoto

Imari Municipal Board of Education Ichimoto Naoyuki

(1) Status of Matsuura River Basin Ruins

The current Matsuura River runs from its headwaters on the eastern slope of Jinroku Mountain in Yamauchichoinubashiri in Takeo City to the river mouth in Karatsu Bay. The river passes through the cities of Imari and Takeo as well as the Karatsu City area and has a total length of 45.25 km. These three cities contain a large number of ruins from the primitive to early modern times, giving the area an abundance of historical assets. Water is essential for human life; therefore, a very high number of ruins have been found in the Matsuura River basin. The above map is an excerpt of this basin area from a map of Saga Prefecture ruins issued by the government. Along the banks of the main Matsuura river, there are 191 ruins sites, among which 172 are from the ancient to medieval times. Let's have a look at a typical site along the riverbank to understand the historical role of the Matsuura River.

(2) Daikoji Temple Ruins (Paleolithic to Jomon Periods)

Daikoji Temple is a scattering ground and

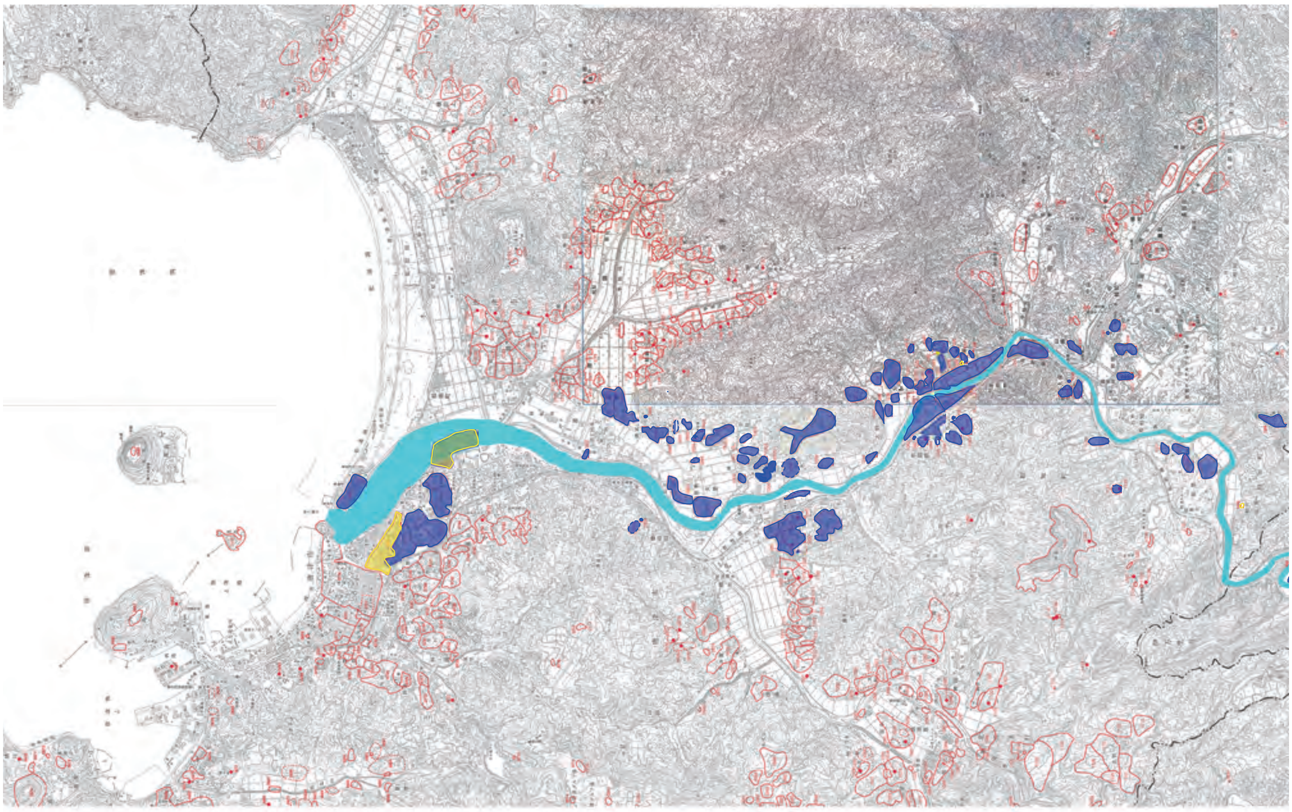


Image 1. Distribution of ruins in the Matsuura River basin (added to the Saga Prefecture ruins map)

early modern cemetery mixed site dated to the Paleolithic to Jomon periods and located in Daikoji, Matsuurachomomonokawa. Geographically speaking, the Matsuura River basin flows in a northerly direction, meandering from Takeo City. The ruins are situated on a 38 m river terrace created by the river itself. The current distance in height from the river is about 15 m. The excavation was conducted by the Imari Municipal Board of Education in 1990–1991 due to a road improvement project in the area.

Here, I will introduce the results of the Paleolithic and Jomon period studies. Based on the excavated artifacts, the site is thought to be from the Upper Paleolithic (approximately 30,000 to 15,000 years ago) and Jomon Periods (15,000 to 2,000 years ago). Among these, there are Paleolithic stone implement groups from three periods. The oldest of these groups is from the period that primarily used knife-shaped stone tools (the top right two items in the photo) made of stone blades (as a standard, they were cut from the base stone to ensure that their length would exceed their width) around the Aira Tanzawa ash-fall deposit period (29,000 to 26,000 years ago). The following group is from the period wherein knife-shaped stone implements made of flakes of indeterminate form were primarily used (stone flakes chipped from the base stone through various methods, such as striking) (the top left two items and the bottom right item in the photo). The last is the group from the period wherein microlith blades were primarily used (the left four items in the bottom of the photo).

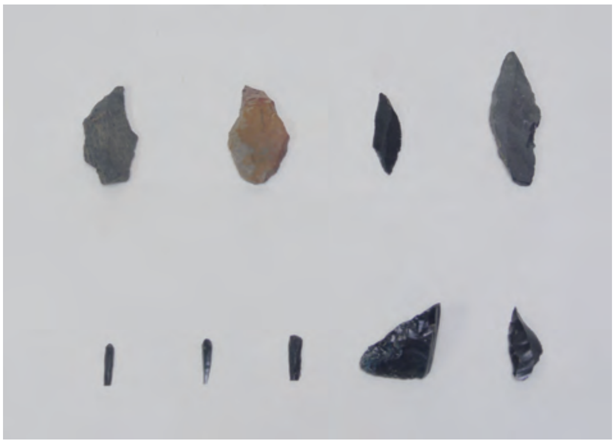
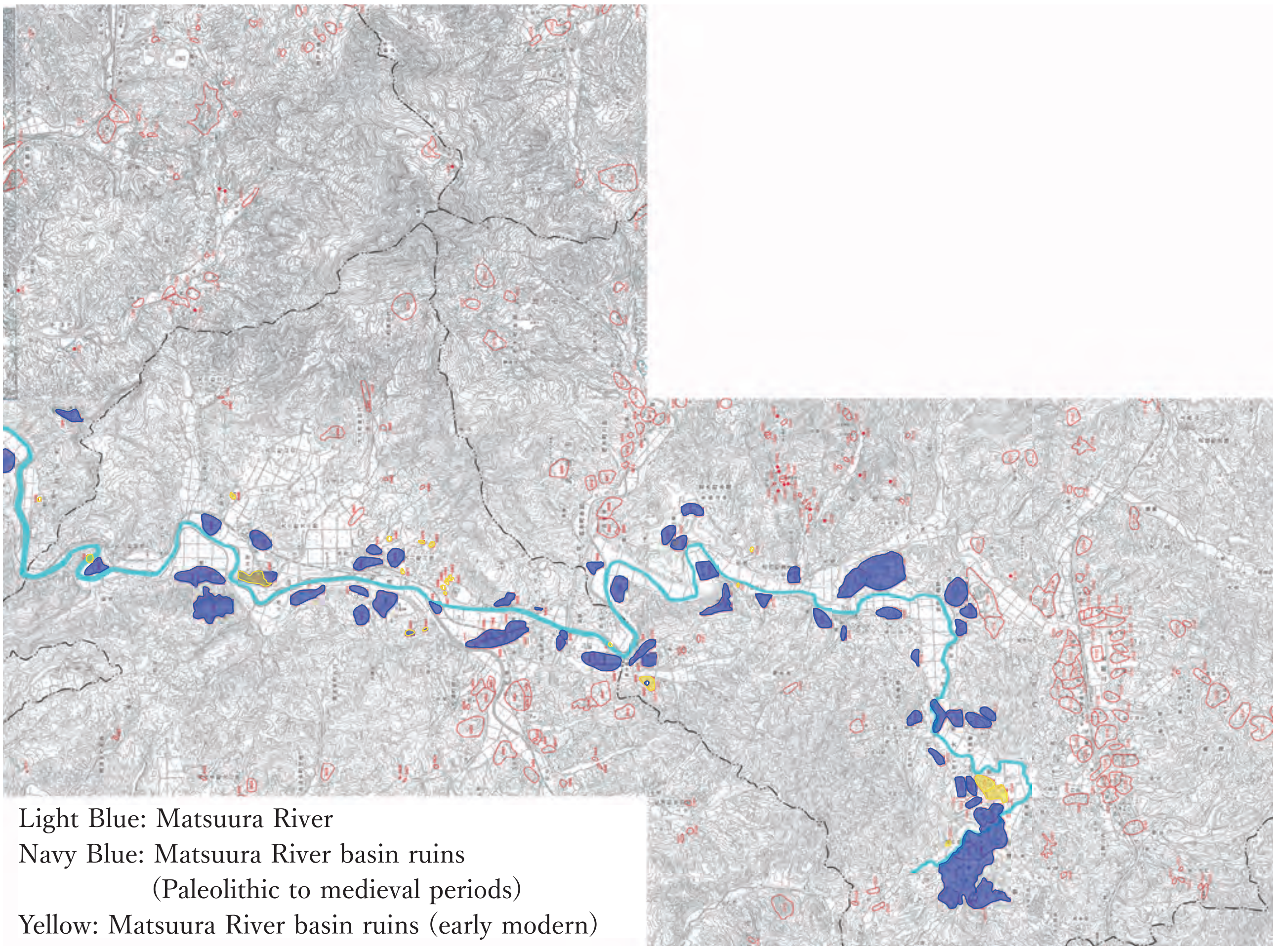


Photo 1. Artifacts excavated from the Daikoji Temple ruins



Although the Jomon Period flint arrowhead artifacts have been excavated, the exact period during which they were used is unclear.

In Imari City, Koshidake mountain provides a major source of obsidian. This obsidian was treasured as quality material for stone implements from the Paleolithic to the first-half of the Yayoi Period. It was traded throughout Kyushu and was transported as far away as Okinawa and the Korean peninsula. Since the Daikoji Temple ruins are nine kilometers away from Koshidake, which is relatively close, most of the stone tool materials from any period are therefore Koshidake obsidian.

This obsidian, as a quality material for stone tools, was a lifeline for the people in those periods. There was, therefore, a need to regularly obtain this stone from Koshidake. There was, therefore, a need to regularly obtain this stone from Koshidake. While traveling to and from Koshidake for this, people are thought to have built campsites. While traveling to and from Koshidake, these people are thought to have built campsites, due to the discovery of piles of heated stones that were in the ruins, serving as proof of camping activities. This is a slightly elevated area near the Matsuura River where it is easy to obtain water, thus making it optimal for campsites. The area is, therefore, thought to have been repeatedly used by people across multiple periods. It is also thought that people made stone tools from this obsidian and hunted at these campsites.


Photo 2. Bronze swords and bronze halberds excavated from the Ukikunden ruins (Karatsu Municipal Board of Education, 1997)

(3) Ukikunden Ruins (Yayoi Period)

The Ukikunden ruins are located in Ukiazakunden in Karatsu City. They are in front of two small hills to the northeast of Yuhiyama, in the flat area of the Matsuura River.

Ever since Rokuji Morimoto introduced these ruins in 1930, the East Asian Archaeological Society and a joint Japanese-French expedition have conducted studies, and the Karatsu Municipal Board of Education has also conducted numerous excavations. Precious artifacts have been excavated, and the Hizen Karatsu City Excavated Artifacts (first-half of the Yayoi Period; thin bronze swords, thin bronze halberds, bronze swords, bronze halberds, bronze dagger-axes, bronze mirrors with multiple knobs and minute patterns, bronze bracelets, magatama, green necklace gemstones) have been designated as “National Important Cultural Property,” and the “Copper Tongue Excavated from the Ukikunden Ruins” is a prefectural important cultural property. The primary focus of this site is the late Jomon to the early Yayoi Period shell mounds and the late-early Yayoi to late Yayoi Period jar burial tombs. Remains of dwellings have also been found, thus a complete lifecycle can be seen in these ruins. In particular, the 126 jar tombs indicate the scale of the site.

(4) Kurisozui Mound Tomb (Kofun Period)

The Kurisozui mound tomb is a circular ancient tomb with a rectangular front 108.5m in length and is located in Sozuisako in Karatsu City. According to excavations conducted thus far, the site may be dated to the early fourth century. Regarding the internal structure, the rear circular portion has a dugout stone chamber, and the front has a dugout stone chamber crossed by wooden beams. In the stone chamber, there may have been an unusual boat-shaped wooden coffin in this type of tomb. In the same chamber, one mirror and two green pipe-shaped necklace gemstones used as grave accessories were discovered as well as a small knife between the stone roof and the top of the chamber. The mirror was a shipborne dragon mirror from the later Han Dynasty, thus indicating that the person buried in the tomb had a connection to mainland Asia. Due to its academic importance, Karatsu City has designated it a historical site.

(5) Sumiyoshi Castle Footprint (Medieval Period)

The footprint of the Sumiyoshi Castle is located in Yamauchichomiyano, Takeo City. The hilltop castle, at the eastern foot of Kurokami mountain, also served as a residence. Although the era when it was constructed is unclear, the Goto Clan, which controlled the Takeo City region, repaired the ruins in the Warring States Period, which is how they arrived at their present size and form. Thus far, a dry moat, partial stone barrier, and a well have been found. The main compound has an altered pentagon shape and features small earthwork enclosures and hillside earthwork enclosures. This is a valuable ruin showcasing the conditions of a residential castle during the Warring States Period shogunate in western Kyushu, so Takeo City has designated it a historical site.

Photo 3. Kurisozui mound tomb Photo of dry moat (from the northeast)

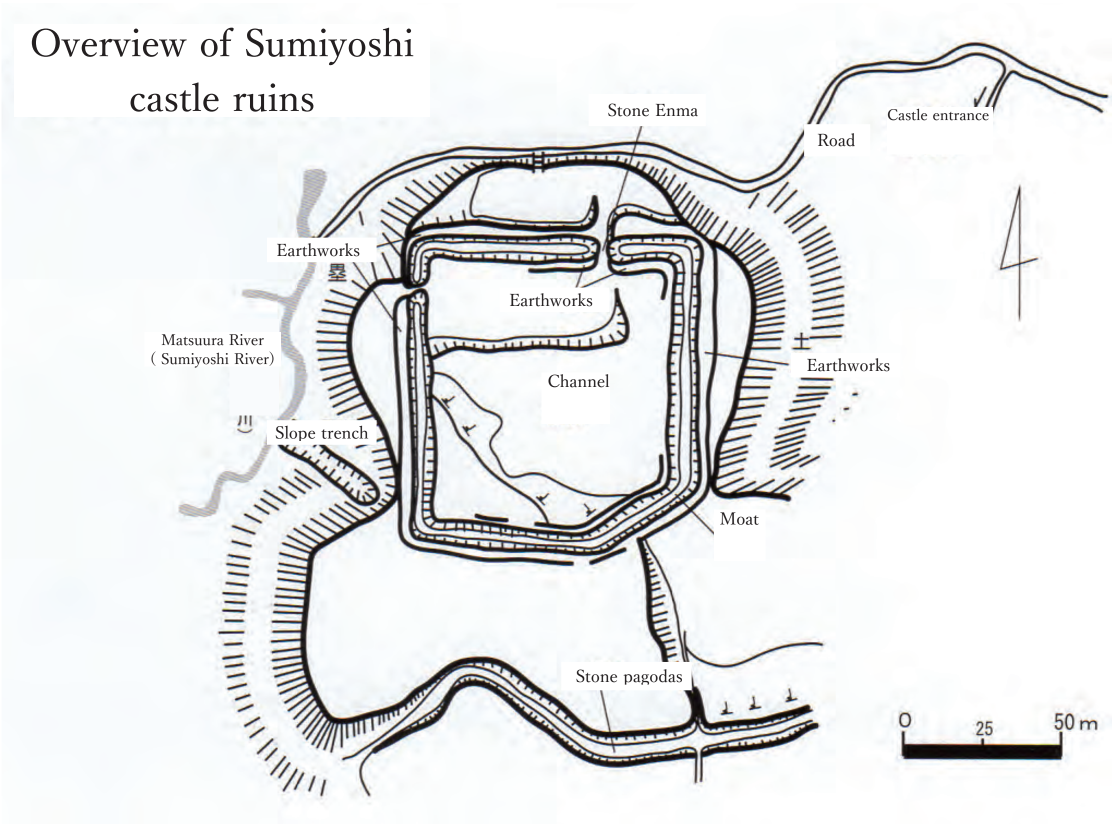


Image 2. Sumiyoshi Castle footprint overview

Modern Irrigation and the Ceramics Industry on the Matsuura River

Imari Municipal Board of Education Ichimoto Naoyuki

(1) Irrigation Facilities with Continued Use in the Present Day; the Umankashira Weir

The irrigation facility called Umankashira is located in Matsuurachomomonokawa in Imari City. Construction for this facility was planned by Narutomi Hyogo Shigeyasu—who was a chief retainer of the Nabeshima Clan and was knowledgeable in civil engineering and engineering. The site was completed in 1611 (year 16 of the Keicho Era in the Edo Period); the Structure was built to bring water from the lower water level of the Matsuura River to the Momonokawa plateau to enable rice paddy cultivation.

In terms of the order of the working mechanism for irrigation; first, a water diversion channel was created from Oide, which has a higher water level and is approximately 1 km upstream, to draw in water from the main river. Next, the diverted water is drawn along the channel to the dam and flows down from the riverbank. Third, the water is then siphoned across the riverbed using the rear part of an inverted siphon onto the opposite bank.

The inverted siphon water pipes were lengthened by connecting numerous bottomless pails with wooden connected pipes called *oketoi*. It is believed that they were used to disperse the load on the pipes placed on the riverbed, which have now been replaced by concrete pipes.

However, the structure has functioned unchanged since the Edo Period, and it has been certified by the Japan Society of Civil Engineers as a recommended civil engineering heritage.

Photo 1. Aerial photo of Umankashira and related irrigation facilities (notations by the Geospatial Information Authority of Japan)

(2) Matsuura River Basin Kiln Sites

At the end of the medieval period, it is said that the Hata Clan, who were daimyos during the Warring States Period, brought potters from Korea to start pottery production in Hizen. The Kishidake Castle, which was their base, was geographically close to, yet not directly in the Matsuura River Basin. Pottery production is considered to have started in the 1580s in this area. However, with the Hata Clan's subsequent replacement (*kaieki*), the Korean potters left the Kishidake area, and in the Keicho Era (1596–1615) pottery production had become scattered, resulting in the number of kilns rapidly increasing. Due to these factors, there are many remains of kilns found in the Matsuura River basin today. (reference: the ruins map in the previous section)

In Okawa-cho kawahara azatsuji in Imari City, there are six such kiln sites. Excavations have revealed that four kilns originated from the same period of Kishidake pottery production to the time that this production dispersed. These sites are in three clusters; the Yakiyama upper kiln site, Yakiyama middle kiln site, and the Yakiyama lower A kiln site.

All of these were operated from the 1580s to around 1600; they are *waritake* kilns originating from the oldest period for kiln sites in Hizen. At this stage, there was no mass production in firing or other measures for increased efficiency, and there are no traces of multi-layered firing. The kilns at all these sites fell apart with the passage of time, and later collapsed, thus their exact size is unclear.

Compared to the other two clusters, the Yakiyama upper kiln site is characterized by having produced a rich variety of products. Among the pottery excavated were decorated Karatsu bowls and plates, other bowls and plates, mortars, pots, lipped bowls, water pitchers, bottles, lids, vases, and jars. Out of the three site clusters, this was the only site producing particularly large jars and other small and mid-sized items together.

At the Yakiyama middle kiln site, bowls, plates, pots, water pitchers, bottles, and other items have been excavated, but no decorated Karatsu items have been found.

Decorated Karatsu plates, bowls, pots, bottles, *mukozuke* side dishes and lids, and other items have been unearthed at the Yakiyama lower A site.

(3) Karatsu Ware Distribution and the Matsuura River

The name of the shipping port was used for Edo Period ceramics, not the area of origin. Therefore, the name Karatsu was used, despite the fact that the products were produced in Imari and Takeo. These ceramics were most likely shipped down the Matsuura River from these cities to Karatsu, because sunken Karatsu ware has been found at various places in the riverbed.

Although at a glance it would not seem as if the Matsuura River and Karatsu ware were directly related, they have a close connection.

Photo 2. Decorated Karatsu bowl and lid excavated from the Yakiyama upper kiln site

The Matsuura River and Karatsu Coal Fields in Modern Times

Kyushu University Teramura Jun

Image 1. *Hizenshusanbutsuzuko, Coal and Ceramics Overview* (National Archives digital archives)

There are many burial mounds in the Matsuura River basin, thereby indicating vibrant human activity in the area since ancient times. In addition, at the beginning of the early modern period, the originally separated Matsuura and Tokusue rivers were joined, and the modern positions of the river and its mouth were decided. Karatsu Castle was built alongside the Matsuura River mouth, which served as a port during this period.

Karatsu prospered as a seaport on Karatsu Bay, and due to riverboat transport on the mainstem of the Matsuura River, as well as the Kyuragi and Tokusue branches, these channels flourished as shipborne transportation routes. The Matsuura River supported trade in the Karatsu Domain as well as that from nearby Imari, Taku, and Takeo.

Developments supporting transportation on the Matsuura River from the final days of the Tokugawa Shogunate to modern times were brought about by the Karatsu coal fields.

(1) Beginning of the Karatsu coal fields

The Karatsu coal fields were discovered by accident by a peasant farmer in Doumeki, Kishiyama, Kitahata during the Kyoho Era (1716–1735). The *Karatsuryakkijofuzuisen* states [archaic Japanese]; therefore, it appears that a person who heard the rumors came from Fukuoka, where coal mining was already prospering, to start coal mining in the area.

During this period, coal was used in place of firewood. Coal was also used in large quantities in salt and tile making, which flourished around the Seto Inland Sea. Since ancient times, this region featured industries that used large amounts of firewood, including Tatara steelmaking and salting. There were, therefore, many treeless mountains, and it is well known that a significant amount of soil was lost.

Using coal in place of firewood provided a replacement for the natural resource of wood.

The first part of the Karatsu coal field mined in earnest was the coal mine in Ochimura along the Kyuragi River in 1792 (year 4 of the Kansei Era), following which the coal field was fully opened in the Bunsei Era (1818–1829).

During this period, the primary method used for mining was a “shoestring” method consisting of digging a hole so narrow a person could barely squeeze in. The person would then load coal into a bamboo basket that was pulled up to the surface. The tunnel dug for mining was called a *mabu*. *Mabu* was a common term in the mine tunnels, and it was also used in the Iwami silver mine and the Sado gold mine. There were also regions called *manbo* and *manpo*.

(2) Coal Wholesalers and Riverboats

In the Karatsu Domain, coal mining was common along the Matsuura River (main river and tributaries), and the mined coal was loaded on riverside boat ramps. This coal was collected at Mitsushima on the right bank of the river mouth, and was sold by coal wholesalers both inside and outside the domain. During that time, only Matsumotoya and Yoneya were approved as coal wholesalers by the Karatsu Domain; thus, these two wholesalers controlled the entirety of the mining in the Karatsu coal fields.

Riverboat transport of the coal was arranged by these wholesalers as well, and riverboats of 1.2 tons (2,000 kin) and 2.4 tons (4,000 kin) traveled up and down the Matsuura River.

Attached is an excerpt regarding coal from an old drawing explaining the products of the Karatsu Domain in the scene; this excerpt describes people mining coal, piling it on the riverbank, and then transporting it away using riverboats.

(3) The Karatsu Coal Fields on the Wave of Modernization

At the end of the Edo Period, both demand for and output of Karatsu coal increased.

This was not only due to the increased demand for coal in daily life but also the extremely important change that was the opening of the nearby Nagasaki port. Due to the resulting increase in steamship traffic at the port, there was a significant increase in the need for coal as a fuel. However, the Chikuho and Kasuya mines, which were leading coal mines in Kyushu, experienced decreased output at the same time due to technological limitations, such as those involving drainage.

Due to this situation, the Karatsu coalfields, where mining had only been conducted for a short time, experienced many changes Some of these included the ability to produce a notable volume of coal at relatively low cost, as well as easy boat transport to destinations such as Nagasaki and Fukuoka. Karatsu, therefore, dominated the coal market in Nagasaki and other places.

Furthermore, the Matsuura River was a significant factor in the development of these fields.

Most of their mines were close to the Matsuura River and two of its branches—Kyuragi and Tokusue Rivers. After being mined, the coal could be placed onto riverboats and transported to the mouth of the Matsuura River. The transport distance was short, at only half that from the Chikuho mine to the mouth of the Onga River; thus, the conveyance was very efficient.

At the beginning of the Meiji Period, after Japan was opened to the outside world, Western technology flowed into the country, and steam engines became widely used. Steam-powered ships and trains were introduced, and the demand for coal steadily increased. A navy base was built in Karatsu, and coal from the Karatsu coalfields powered naval vessels.

With so many coal mines opening duringthe Meiji Period, wealthy, powerful outsiders came to the area to purchase coal mining rights and open new mines. Near the end of the Edo Period, powerful clans became conglomerates (*zaibatsu*), such as Mitsubishi, and went into mining in the beginning of the Meiji Period. As a result, the population of the Matsuura River basin exploded, and the area became vibrant.

However, with the increased mining volume, riverboat transport of coal approached a limit. Furthermore, rail transport was starting to spread, and steam-powered trains were introduced into the area. In 1905, Ochi and Nishi-Karatsu were linked by rail lines, and the river transport of coal was quickly abandoned.

Coal mining continued after World War 2, and at its peak, coal was sold throughout Japan and exported to China and Singapore.

The introduction of coal powered steam engines, coal power development, and the spread of electric power infrastructure, similar to the capillaries of the human body, all coincided with the beginning of modernization. During such a turbulent period, the Karatsu coal fields served as a foundation for this, and Matsuura riverboats were essential for transportation of the product.

As we can see, the Matsuura River basin played a key role in the modernization of Japan.

Works cited

Ide, Isei. *A History of Coal Mining in* Saga Kinkado (February 1972)

Ochimura History Compilation Committee. *History of Ochimura, Last Volume* (1977)

Kizaki, Seihyo, *Hizenshusanbutsuzuko, Coal and Ceramics Overview*, copy National Archives digital archives

【Remaining Traditional and Regional Knowledge】

Photo: Shimauchi Risa

The Stone Weirs of the Matsuura River

Kyushu University Teramura Jun


Photo 1. Reidaikyo Bridge (Misatomachi, Kumamoto Prefecture)


Photo 2. Yamada Weir (Asakura City, Fukuoka)

Since ancient times, Kyushu and its culture have centered heavily around the use of stones, which are present in the many stone structures throughout the area. Ninety percent of the stone arch bridges existing in Japan today are in Kyushu. In addition to the castles, stone walls are extremely common in the terraced rice fields of Kyushu.

Stonework became commonplace starting from the Kofun Period, much of which continues to serve a purpose in its original form in the present day.

This stonework was frequently used in rivers, including embankment slopes, stone, and basket dikes. It was also found in *mizuhane* structures to control the river, weirs, and other structures, such as channels, which use river water.

Due to this history, there are many stone weirs on the Matsuura River.

(1) Movable and Fixed Weirs

There are numerous weirs on the Matsuura River. There are many types of weirs, including drainage crossings and civil engineering structures that let water through. In Kyushu, they are often called *iseki* (weirs) because as weirs, they draw in water from wells (channels).

Modern movable weirs use power, such as motors, to raise and lower weir gates to adjust the water level. There are many types of movable weirs with individually-shaped gates and materials, and as appropriate, they can be raised to draw in water and lowered during floods.

Weirs built using piles, grass, and brushwood before the early modern times were constructed by sticking piles into the river and placing grass, stones, or rectangular timber between them. They were managed on a yearly basis and were thus built during early Spring and removed in the Fall. Some weirs included a function to automatically float away so as not to impede strong floodwaters; such weirs required time-consuming


Photo 3. Movable Weir

maintenance during such occasions. Although grass weirs continue to be used on the Jobaru River in the Chikugo River system in Saga Prefecture and the Kawaharazono Weir on the Kushira River in the Kimotsuki River system, very few of these have been sufficiently managed.

Fixed weirs, however, consist of a permanent drainage crossing and let water through when they are raised.

Currently, most dams are built using concrete, but in the past, they were built using wood and stone. Wooden frames were driven into the riverbed, and stones were inserted or piled up inside them, which ensured the structure was durable.

These weirs required a significant amount of labor to construct and were subject to notable external pressure during floods, but they had the benefits of providing stable water supply and requiring little effort to maintain.

Nowadays, fixed weirs are no longer built by piling up stones; most are built using concrete.

Most new weir constructions are on major rivers and are of the movable type. On terrain with significant drops and among mid-sized weirs, concrete fixed weirs are relatively common. These types of weirs are frequently used even for relatively small-scale agricultural water intake and are thus considered most common among these structures.

Stone weirs tend to be older than concrete ones, with most considered to have been built between the Edo and Showa Periods. The number of stone structures has been steadily declining as they are covered in concrete during maintenance or are replaced with new weirs. Through their very existence, these stone weirs have historical and technological value.

The Matsuura River currently includes several such weirs. Some fall within the range of large structures, including the Daikoku and Haginoo Weirs, to smaller valley weirs on tributary rivers.

(2) Matsuura River Weirs

We can currently confirm the existence of at least 75 stone weirs on the Matsuura River. There are others that cannot be confirmed because they either have been covered in concrete and thus cannot be distinguished from concrete weirs, or cannot be approached due to fences built to keep animals away. Therefore, there may be more stone dams than the confirmed number indicated here.

It is extremely rare for multiple stone dams to be built on one river.

Dams usually take in water at a higher elevation than the area benefited (the location of use). Therefore, dams are usually built upstream from farm fields that use

Photo 4. Kawaharazono Weir (Kanoya City, Kagoshima Prefecture)

Photo 5. Concrete Weir

Photo 6. Stone weir

them. The number and location of dams are related to the distance between the benefiting land, the channels between the dams, and the size of these structures.

Before early modern times, water was drawn in close to where it was to be used, by building numerous small weirs.

However, doing so in modern times would lead to significant problems, in terms of damage risk and maintenance efficiency. A trend has been noted of consolidating multiple weirs into one location to draw in water and distribute it into channels.

Although there is a high risk of weir damage if there are numerous small eirs, even if one weir breaks it will not lead to significant damage and the necessary functioning will be divided amongst the other weirs. Such consolidated weirs are large and tough structures, but if they are damaged, the effect is extremely widespread.

Both of these are methods to counter risk, but there is an immense difference between the traditional thought of dispersing risk and the modern method of building tough structures against assumed risk.

Therefore, based on perspectives that have varied notably over time and even with early modern weir building technology, many stone weirs were built as tough and durable structures with masonry technology based on the stone culture of Kyushu.

Image 1. Stone Weirs on the Matsuura River system

Moreover, most of the river basin consists of sedimentary rocks, such as sandstone and mudstone; thus, there is an abundant supply of relatively soft and easy-to-process stones nearby.

(3) Age of Construction of Stone Weirs on the Matsuura River

It is unclear when and by whom most stone weirs on the Matsuura River were constructed. The names of most of these structures are also unclear.

There have been few new stone weir constructions since the end of World War II, and these are thought to have been constructed at the beginning of the Showa Period. However, we have yet to determine when the oldest weir was built or during which period the most weirs were constructed.

Nevertheless, construction had already started on the below-mentioned Daikoku Weir and the Haginoo Weir, which are among the largest weirs on the Matsuura, dating back to around the year 1500. Building such large weirs required a higher level of technology compared to building small ones; therefore, it is highly likely that smaller stone weirs were built on the river before this time.

Even if stone weirs are built well, they often become damaged due to natural degradation over time; therefore, not all of these weirs have survived.

(4) Stone Weir Shapes

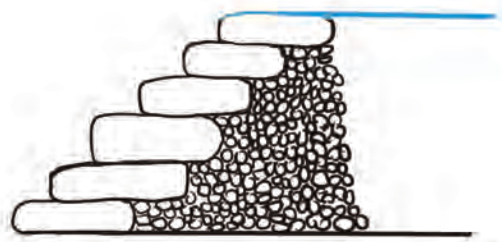
Most existing stone weirs on the Matsuura River feature various shapes that can primarily be classified into six types, based on how the stones are stacked. Using cross-sectional shapes, the differences in stacking have been classified into the following methods:

◆ Type methods

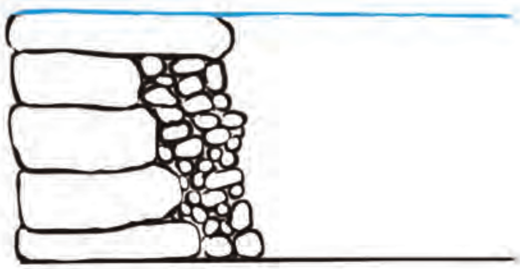
[1] Horizontal type

This type of dam is stacked in a step-like pattern when observed from the side, and features rectangular stones laid horizontally. When viewed from the surface, it appears similar to coursed masonry, but step-like

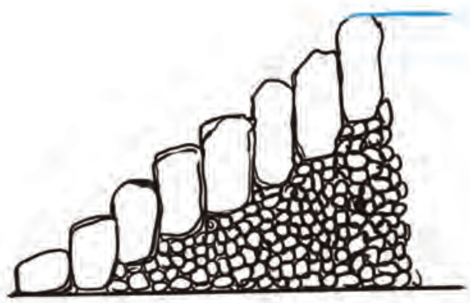

[1] A typical horizontally stacked dam


[1] A horizontally stacked dam cross-section


[2] A typical perpendicularly stacked dam


[2] A perpendicularly stacked cross-section


[3] A typical vertically stacked dam


[3] A vertically stacked dam cross-section

stacking is not typical for stone walls.

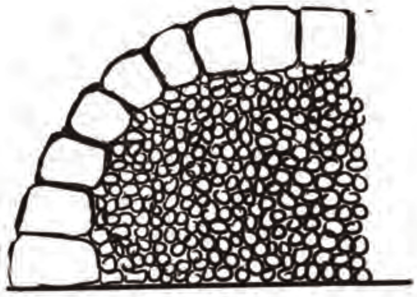
In weir construction, because the base of the structure can be firmly secured, they have a low center of gravity and can withstand the intense water pressure. Although they can be expected to dissipate the energy of the water due to splashing on the stepped surface, the stones wear down over time because of this.

[2] Perpendicular type

When viewed from the side, stones in these dams are stacked to ensure that they appear to be cut perpendicularly. This is one of the typical methods of stacking masonry. Other river systems also have uncoursed masonry with square stone narrowing at one end; however, on the Matsuura River, the stacking is completed with coursed masonry.

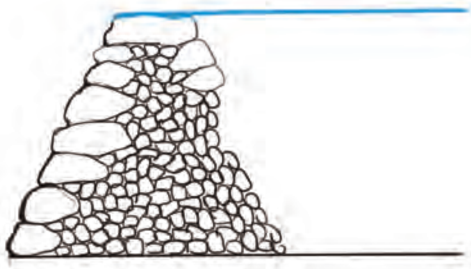
Most of the current hydraulic drop and bottom protection structures are cut perpendicularly,and they have an energy dissipating effect due to the difference in elevation. However, this difference in elevation leads to the river-downstream from the weir-becoming deeper.

[4] A typical arch dam



[4] An arch dam cross-section

[5] A typical steep slope dam



[5] A steep slope dam cross-section

[6] A typical gentle slope dam

[6] A gentle slope dam cross-section

[3] Vertical type

Although this type of stacking is similar to horizontal stacking in that dams of this type appear to be form a staircase when observed from the side, in this case, the long ends of rectangular stones are placed in a vertical orientation, as if piercing something from above.

It is one of the rarest types of stone-stacking methods to be found.

[4] Arch type stacking

When observed from the side, this type of dam is curved in an arch shape, which is also called "roll-stacking" when used for stone walls.

Stones used in this masonry must be shaped with high precision. Compared to horizontal and vertical stacking, the arch dam cross-section is symmetrically arranged.

[5] Steep slope type

This method is close to both horizontal and perpendicular stacking, and the weir cross-section surface does not feature steep slope unevenness. The trapezoidal shape is a common structure among concrete weirs.

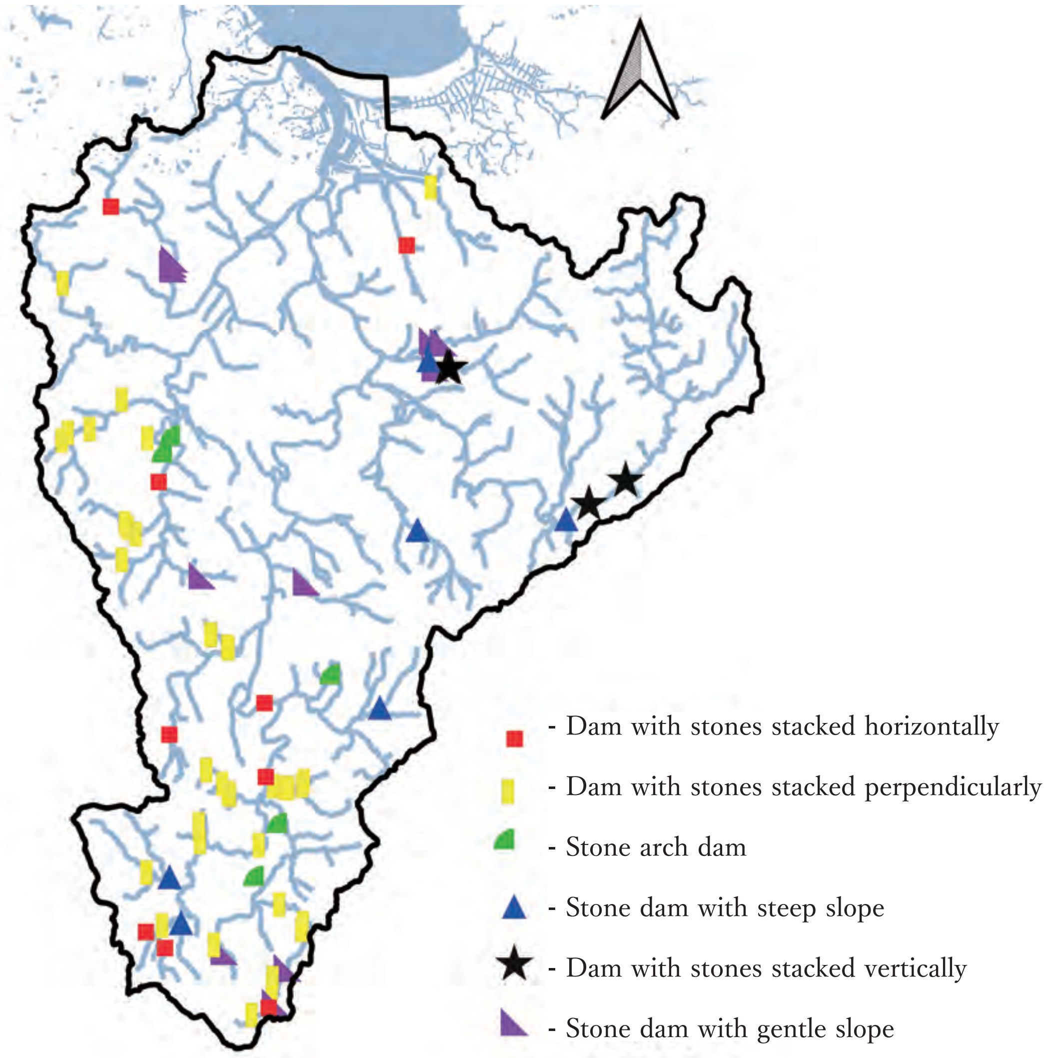


Image 2. Distribution of stacking methods

[6] Gentle slope type

This type of weir features a gentle slope, and compared to other types of stacking, the shape allows water to flow over the weir. Although this resembles the vertical stacking type, there is little unevenness on the surface, thereby resembling a smooth ramp.

◆ Distribution of stacking methods

Perpendicularly stacked weirs are the most common type of stone weirs on the Matsuura River, accounting for 37 of the 75 known structures. The next most common type of dam is the dam with a gentle slope, constituting 11 of the 75 structures, among which 3 have been recently constructed; thus, only 8 gentle slope dams feature the traditional stacking method.

Further, among the characteristic stacking types, there are nine horizontally stacked structures, four vertically stacked structures, and five arch weirs. There are notably fewer of these structures, compared with the perpendicularly stacked weir sites.

However, there are few perpendicularly stacked weirs among the large stone weirs, such as the Daikoku and Haginoo Weirs, on the main stretch of the Matsuura River. These large dams tend to be horizontally and vertically stacked.

Historical weirs, such as Haginoo Weir that was installed in the 1550s, have undergone multiple repairs for damage and deterioration which have resulted in the present-day structure. These weirs are thought to have become optimized through experience and innovation.

As a result of the earlier generations repairing and maintaining the many remaining stone weirs on the Matsuura River over a long period, the structures have been preserved in their original form.

The Daikoku Weir and Other Stone Dams Nationwide

Kyushu University Teramura Jun

Photo 1. Daikoku Weir orthoimage

(1) History of the Daikoku Weir

The Daikoku Weir is an intake Weir created in 1595 on the main section of the Matsuura River by Shimanokamihirotaka Terasawa, the daimyo of the Karatsu Domain at that time.

This Weir was built on the border between the Matsuuramura and Okawanomura villages, which was also the border between the Karatsu and Saga domains.

Although construction started in 1595 (year 4 of the Bunroku Era), due to factors such as hard bedrock, the large size of the rock structures, and damage from frequent flooding, the Weir was not completed until nearly 40 years later in 1633 (year 10 Kanei

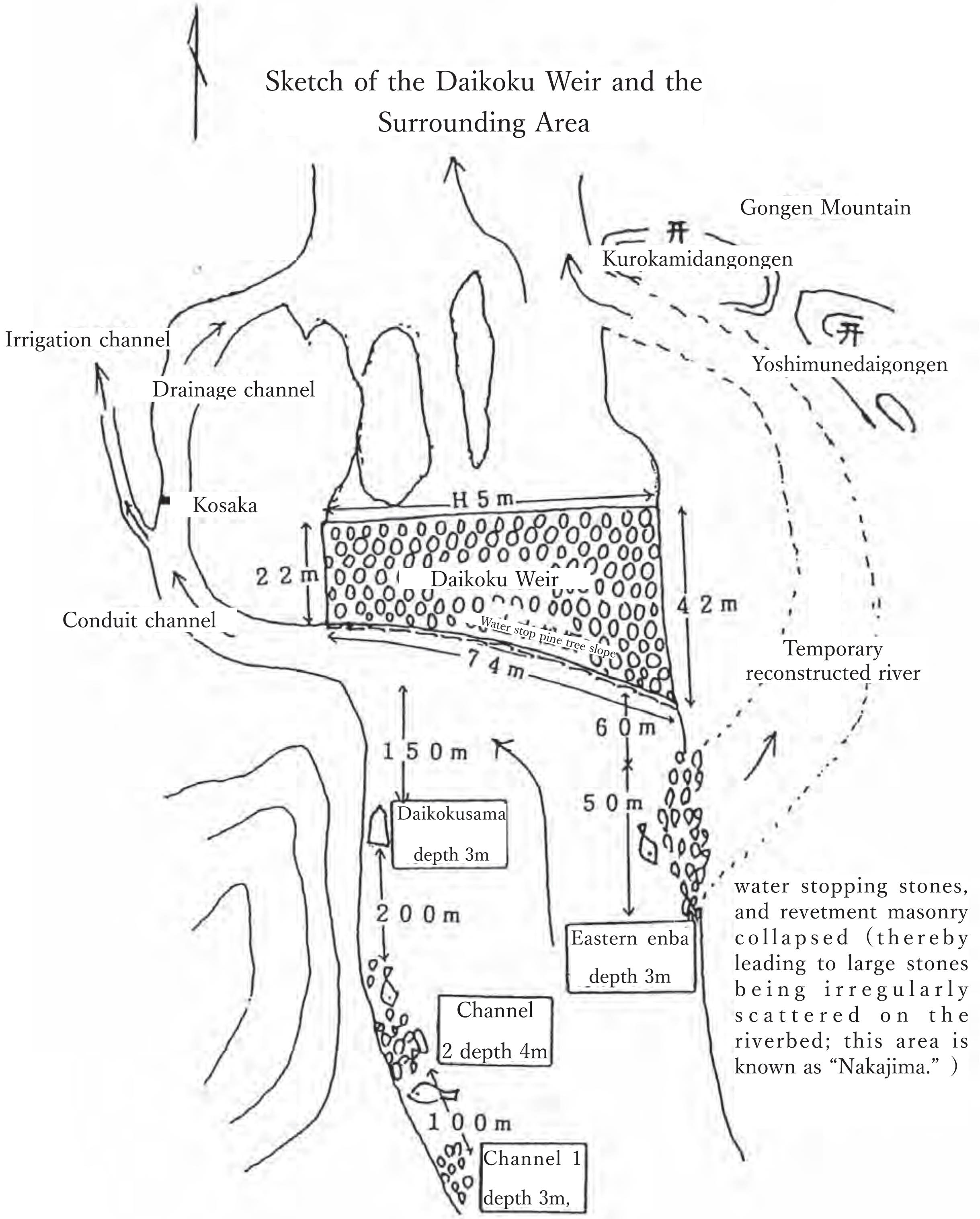


Image 1. Daikoku Weir sketch (from *100 Years of Okawacho Agricultural History*)

Era).

During construction, the daimyo Shimanokami Terasawa was concerned about the many Weirs that had washed away and received the following advice from a mountain priest named Kakyu Tashiro: “You should build an island to divide the main river (*Nakanoshima*) in two so that you can draw water from the divided river.” The daimyo decided to use this structure and thus completed the Daikoku Weir.

Moreover, because this weir was built using stone; a significant amount of this material was required. Unfortunately, the required amount could not be found locally, so the stone was cut from nearby Mount Bizan and transported to the weir site.

Shimanokamihirotaka Terasawa was originally a retainer of Nobunaga Oda. After the death of Nobunaga, he served under Toyotomi Hideyoshi and became the first Karatsu daimyo. He was knowledgeable about public service projects, and anecdotes about the renewal of the downstream section of the Matsuura River continue to be shared in various regions even today. However, he was a strict ruler, who was known for his various public service projects and his demanding collection of annual tribute.

Kakyu Tashiro was a monk with extensive knowledge and became a favorite of Shimanokami Terasawa due to his wisdom. Hence, he gave Hiari Castle, which was situated near the Daikoku Weir, to the monk.

However, Kakyu, who provided advice about the weir, was executed by beheading for “having spoken impertinently” to the daimyo.

His advice about the Daikoku Weir was initially indicated as the reason for his punishment, but Kakyu had sympathized with his nephew from Amakusa, who took shelter in his temple while proselytizing Christianity. He was punished under the edict of Toyotomi Hideyoshi, who banned this religion. Moreover, due to the method of his execution and the timeline of events, the monk's execution is considered closely related to this edict.

(2) Structure of the Daikoku Weir

The method of dividing the river at *Nakanoshima* and drawing in water from there is similar to the Ishiibi on the Kase River in the neighboring Saga Domain. Moreover, it includes numerous devices to counter floods.

[1] The Existence of *Nakanoshima*

At the Daikoku Weir, the river is divided on the left bank (in Japan, the right and left banks use a downstream orientation), and the diverted river joins the main Matsuura River again slightly downstream.

Photo 2. *Nakanoshima*

Photo 3. Intake Weir

Photo 4. Aerial photo of Ishiibi

The land surrounded by the main stretch of the river and the diverted river is called *Nakanoshima*. Although in the literature, its meaning is indicated as “making an island,” it does not mean to “pile up earth” in the middle of the river to make an artificial island. The original ground was excavated to create a branched river, and an island surrounded by the two rivers was created. Using the original ground without change led to the creation of an island stronger than dumping earthen material would have.

[2] Drawing wWater from the Tributary River

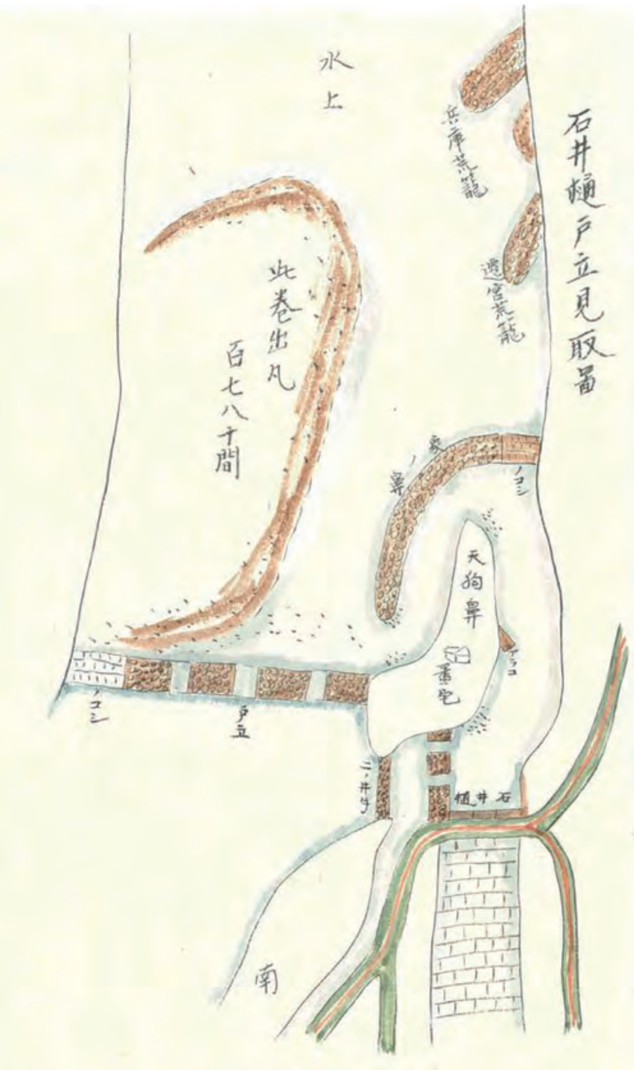
There are numerous benefits related to the water from the tributary river that divides the flow of the main river.

Placing a sluice gate directly on the main section of the river required a structure commensurate with the size of the river. Building and managing such a structure, which can easily become damaged, would be burdensome.

The tributary river separated by *Nakanoshima* is notably smaller than the main Matsuura River; therefore, such a sluice gate would also be smaller, thereby leading to further construction and management.

There are also benefits to not directly using water from the diverted river for agriculture; this ensures that floodwater does not mix with the irrigation water, driftwood, and other matter not flowing downstream. Reduced inflow of sediment is yet another benefit of using this method.

The Daikoku Weir was built during a time when constructing such a strong, long, and massive structure was challenging. The weir features various methods of dispersing the force of the river (e.g., in flood situations), to readily deliver the blessings of the river to the local people.



Drawing 1. Ishiibi (from the *Sodoyoshu*)

(3) The Daikoku Weir and Similar Historical Weirs

The Daikoku Weir incorporates various traditional technologies, such as masonry stacking and the creation of *Nakanoshima*. However, this technology was not only used in the construction of this structure. Ishiibi is situated near the Daikoku Weir on the Kase River in Saga. Ichinoi weir is a weir on the Katsura River in Arashiyama, Kyoto. If we trace these structures to their origins, the Dujiang Weir in China has a similar structure, regardless of the different size and age.

[1] Ishiibi

Ishiibi was built by Narutomi Hyogo Shigeyasu, a chief retainer of the Saga Domain, during the Genwa Period (1615–1623).

Similar to the Daikoku Weir, Ishiibi is a stone weir that draws in water from a tributary river divided by a

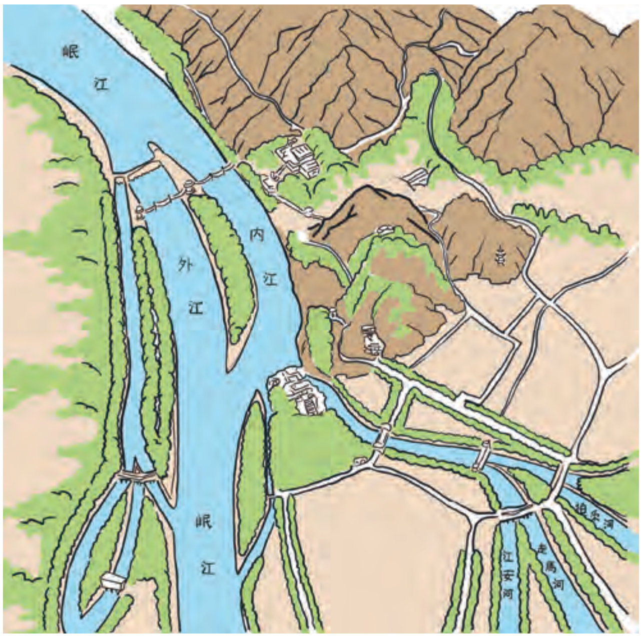


Image 2. Dujiang Weir (tracing)

Nakanoshima, but the structure is more complicated, compared with that of Daikoku Weir. Ishiibi's tributary river diverted by *Nakanoshima* features elephant trunks and turtle stones, which are devices used to reduce the power of the river's current.

The water drawn at Ishiibi flows from the highest point, of the low-lying area of Saga, by way of the Tafuse River and is eventually used at both Saga Castle and surrounding agricultural fields.

Although the Ishiibi was built during 1615–1623, construction started on the Daikoku Weir in 1595 but remained incomplete until 1633 due to difficulties related to building the structure. The Ishiibi was built within this period, and although it is unclear whether Kakyu referenced its structure, these two weirs are presumed to be related.

[2] Ichinoi Weir

The history of the Ichinoi Weir, located on the Katsura River in Kyoto where the river emerges from the Hozukyo Gorge, extends to ancient times. The origins of the weir are considered to extend as far as the Kadono Ooi, which was built around the late 5th century. Given its appearance has transformed since then, we're able to see a variety of weirs in Arashiyama. The rich natural beauty of the various seasons reflected on the surface of its waters is the reason it is considered to be one of the best scenic spots in Japan.

The Ichinoi Weir currently has fixed and movable parts and is perpendicular to the river current. However, until the current concrete weir was completed in 1952, the structure consisted of many piles driven into the river and erected at an angle that set it against the river flow.

Although its structure differs from the Daikoku and Ishiibi Weirs, the Ichinoi Weir also has a *Nakanoshima*, and it takes in irrigation water from a diverted river section.

[3] Dujiang Weir

The Dujiang Weir is an intake weir in Sichuan Province, China. Built in 3 B.C., with over 2,000 years of history, its original form has been maintained.

Similar to Daikoku, Ishiibi, and Ichinoi Weirs, the Dujiang Weir also has a *Nakanoshima* and draws in water from a diverted river branch.

Approximately 2,000 years ago, the water intake method that was a prototype for the Daikoku Weir had already been created. Considering the ages of the Dujiang Weir(2,000 years old), the Ichinoi Weir (1,500 years old), and the Ishiibi and Daikoku Weirs (400 years old), it is obvious these weirs have withstood the effects of time and thus attest to the great durability and effectiveness of these structures, which divert water with a *Nakanoshima* and draw water from the diverted river branch.

The Li Clan that built the Dujiang Weir were provincial constables during the Qin（奏）Dynasty. Moreover, it has been claimed that the Hata（奏）Clan that built the Kadono Ooi, which is the prototype for the Ichino Weir, came from China. Hata（波多）is also a place name in the Matsuura River Basin, and one theory has it that they had some involvement with the immigrant Hata（奏）Clan, similar to the case in Kyoto. Although the locations, periods, shapes, and backgrounds of these weirs completely differ, their importance can be gauged in terms of the technology that has been continuously used across various periods.

Photo 5. Ichinoi Weir

Works cited

Hometowns and Rivers Horita, Kaneo (1997)

100 Years of Okawacho Agricultural History Miyamoto, Iwami Chuoh Publishing Co.

The History off Matsuura Yoshimura, Shigesaburo, Matsuura Publishing Committee (1956)

Sodoyoshu Nanbu, Nagatsune (1834)

The Ichinoi Weir at Saga Arashiyama, which Irrigates Rakusai, which Preserves Landscape and Natural Features Kyoto Prefecture Agriculture, Forestry and Fisheries Division, Agriculture Department, Maintenance Section (March 2006)

Haginoo Weir and Umankashira

Kyushu University Teramura Jun

(1) Haginoo Weir, Umankashira, and Oide

Similar to the Daikoku Weir, Old Matsuura-cho momonokawa has the stone Haginoo Weir as well as a structure called Umankashira which was built to carry Oide irrigation water drawn from Haginoo Weir to the opposite bank of the Matsuura River.

These structures, which were built by Narutomi Hyogo Shigeyasu, were considered by the chief retainers of the Saga Domain to be the "gods of flood control and irrigation."

Narutomi Hyogo worked on numerous flood control and irrigation projects throughout the Saga Domain, beginning with the Ishiibi on the Kase River. Having built the water management system on the Saga Plains, his achievements are praised throughout the prefecture, even today. In addition to town names including Hyogomachi and Shigeyasumachi, he is celebrated as a god of water at the Shiraishi Shrine in the old Miyakicho.

The main stretch of a large river should theoretically be the lowest point in the area. Therefore, even if the river was running very high, drawing irrigation water from the main part of the river would still be an extremely difficult task. When drawing irrigation water, it was necessary to do so upstream from the location one intended to use the water in. However, the high water-flow on the main stretch of a river also indicates that there are powerful floods-water intake structures, such as weirs, can also have a significant impact in reducing them. Therefore, notable effort and a high level of technology are required to draw water from the main part of a river.

The irrigation water taken in by the Haginoo Weir is delivered to the agricultural fields of the Momonokawa area on the opposite bank downstream by passing through the Oide irrigation canal and through Umankashira.

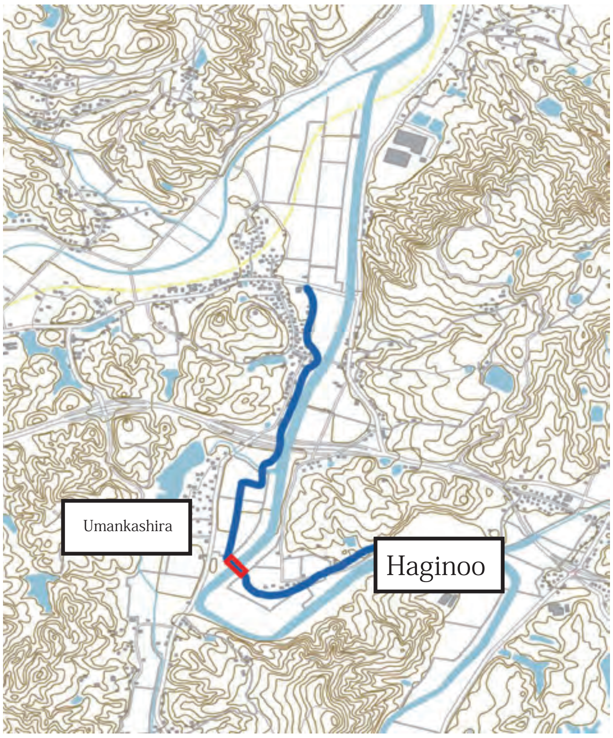
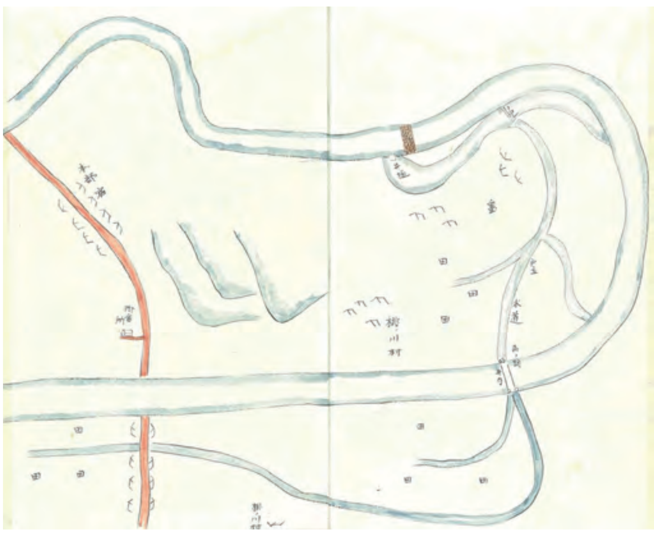


Image 1. Haginoo Weir, Umankashira, and Oide irrigation water level diagram from a Geospatial Information Authority of Japan map



Drawing 1. The Haginoo Weir and Umankashira in the *Sodoyoshu*

(2) Haginoo Weir

The Haginoo Weir was first built in 1550 (year 19 of the Tenmon Era), is a stone weir located on the rightside of the riverbank, and has a sluice gate included as well. For water intake, the sluice gate is situated in the middle of a channel to further take in irrigation water and has a spillway in case of high water levels. Although this weir is similar to the Daikoku Weir and Ishiibi, it is slightly different because there is a clear sluice gate situated on the main river. Thisprevents excessive sediment from flowing into the water channel by promoting sediment subsidence.

Moreover, there is an open levee upstream from the Haginoo spillway; therefore, when a flood occurs and the water level rises, the floodwater that backflows from here and overflows can return to the river.

Although the surface of the Haginoo Weir is now covered in concrete, it was originally built from stacked quarried stone, and this masonry can be observed even in the present day.

(3) Umankashira

Umankashira was built in 1611 (year 16 of the Keicho Era) by Narutomi Hyogo Shigeyasu.

Although the irrigation water drawn in by the Haginoo Weir initially flows to the right bank of the Matsuura River, it eventually flows over to the left bank by means of a channel that crosses the river. Some type of structure is required for a channel to cross a river, and the greater the volume of water, the tougher the

Photo 1. Haginoo Weir structure

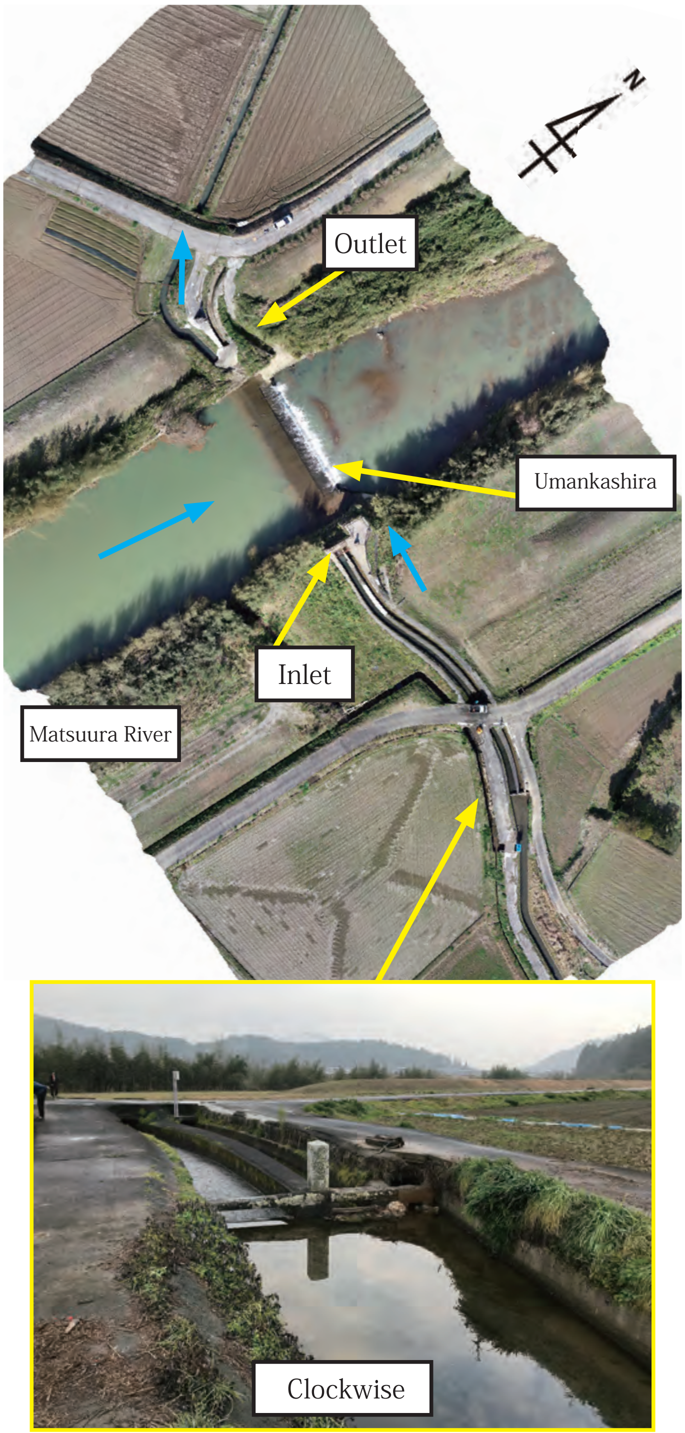


Photo 2. Umankashira orthoimage


Photo 3. Tsujunkyo Bridge (Yamatocho, Kumamoto Prefecture)


Photo 4. A wooden water pipe spanning a stream that runs around fields in Akizuki, a historic building preservation district (Asakura City, Fukuoka Prefecture)

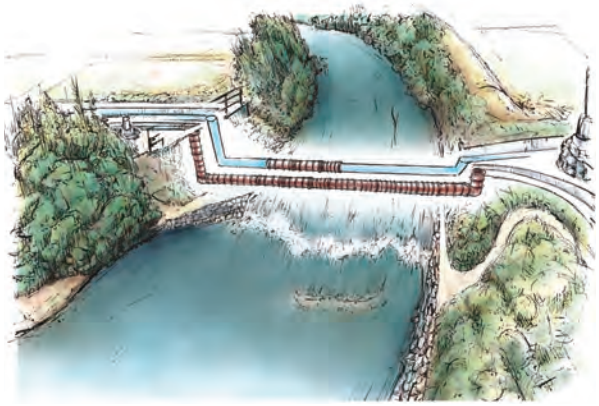


Image 2. Sketch of Umankashira

structure must be. Various devices have existed for this purpose since ancient times.

For example, for the Tsujunkyo Bridge in Yamatocho, Kamimashiki District, Kumamoto Prefecture was built as a large, stone arch bridge to ensure that water pipes could cross the Gorogataki River. Moreover, streams and channels could be laid across using wood or bamboo pipes.

Using these methods to transport water, Umankashira uses the reverse siphon hydraulic principle for the water channel to cross a river.

Umankashira draws water from a sinkhole on the right bank of the Matsuura River to a cylindrical water pipe called an *oketoi*. The pipe crosses the bed of the Matsuura River and gushes from an outlet on the opposite (left) bank.

These pipes are created using wood, by overlaying several pipes resembling cylinders on each other. Even if there was warping due to floods or other causes, such a structure did not easily leak. Although *oketoi* easily corroded and had to be replaced each year, improved results were not obtained by using stronger pine logs or cube-shaped pipes, thus the original *oketoi* pipes were used again. They remained in use for 300 years, until they were replaced by concrete pipes in 1928.

The Umankashira channel splits into three upstream from the sinkhole, with one of the channels leading to the Matsuura River right bank and the other two leading to the left bank through the Umankashira. It also has two sluice pipes, because if there were only one pipe and it were too big, it would collapse under pressure. If there are two pipes and one breaks, the other pipe can be used, and the positioning of the channel after the siphon pipe outlet varies.

As observed from upstream, the left bank outlet is low, and the outlet on the right is high. The water flowing from the right outlet irrigates the farm fields nearby and eventually flows into the left channel downstream. The left bank channel accepts drainage from the nearby rice paddies while irrigating the Momonokawa farm fields downstream.

A *nogoshi* is included at the outlet of the channel on the left bank, through which excess water is dropped into the Matsuura River.

A *nogoshi* is an overflow dike where a part of the channel ridge or another point is lowered, and it is hardened using various methods, such as stone pitching, to ensure that floodwaters and irrigation water can overflow at a specific point. These are seen throughout Saga Prefecture, such as in the flood control sites on the Jobaru River and at the Hamaguri waterworks, where it is used in the irrigation water channel.

Reverse siphons like those at Umankashira are also called *Fusekoshi*, and although they are used in the channel connecting Tatsumiyosui and Kenrokuen in Kanazawa City, Ishikawa Prefecture and the Tsujunkyo Bridge mentioned above, these are public service projects that would be difficult to build without sluice pipes that did not leak or with the use of specialized technology, such as precise measurements.

Moreover, according to the *Sodoyoshu*, a similar Umankashira was also included on the Arita River, with the one on the Matsuura River called Ouma and the one on the Arita River called Kouma.

Photo 5. Umankashira outlet, divided into upper and lower channels.

Photo 6. Umankashira *nogoshi*. The overflow portion has concrete block pitching to resist damage.

Photo 7. Jobaru River *nogoshi*. Part of the embankment is lowered so that flood water flows from the chosen location.

Works cited

Sodoyoshu Nanbu, Nagatsune (1834)

Umankashira local information board

Imari as Seen in Drawings and Maps Imari Municipal History Compilation Office (2007)

The Floodplain Open Levees of the Matsuura River

Kyushu University Teramura Jun, Kitamura Keita

Most of the Matsuura River flows through a mountainous region. Although there are many rapids in the upstream stretches of its tributaries, the main river and the major tributaries have a very gradual slope, with a gentle river current.

Wide rivers narrow when they pass through valleys, and when floods occur, the riverbanks often overflow upstream from the valley. In the plains of these mountainous areas, the Matsuura River has also frequently overflowed. These plains that frequently overflow are called floodplains, and any damage incurred by people due to flooding (including fatalities and damage to homes and other property, such as farms) is called flood damage.

Floodplains are relatively flat, and water is readily available; therefore, they are favorable locations for large farms, and since ancient times, people have been converting them into farmland.

On the Matsuura River, these plains have been developed into rice paddies. However, heavy rains causing flooding on the floodplains damage agricultural land and crops. Moreover, since ancient times, humans have taken the utmost effort to prevent flood damage.

One such example being the open levee, a traditional flood control technology which is representative of the Matsuura River.

(1) The Two Types of Open Levees

Open levees are a particularly well-known traditional flood control technology in Japan and are broadly classified into two types.

Currently, the term “discontinuous levee” is used for open levees. Compared to a continuous embankment stretching upstream and downstream, as is commonly noted on ordinary rivers, embankments that purposefully do not continue for various reasons are called discontinuous levees.

The Shingendutsumi built by Shingen Takeda on the Kamanashi River is a well-known type of open levee and is considered the first of such structures. Shingen Takeda, however, did not use this term. The first time open levees appeared in the literature was during the Meiji Period, when it was used by a newspaper reporter named Morotomo Nishi in his commentary titled *Flood Control Theory*. In his work, he referred to a special type of embankment on the Joganji River as a *kasumi-gatatei* (literally a “mist-shaped embankment”). Following this, perhaps due to frequent disasters occurring across Japan, politicians and civil engineers began using the term “*kasumi-tei*’ (open levee) in the National Diet and other venues, thus leading to the term becoming widely used.

Both the Joganji and Kamanashi rivers are striking examples of alluvial fan rivers. Alluvial fans are a type of alluvial terrain formed when rivers with a high volume of sediment from mountainous areas exit the mountains, and deposit the sediment in a fan-like formation. Alluvial fan rivers are characterized by having a steep gradient.

However, the Matsuura River has a gentle slope across its basin, thus the characteristics of both the river and terrain notably differ. Yet, discontinuous levees (open levees) are observed across Japan, including on rivers with gentle slopes, such as the Matsuura. The Toyo River in Aichi Prefecture, the Kumozu River in Mie Prefecture, and the Gokase River in Miyazaki Prefecture are well-known for these structures.

The same term "open levee" is also used for traditional flood control facilities on rivers with completely different characteristics because the embankments are discontinuous. If the river has different characteristics, the facility purpose, origins, form, and functions will also differ. An alluvial fan open levee and a floodplain open levee are completely different structures.

Here, I will primarily use the term "alluvial fan open levee" for levees on rivers with swift currents, such as alluvial fan rivers, and "floodplain open levees" for structures on floodplains with gentle slopes.

◆ Alluvial fan open levees

At levees on alluvial fans, short embankments are built in succession for multiple layers.

On alluvial fan rivers, these are made using large rocks, gravel, and sand. In this case, the river is wide and most of the width is covered by a gravel riverbed. In such a wide river, the current flows in various directions. Therefore, large floods often lead to changes in the location of these rivers. For example, if one does not hold the end of a hose or showerhead and turns on the water at full force, the hose will wildly swing around. A similar phenomenon occurs in nature with alluvial fan rivers.

In alluvial fans, a large volume of sediment washes down from the mountains. However, because there is also a large volume of water and a slope, waterways are easily formed, and spring water wells up; these are the notable benefits of developing agricultural land at these locations. The Kaga Domain, one of the many *tozama* (outside) daimyo in the Edo Period, possessed an expansive agricultural land called *Kaga Hyakumangoku* in the Ishikawa and Toyama prefectures, but most of this area featured rice paddies developed from an alluvial fan.

Alluvial fan rivers in their natural state do not have a fixed course and overflow their banks; therefore, flood control is required to control the course. For this reason, traditional flood control structures built on alluvial fan rivers mostly in the Edo Period are alluvial fan open levees.

To control the river course on an alluvial fan, first, the "neck" of the river must be controlled at the top of the fan to determine the river direction. Spur dikes, such as megaliths and large stone piles, are placed to set the direction where the dike meets the river. At most such sites, the river is pushed to the edges of the alluvial fan, because it enables

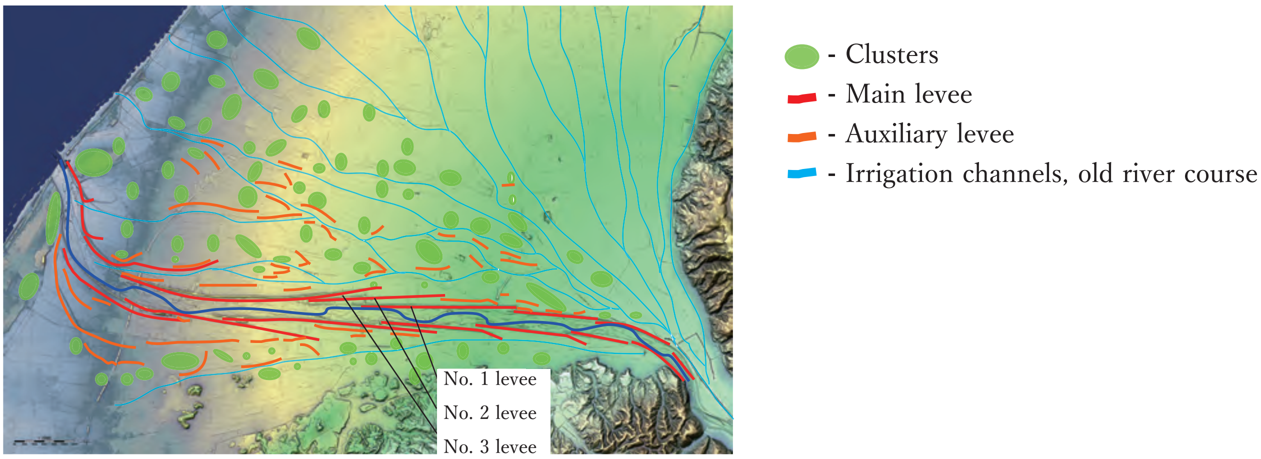


Image 1. Tedori River alluvial fan and open levees

us to find a good location for drawing water. On the Tedori River, the river was fixed on the south side of the alluvial fan, and the old river course that remained in a webbed pattern in the alluvial plain was used to allow irrigation channels for the development of rice paddies.

Next, a wide river was narrowed to some extent and fixed at a width that allows for the river to flow. In places where the river did not flow in the intended direction, short embankments were installed like fish scales in a series. These embankments were built to ensure that when the river current hit, it bounced back. These series of embankments marked the start of open levees.

Currents on alluvial fan rivers are powerful and contain a high volume of sediment, thus making them very destructive. Therefore, many embankments were destroyed. However, during that period, people were familiar with the great power of nature and built embankments to ensure that even if one were destroyed, the water would be stopped by the next structure and the overflow would flow back into the river. This is why several small, discontinuous levees are built in succession.

The series of alluvial fan open levees are called, starting from upstream, No. 1 levee, No. 2 levee, and No. 3 levee. The embankments built in front of the clusters inside the levees are called auxiliary levees. Their locations and sizes transformed based on the level of importance and the period. On the Joganji River, they became larger with each passing period.

Alluvial fan open levees had two secondary functions; draining tributaries and local run-off from between embankments and reducing the power of floods by planting forest buffer strips of bamboo, pine, or other trees in between the overlapping areas.

Furthermore, alluvial fans have steep slopes, and even if the overlapping portions of alluvial fan levees were short, floodwaters from the discontinuous parts of the embankment would not overflow into the embankments. Therefore, alluvial fan open levees are open levees with:

- Fixed channels
- Overflow return to the river
- Drainage of local run-off
- Reduced backflow

A long time ago, when there were floods and water collected within the open levee, fish and driftwood would gather there. This created areas which were used to catch fish and gather firewood.

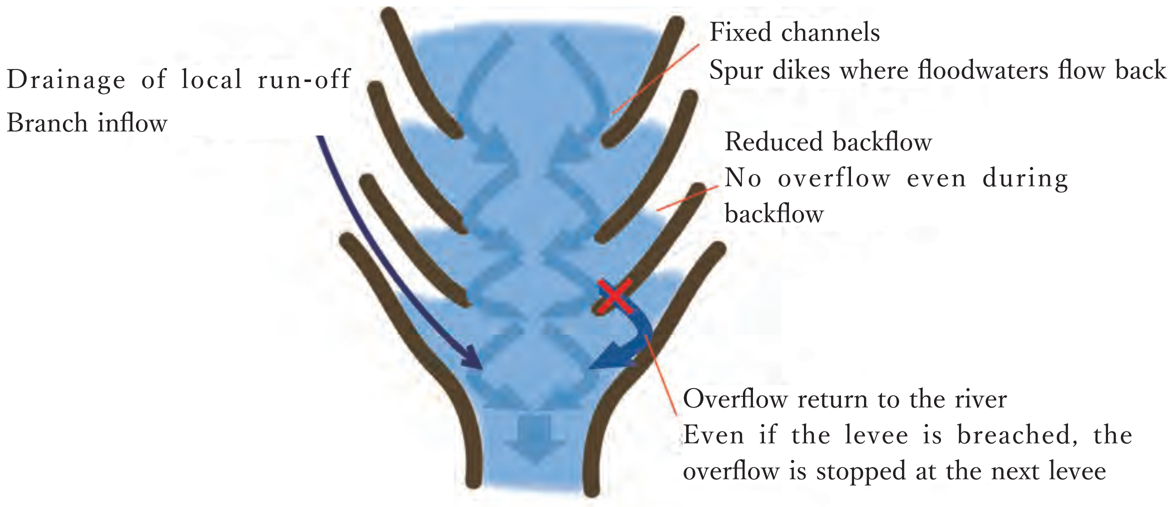


Image 2. Alluvial fan open levee (created by: Teramura and Shimatani)

Photo.1　Pine trees in Arakawa

◆ Floodplain open levees

Floodplain open levees significantly differed in form from the alluvial fan open levees, which featured a series of short embankments—the space in the overlapping areas of the embankments was extensive.

Moreover, certain areas of floodplain open levees were often adjacent to river terraces and mountains, thus the builders found methods to limit the space in the open levees. If there was no suitable terrain, such as river terraces, embankments were created to fulfill such a role.

The basic function of this type of levee was for floodwaters to accumulate in the space within the open levee.

Floodplain open levee openings (the discontinuous part) were in the farthest downstream point where the embankments overlapped. When a flood occurred, floodwaters flowing from here would backflow into the floodplain open levee and accumulate there. Moreover, since this opening was at the farthest point downstream, it was unnecessary to use pumps or other equipment for drainage. This area would naturally drain as the water level reduced.

In some cases, because the mechanisms for handling the flow of floodwaters are extremely complex, we lack sufficient knowledge for explaining the functionality of these levees and have, therefore, discussed their functions.

We will later explain the flow validation for floodplain open levees.

These levees serve a role similar to very small dams that collect floodwater by flowing it into an open levee.

Moreover, on floodplain rivers, because flood control at the confluence points with tributaries is notably difficult, if the water level is high on the main river due to flooding and the level of the tributary is not higher, floodwaters cannot drain from this branch to the main stretch of river. If this occurs and the

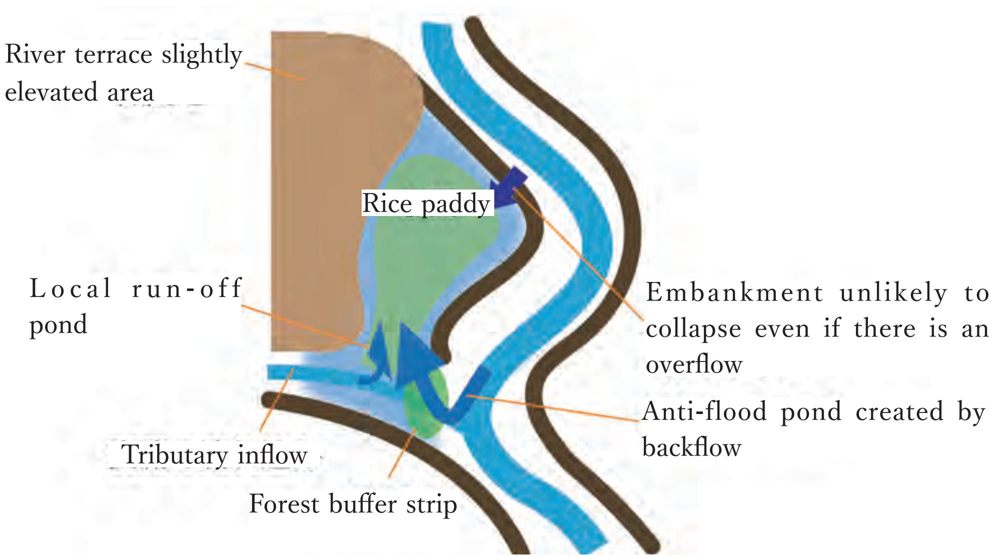


Image 3. Floodplain open levee (created by: Teramura and Shimatani)

water overflows within the embankment, it is called a levee internal flood. Floodplain open levees are often built at confluence points with tributaries; therefore, they have a function to contain such floods. There are often rice paddies within these levees, thus it is thought that floodwaters bring fertile soil to this agricultural land. Moreover, floodwaters that flow into farming areas reflux from downstream; another benefit is that because this current is slow, it does not damage farmlands by destroying rice plants or ridges between the fields.

Furthermore, planting bamboo groves or trees near the opening serves to further reduce the current, which can prevent driftwood and trash from flowing into agricultural fields.

In addition to catching fish and driftwood similar to alluvial fan open levees, when the rice plants were inundated and the water receded, in various regions people found methods to go into the rice paddies to shake off the water and mud.

Therefore, floodplain open levees serve the following functions:

- Floodwater retention with anti-flood ponds
- Levee internal flood retention
- Preservation and fertilization of agricultural lands

Moreover, they provide various secondary effects.

(2) Matsuura River open levees

The Matsuura River features a gentle slope and many relatively small, basin-shaped flat areas surrounded by mountains.

The river basin has several open levees and spots with discontinuous embankments.

These open levees are built on the gentle slopes of flat lands therefore, they can be considered floodplain open levees.

These levees do not have notable water retention capacity and on an individual level, there are still some rice paddies with functions similar to the current floodplain open levees across the river basin. These rice paddies occupy a total of 140 ha and can retain up to 2.8 million m^3 of floodwater.

This is three times the water retention capacity of the Mutabe dry retention basin that was recently built on the nearby Rokkaku River.

The Mutabe dry retention basin cost approximately 11.1 billion yen; therefore, the Matsuura River floodplain open levee water retention function has a potential flood control value of 34.5 billion yen.

The level of a river's flood control safety is not indicated merely by its water storage capacity; there are various other superior points in dams and floodplain open levees.

Matsuura River basin floodplain open levees are characterized by mostly being located at the confluences with tributary rivers, and in many cases are located in mountainous areas. In this case, mountainous areas indicate that terraces and mountains are adjacent to the river, and that the original terrain can be used in place of embankments. They, therefore, play the role of extremely firm embankments. Furthermore, because tributary river confluence points are the joining point for rivers, embankments will be discontinuous and naturally assume the shape of floodplain open levees. The Matsuura River floodplain open levees were built using natural terrain.

Floodwaters backflow into the floodplain open levees on the Matsuura River which are frequently inundated with water. However, even in the present day, there are rice paddies in most of these levees.

Even if this type of levee floods, if the water level on the main river is reduced, the levee will naturally drain, and thus the rice plants will not be in water for extensive periods. Even if the plants are completely submerged, if the period of submersion

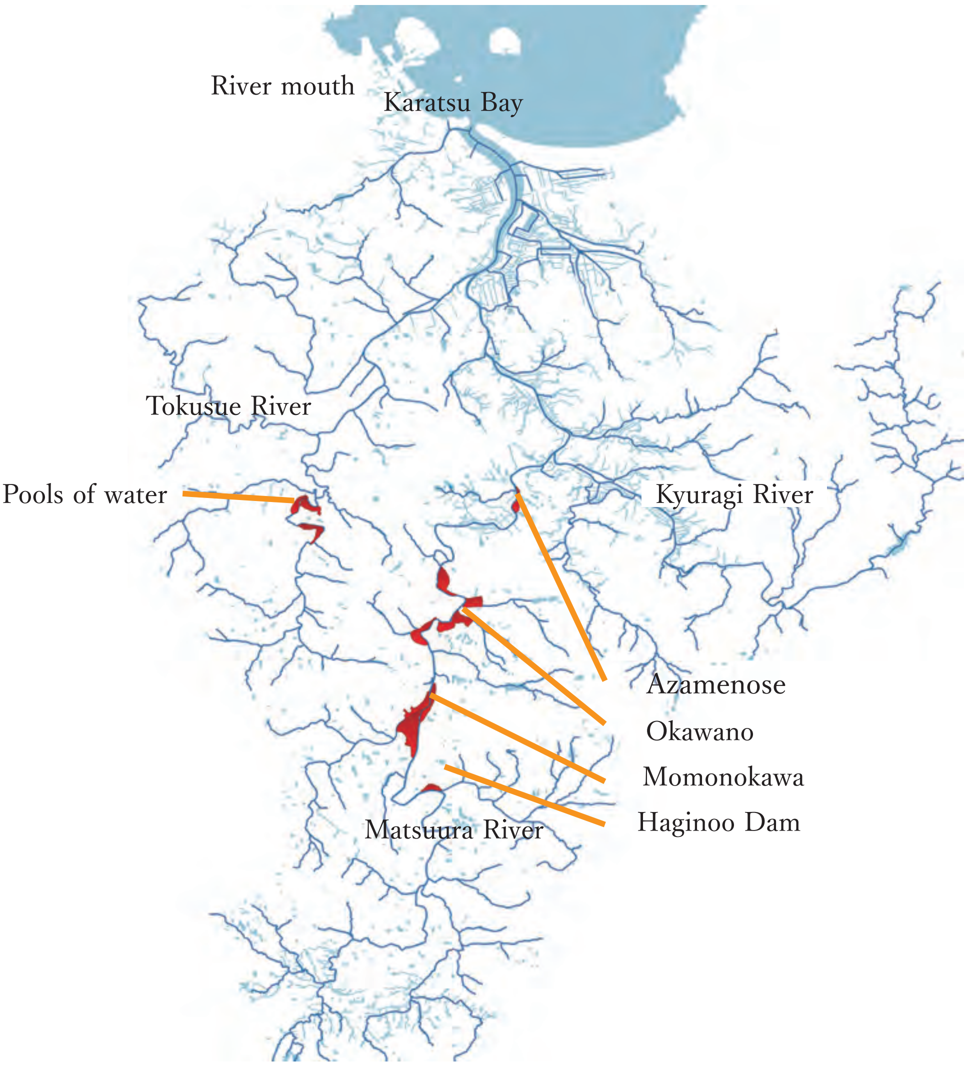


Image 4. Floodplain open levees currently existing in the Matsuura River basin

is 48 hours or less, they will not die. In the case that.

If the rice plants are in the blooming stage, the damage will be significant; however, during other seasons, damage to the rice paddies in floodplain open levees is uncommon.

These levees on the Matsuura River serve as an optimal flood-control technology to use the floodplain while ensuring the least damage to agricultural lands.

The date when the Matsuura River floodplain open levee was built has yet to be determined, but it is considered to have come to its current form based on years of experience dating back to the Edo Period or earlier.

The floodplain open levee of the Matsuura River is a regional asset embodying regional knowledge built over many years.

Works cited

Teramura, Jun; Okuma, Takashi. *Research into the Function and Classifications of Discontinuous Embankments*. A compilation of civil engineering history research papers (2007) 26.0: 73-83

Okuma, Takashi. *An Inquiry into the Functions and Etymology of Open Levees*, a compilation of Japanese civil engineering history research presentations (1987) 7.0:259-266

2017 Japan Society of Civil Engineers' Design Award, Japan Society of Civil Engineers

The floodplain open levees of Okawano

Kyushu University Kitamura Keita

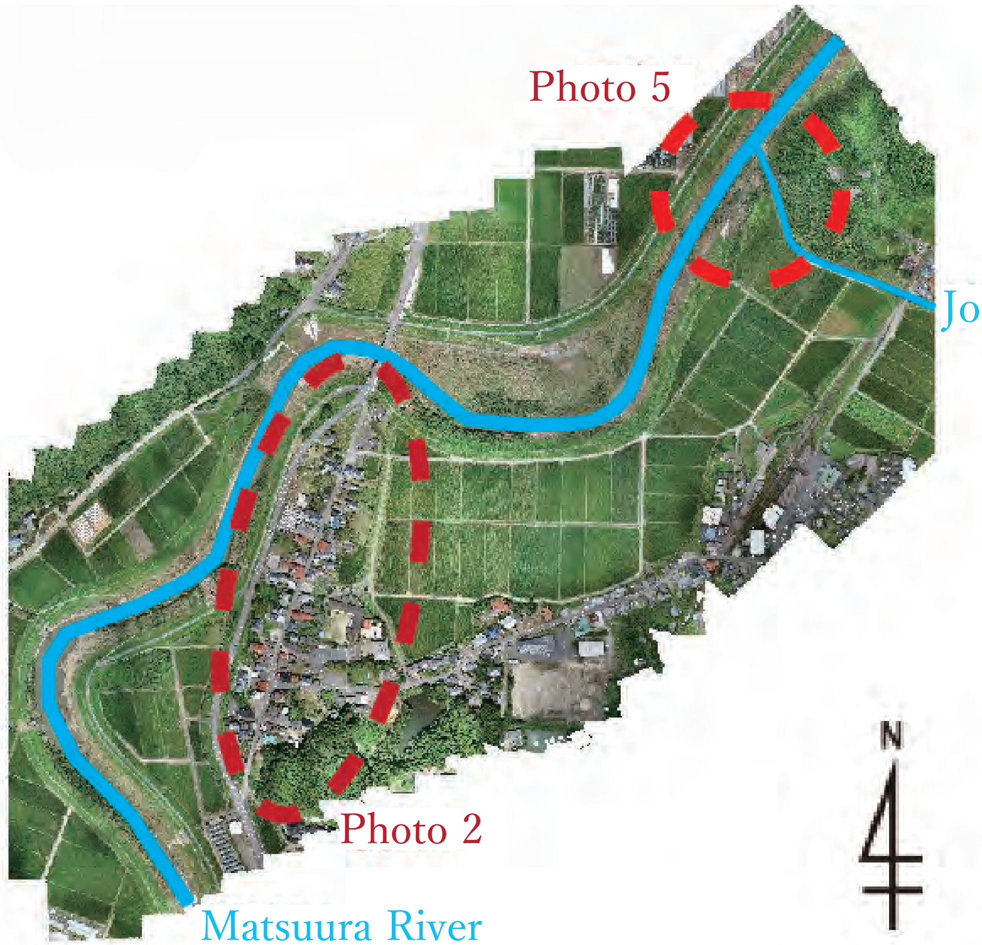


Photo 1. The floodplain open levees of Okawano

(1) Okawano

Okawa-cho-okawano in Imari City in Saga Prefecture is a farming village situated approximately 25 kms upstream from the mouth of the Matsuura River. This area features the floodplain open levees explained in the preceding section.

The Okawano levees are at the confluence of the Matsuura and Jono rivers. Therefore, if the water level on the main river increases, approximately 16 ha of rice paddies from the opening of the floodplain open levees will become flooded. These rice paddies are surrounded on four sides by the embankments on the main stretch of the Jono River, river terraces, and part of the ring levee.

(2) Ring Levee Village

There is a village surrounded by an approximately 2.5 m ring levee at the same elevation as the rice paddies. A ring levee is a bank surrounding this village, with a long history. Based on the records, the area was established as a village in the early modern times, with the ring levee being built at the same time. However, the first levee was shorter

Photo 2. Ring levee village

than the current levee and was thus easily breached. Therefore, this ring levee frequently collapsed during floods, and homes inside were immersed. The structure was raised and strengthened each time a flood occurred. The current form of the levee was built in 1993, three years after the 1990 flood damage.

There is a record of past flood damage in the ring levee village (Photo 3). The great flood monument was erected after the September 1948 flood, and the floodwater level is inscribed on it. Moreover, the 1.6 m water level from the 1990 flood is recorded on the utility pole beside the monument. These records convey the history of flood damage to future generations.

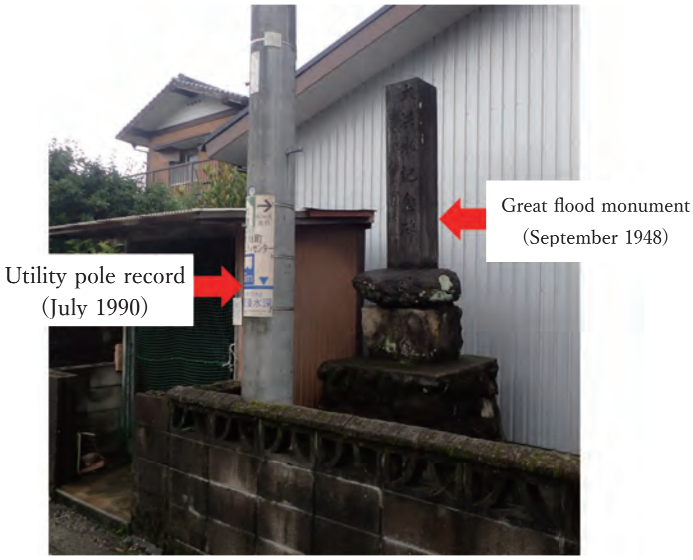


Photo 3. Record of the floodwaters

(3) August 2019 Heavy Rains

Record heavy rains of 100 ml an hour occurred in the Matsuura River basin on August 27 and 28, 2019. During this storm, floodwaters flowed into the Okawano rice paddies from the opening of the floodplain open levees. This was the most severe flood since the heavy rains of 1990, and one of the largest such events to date.

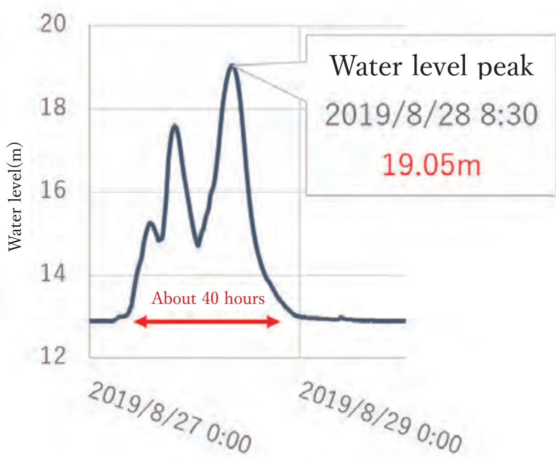


Image 1. Changes over time in Jono River water levels

I conducted local studies of this flood and simulated

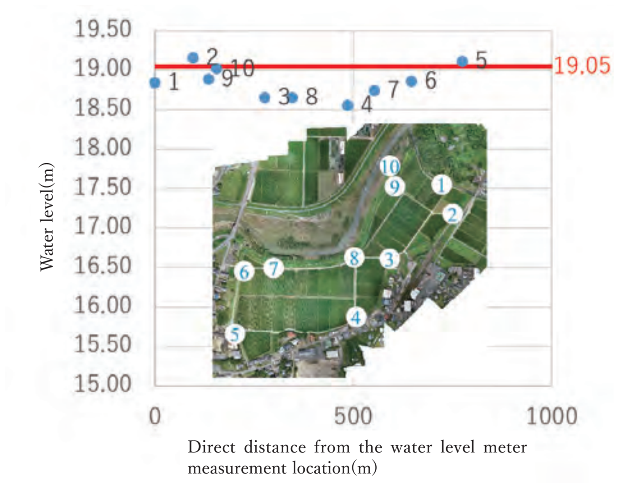


Image2. Relation between the highest water level on the Jono River and the water level traces in the rice paddies

recreations to study the floodplain open levee flooding and the flood control effects.

(4) Local Study of Okawano Directly Following the Heavy Rains

Readings of water level gauges on the Jono River are presented in the image. The normal water level is approximately 13 m, with the highest flood level being 19.05 m recorded at 8:30 am on August 28, 2019. The water level returned to normal approximately 40 hours after it had increased (Image 1).

The relation between the highest water level on the Jono River and the water level traces in the rice paddies is presented in the image. During this flood, at least one meter of flooding was noted across the rice paddies. This water level trace was mostly consistent with the highest water level on the Jono River, regardless of the direct distance from the water level meter measurement location.

The condition of the rice plants is shown in the image (Image 2).

Although the rice plants were covered in water, few plants were knocked down, and none were buried in sediment. Only those near the floodplain open levee opening were knocked down, along with the flood protection forest. A large amount of flood waste, including driftwood, was noted in this forest.

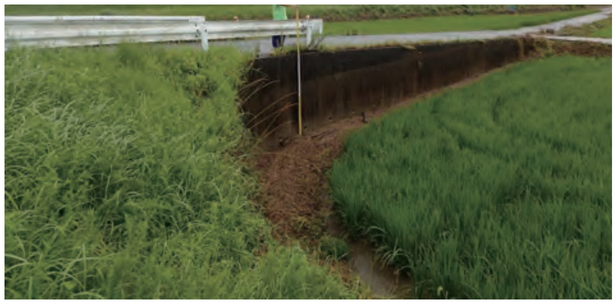


Photo 4. Rice plants after being covered in water

(5) Interview Surveys

I interviewed farmers living in the ring levee village in Okawano. The farmers noted that the rice harvest was not severely damaged, considering the level of flooding. In rice paddies in the past, the rice plants were not destroyed by flooding and only flood waste, such as driftwood, was carried in with a low amount of sediment. This may be caused by the fact that the geology of the floodplain is mudstone—the mud that had covered the plants was eventually washed away by rain. When the rains subside and the water level lowers, driftwood is removed. The location where the driftwood accumulates is typically pre-determined. The primary concern is regarding disease. Immersion in water (such as when a flood occurs) washes off the disinfectant, thereby leaving plants susceptible to disease. Moreover, since ancient times, it is said that floods increase the fertility of the soil, thus providing bigger harvests.

A close relationship was noted between the daily life of the local people and the Matsuura River. A representative example of this is the Japanese dace locally called the *ida*. People are so familiar with this fish that it was featured in the Kurokamiyama

Photo 5. Floodplain open levee opening after a flood

Photo 6. Ida (Japanese dace) credit: Yuichi Kano (ffishu.asia)

Software	iRIC version3.0
Solver	Nays2DH
Terrain data	Geospatial Information Authority of Japan basic map information
Digital elevation model 5m mesh	
Water level data	Ministry of Land, Infrastructure, Transport and Tourism water level observatory August 2019 heavy rain measurement data (Kawanishi bridge, Wadayama bridge)
Flow rate data	Calculated by the Kawanishi bridge H-Q method
Shape format	5m square mesh

Table 1. Software and data used

great snake legend, and the area around Okawano was well-known for *ida*. Moreover, after a flood occurred and the waters receded, people collected and consumed the koi, crucian carp, and catfish left behind.

(6) Flood Simulated Re-creations

I conducted a simulated recreation of the floods during the August 2019 heavy rains for the Okawano floodplain open levee. The software and data I used are presented in Table 1.

I also provide a flow speed vector image showing the volume and direction of the flow at flood peak time as well as a contour diagram showing floodwater levels in different colors. If the flow velocities at various locations are compared, it can be noted that the velocity in the rice paddies is extremely gentle, compared to that of the main stretch of river. This is considered to be caused by the inflow from the backflow out of the downstream opening. Moreover, by observing water levels, it can be noted that the level at the floodplain open levee opening is constant. Furthermore, the floodwaters that pooled in the rice paddies naturally flow from the opening as the level on the main river reduces. As a result, the rice plants were immersed for between 8 to 40 hours.

With flooding from floodplain open levees, the possibility of rice plants being knocked down or dying due to immersion for long periods is low, thereby suggesting that damage to floodplains was minimized.

The peak time cross-section flow rate over 40 m downstream from the Okawano floodplain open levee is presented in the image. The orange line indicates when 16 ha of rice paddy flooding from the levee is allowed, as is currently the case, whereas the blue line indicates when this flooding is controlled by closing the levee opening. Comparing these two lines with flooding from the floodplain open levee, although the flow volume decreased until arriving at peak flow volume—the maximum amount of water flow during a flood—after this peak, the volume increased. In addition to a flow volume peak cut of 5.3 m^3/sec., the peak was delayed by 10 minutes.

When using normal anti-flood ponds, drainage is

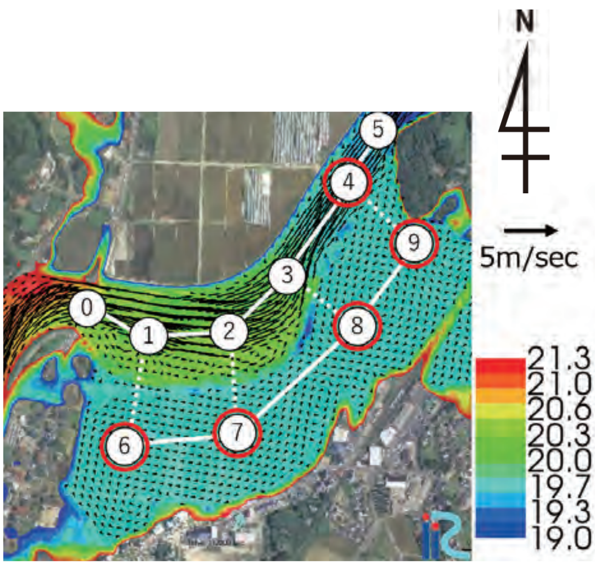


Image3. Okawano flow rate vector image and water level contour image (flow volume peak time)

Main river			Floodplain		
Location No.	Flow rate (m/sec)	Water level (m)	Location No.	Flow rate (m/sec)	Water level (m)
0	4.07	20.73	-	-	-
1	3.35	20.35	6	0.0027	19.59
2	2.72	20.36	7	0.0060	19.59
3	2.45	20.22	8	0.0283	19.59
4	3.52	19.61	9	0.0047	19.59
5	3.78	19.34	-	-	-

Table 2. Location flow rate and water level (at main river flow volume peak)

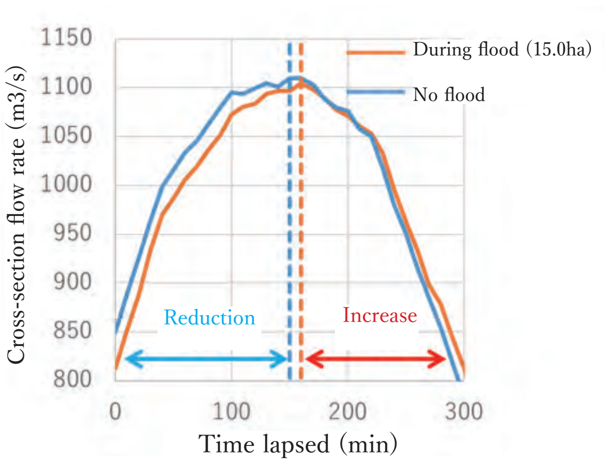


Image 4. The peak time cross-section flow rate over time 40m downstream from the Okawano floodplain open levee

not conducted using pumps or sluice pipes between floods, and the floodwaters are retained. The flood flow volume cut is thus maintained. In comparison, the floodwaters retained in the Okawano floodplain open levee outflow naturally. Although the flow rate peak cut volume is reduced as a result, a unique phenomenon called a flow rate peak delay occurred.

(7) Summary

The floodplain open levee at Okawano had a structure that simultaneously reduced overflow flood damage to rice paddies and the effects of these disasters. However, these were ineffective because of their structures. In Okawano, flood damage experience since the early modern times has been handed down locally. As a result, homes are not built in low-lying, flood prone areas, and locals are sure to strengthen ring levees. Moreover, during the recent flood disaster, harm to people, flood damage to houses, and damage to rice crop yields were largely controlled. This levee and the use of its surrounding land involved structures that reduced the effects of disasters, thereby fusing modern advanced levee building technology with the wisdom shared by ancestors since the early modern times.

Works cited

Okawacho Onkochishinkai. *Okawacho* (1978)

Matsuura History Discussion Committee. *Matsurokoku* No. 60

The Cross-levees of Ono

Kyushu University　Teramura Jun


Photo 1. Ono cross-levee (photo: Ginji Oishi)

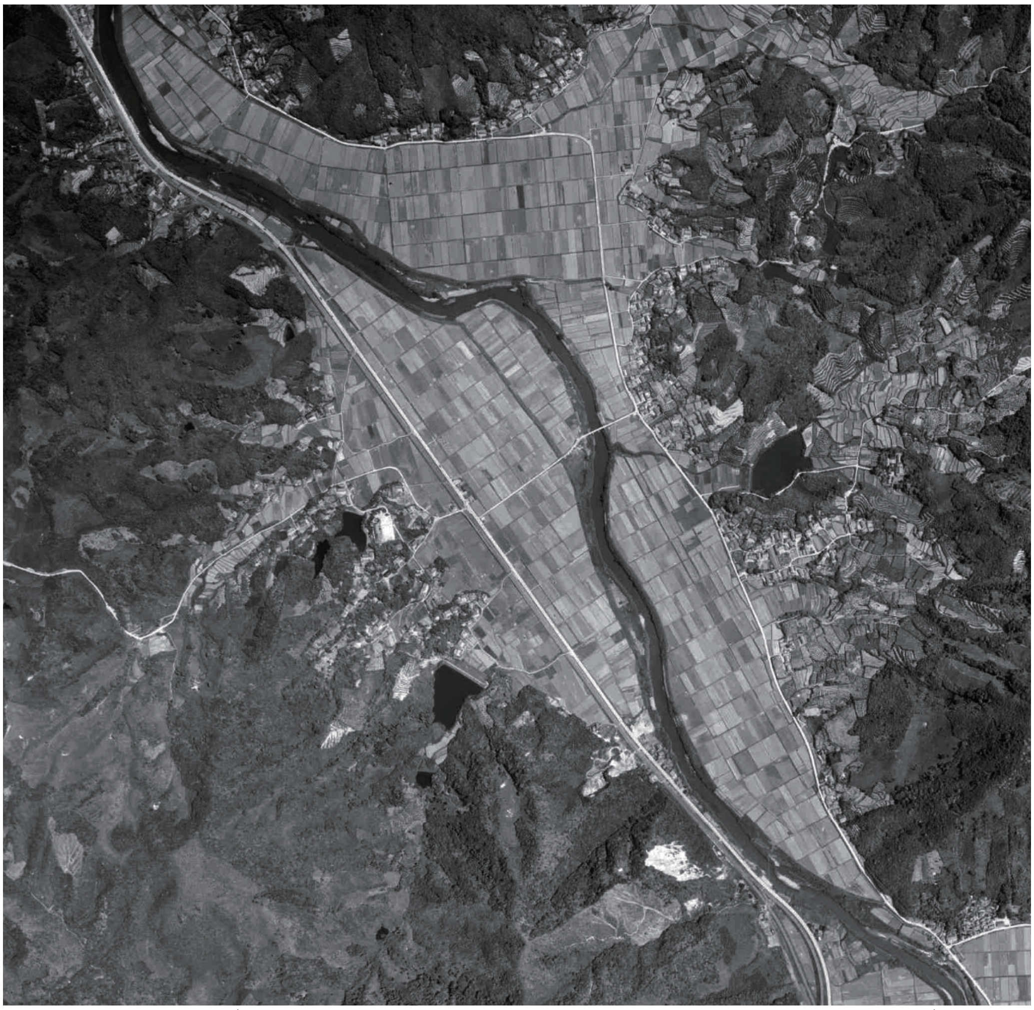


Photo 2. 1964 aerial photo (Geospatial Information Authority of Japan aerial photo MKU643-C10-14 processing)

The remnants of a floodplain open levee can be found in Ochichoono in Karatsu City. Observing this cross levee, we can see knowledge of land use that conforms to the river shape.

(1) The Ono area

The Ono area has an extensive history spanning over 400 years. One theory indicates that the Onuma area during the Heian Period *Wamyosho* is the Ono area in the present day. Moreover, the Marukuma Shrine is considered to have been in its current location since the Muromachi Period.

(2) Cross-levees and Villages

By observing old aerial photographs of the Matsuura River, it can be noted that the flow of the river has been altered. Until around 1980, the river around this area meandered notably around the current cross-levee.

Embankments were built in line with this meandering section, and the embankment that is the current cross-levee continues on this extension. The end of this levee continues to the mountains, and its embankment along the riverbank is discontinuous. This cross-levee used to be a floodplain open levee. Around 1980, this meandering portion of the river disappeared, and this levee was closed. However, because only the cross-levee was sturdy, this remained as a river structure.

The function of using backflow to allow floodwaters from the opening to backflow is similar to the method used at Okawano and other places. Moreover, placing open levees on meandering sections of rivers is common in floodplain areas, as noted on the Toyo River in Aichi Prefecture *yoroi-tei* (now called *kasumi-tei,* or open levee, but formerly called *yoroi-tei*) and the *torinohakasane* on the Shiota River in Saga Prefecture.

Observing the 1881 (year 14 of the Meiji Period) *Higashi-Matsuura District Town/Village Map (Section A) Ono Village,* not only is the cross-levee visible but also the positions of villages have remained mostly the same.

Using the cross-levee and the road cross at the floodwall gate, square lumber was inserted during floods to prevent flood overflow, and materials were stored in sheds in the village.

Drawing 1. *Higashi-Matsuura District Town/Village Map (Section A) Ono Village* (taken from Saga Prefectural Library Digital Archives public domain content)

Even if a flood occurred, most homes were in high, hilly places and were thus not affected. However, one store was frequently flooded.

In the 1881 map, there is a house at the spot where this store is located. Similar to the positions of other houses, sufficient land was used to ensure that homes were not affected.

Photo 3. Floodwall gate with a prefectural road (photo: Naoto Tanaka)

Works cited

Ochicho History, Ochicho History Edition Committee , ed. (1971)

The *funagata yashiki* of the Hidari-Ikisa River

Kyushu University Teramura Jun

Most of the Matsuura River basin is composed of sedimentary mudstone and sandstone, but the farthest downstream and easternmost portions are made of granite and granodiorite. Rivers in such areas have a heavy outflow of sediment and alluvial fans form easily; therefore, they are shallow in nature. The right Ikisa River, a downstream tributary of the Matsuura River, is situated on a granite belt. In particular, the left Ikisa River tributary forms an alluvial fan. Rivers with alluvial fans are prone to flooding and contain a high volume of sediment; this type of terrain tends to damage agricultural fields and residential areas. On such rivers, the methods used to protect these areas from flood damage are different, compared with the methods used for rivers with a gentle slope (e.g., Matsuura River).

(1) *Funagata yashiki*

The alluvial fan open levees presented on page 41 are also a method of controlling alluvial fan flooding. However, on the left Ikisa River, a traditional Japanese flood control method called the *funagata yashiki* (literally "boat-shaped Site") can be noted. The Oi River in Shizuoka Prefecture is well-known for these structures. By building stone walls, slightly elevated ground, and embankments upstream (the direction toward which floodwaters flow) from residential areas, these structures protect houses from floods.

On rivers with steep slopes situated on floodplains (such as those in alluvial fans), on floodplains, powerful floods flow from upstream, but they do not backflow from downstream. Therefore, if protective measures are only adopted in the direction facing the flow of the flood, there is no need to take protective measures downstream. With *funagata yashiki,* stone walls and other structures are built facing upstream. Floods have a powerful flow; therefore, such structures have an edge facing upstream. The term *funagata yashiki* is derived from the fact that these edges resemble the bow of a ship.

(2) Hidari-Ikisa River *funagata yashiki*

Upstream on the Hidari-Ikisa River, we see the Ikisa Dam and Mikaerinotaki waterfall, and because most of the basin is in a mountainous area, the 1.5 km farthest downstream stretch that merges with the Ikisa River is a rapid river on an alluvial fan plain.

At the farthest downstream area, approximately 500 m from the confluence, we see a *funagata yashiki.*

There are currently five confirmed *funagata yashiki* on the Hidari-Ikisa River. The most upstream among them is a mound-like elevated area surrounded by a stone wall. There are trees on the mound, with a small shrine in the middle of this little forest. In the past, a local meeting place

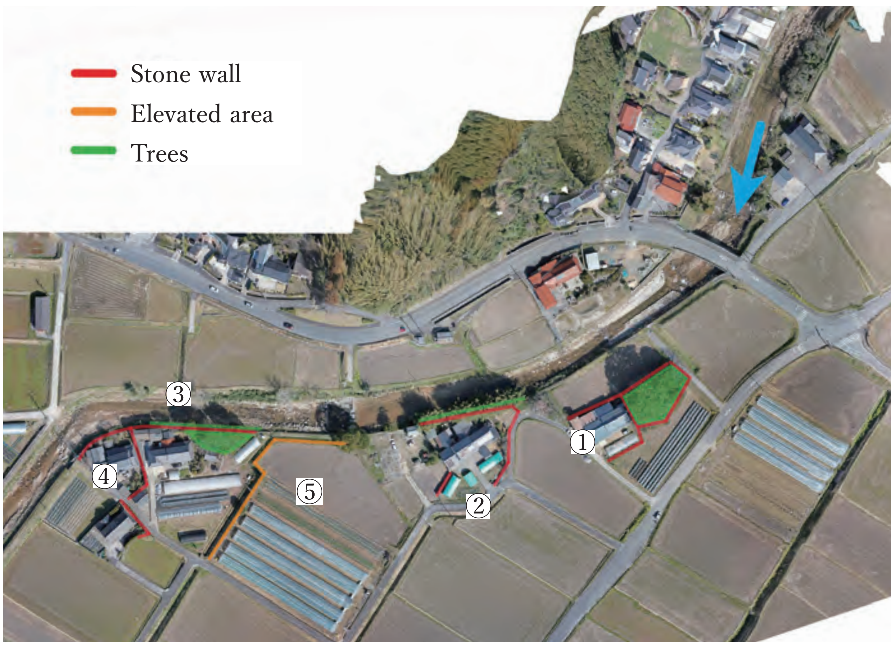


Photo 1. Hidari-Ikisa River *funagata yashiki*

was situated in these woods, thus making it an important location for the local people. Houses are on the other side of the mound surrounded by a stone wall, and there is an entrance/exit point farthest from the river.

The second *funagata yashiki* from the upstream direction faces the river as do the stone walls, extending upstream. There is also bamboo on the riverbank, and bamboo in this grove cannot be harvested.

Although there is a stone wall behind the second *funagata yashiki*, there used to be another house directly downstream from here; therefore, the stone wall is considered to have been created for this structure.

Observing the third to fifth *funagata yashiki* from the upstream direction together, there are no identifiable stone walls upstream from the houses (with the exception of those on the riverbank). However, there are some residential areas at a spot one level lower than upstream that use small differences in elevation to function in a manner that is similar to the *funagata yashiki*. Moreover, between houses, there are stone walls and block fences which act as separate measures for defending against flooding.

(3) The History of *funagata yashiki* on the Hidari-Ikisa River

It is unclear when the *funagata yashiki* in this area were built.

In the *Higashi-Matsuura District Ikisa Village Miniature Drawing* (drawn in 1881) no houses are depicted at the farthest upstream point, whereas houses are portrayed from the second house from the upstream direction. The presence of *funagata yashiki* is confirmed at the farthest upstream point in an aerial photo from 1947 (year 22 of the Showa Period) as well as a strip of trees upstream from the houses, which is the present status of the area.

The local people have indicated that significant flood damage occurred in 1895 (year 28 of the Meiji Period). Moreover, they have indicated that the houses to the river side of the first *funagata yashiki* were washed away, and stone walls and other structures around the remaining houses were fortified.

Over 100 years after these structures were built, they continue to protect homes from floods.


Photo 2. Stone wall surrounding a house


Photo 3. Stone fence and a bamboo grove


Photo 4. A stone fence placed upstream becomes lower in the upstream direction


Drawing 1. Part of the *Higashi-Matsuura District Ikisa Village Miniature Drawing*

The Flood Submerging Bridges and Low-level Crossings of the Matsuura River

Kyushu University Teramura Jun

Although the Matsuura River was a shipping route, people have lived along its banks since ancient times. The river is situated between various key points, such as the Ariake Sea and Sea of Japan, Nagasaki and Fukuoka, with roads (including the Karatsu Highway) having been developed nearby.

People frequently crossed the river by various methods, including flood submerging bridges and low-level crossings, both of which have remained to this day.

(1) Flood Submerging Bridges of the Matsuura River

Flood submerging bridges are also called sinking bridges or submersible bridges. When a flood occurs and river water levels rise, the bridges become submerged in the river. The flood submerging bridge on the Shimanto River in Kochi Prefecture is particularly well-known. Moreover, such bridges are common in this as well as the Oita prefectures.

These bridges are often placed across high water channels and compared to conventional bridges built at a higher elevation, in relation to embankments. Flood submerging bridges have low piers and are short in height. There are benefits to flood submerging bridges including the fact that building costs are significantly lower, and they do not obstruct the river scenery. However, the disadvantages of these structures are that because they become submerged during floods, passage is temporarily impossible, and there is a high risk of damage from floods. They impede the flow of floodwaters; therefore, there is an increased possibility of damage from such disasters. Based on these factors, this type of bridge is gradually disappearing across Japan.

Photo 1. Flood submerging bridge on the Shimanto River

- Flood Submerging Bridges on the Matsuura River

Currently, a total of nine flood submerging bridges

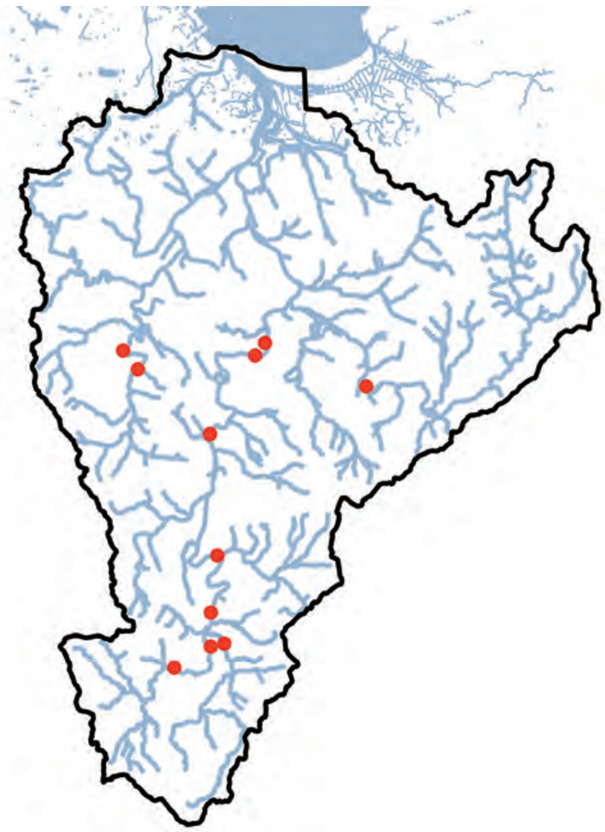


Image 1. Distribution of flood submerging bridges on the Matsuura River

exist in the Matsuura River system. Including the three structures removed in 2019, traces of three additional bridges have been confirmed.

Although there were more flood submerging bridges in the past, I have yet to uncover knowledge about them.

The removal of some of these bridges was part of the Matsuura River improvement plan, and this may have been unavoidable on this river, which has witnessed massive floods in recent years.


Photo 3. Removal of the Okawano flood submerging bridge


Photo 2. The Okawano flood submerging bridge


Photo 4. The Okawano flood submerging bridge had stone girders


Photo 5. The Sari flood submerging bridge

Photo 6. Flood submerging bridge downstream from a weir

Photo 7. Low-level crossing

Image 2. Distribution of low-level crossings on the Matsuura River

In the river basin, this type of bridge is noted on the Matsuura, Tokusue, Kyuragi, and Chokai Rivers. These are the main river and its primary branches, which are relatively large. These bridges can be classified into those directly downstream from weirs and those without any characteristic structures nearby. Most flood submerging bridges without any structures nearby are approximately half the height of embankments, and the bridges downstream from weirs tend to be in relatively lower locations.

The currently existing bridges are all built using concrete. However, the Okawano bridge removed during the winter of 2019 was partially built using stone girders. Therefore, we can imagine that the bridge had existed there for a long time.

(2) Matsuura River Low-level Crossings

At low-level crossings, a road is laid directly on the riverbed, with the river running over the road. They are simple river crossing structures. Given that it is extremely dangerous to cross a river with a high flow rate, even without flood conditions, the roads were necessary and sufficient for past lifestyles (e.g., for crossing the river to go to agricultural fields).

Even nowadays, this type of river crossing is observed worldwide, primarily in rivers in mountainous areas.

- Matsuura River low-level crossings

Low-level crossings on the Matsuura River serve a function ancillary to weirs—they provide a method for crossing the river, and at normal water levels, the river current passes through the area under such a crossing.

Photo 8. Flood submerging bridge and low-level crossing on the Tokusue River

There are currently 20 of these crossings on the Matsuura River, and 13 of the crossings serve an ancillary function, such as river crossing. The remaining seven seemingly do not have any such function; they are merely low-level crossings.

In most cases, these crossings are on rivers smaller than those that have flood submerging bridges, and only one low-level crossing each is noted on a main river and primary branch. The crossing on the Tokusue River, a primary branch, is unique because half of it is a flood submerging bridge. Therefore, we can say that these crossings are placed on rivers smaller than those that host such bridges.

Low-level crossings come in various sizes, from those usable by light automobiles to those that can be crossed only on foot. Bridges can be observed near all these crossings, which are used as extensions of ridges or paths between rice paddies and as farm roads. They are not the primary local roads.

(3) The Future of Flood Submerging Bridges and Low-level Crossings

Flood submerging bridges on the Matsuura River are currently being removed. Moreover, it is highly likely that they will all disappear in the near future. They become submerged during floods, and thus obstruct the downward flow of floodwaters. Due to the blockage of water flow and driftwood becoming lodged, the high probability of water damage is undeniable. Moreover, their use is limited because most of the bridges cannot be crossed by cars. Therefore, they are of low importance as roads and removal are becoming alternative options.

Low-level crossings face similar circumstances. Although their removal is not as remarkable as that of flood submerging bridges, because they serve a secondary function to weirs, they are primarily considered to be tentative river crossings, and there is no reason to actively maintain them. There are no prospects for their sufficient maintenance in the future.

Although ensuring the highest level of disaster safety is an important task, flood submerging bridges and low-level crossings that become submerged during floods provide a cultural value that portrays the relationship between a river basin society and the history of life in the area. Therefore, we must consider methods of increasing flood damage safety while appropriately maintaining these structures.

Photo 9. A low-level crossing passable only on foot

Photo 10. A low-level crossing weir passable by cars

Photo 11. A flood submerging bridge with collapsed girders

Niji-no-matsubara

Kyushu University Kitamura Keita

Photo 1. Niji-no-matsubara seen from afar (photo taken from the Kagamiyama observation platform.

(1) Niji-no-matsubara

Niji-no-matsubara is a pine forest along the coast of Karatsu Bay and is considered one of the three most scenic pine groves in Japan. It has been designated by the national government as a Special Place of Scenic Beauty. This pine grove is approximately 500 m wide and roughly 4.5 km long. It has an area of approximately 214 hectares and contains 1 million black pines. There are two theories about the origin of its name: the first theory is that the original length of the pine grove was two *ri* in length (about 8 km) and the second theory is that the arc shape of the grove and its colorful scenery resemble a rainbow (*niji*).

(2) Origin and Functions

The origins of Niji-no-matsubara can be traced back to early modern times. Shimanokamihirotaka Terasawa, the first Daimyo of Karatsu, was focused on developing new agricultural land. However, the northwest seasonal winds blowing in from Karatsu Bay posed a problem to this plan. The wind, salt, and sediment that the winds carried led to damage to nearby fields. To prevent this, Shimanokami Terasawa passed an order to plant a black pine forest along the coast. Planting Niji-no-matsubara enabled the coastal area to avoid the salty sea breezes and windborne sand damage. To preserve this grove, Shimanokami Terasawa issued a notification that anyone damaging any of his seven beloved pine trees would suffer a punishment equivalent to the punishment issued for those who commit murder.

The original purpose of Niji-no-matsubara was to protect agricultural land from wind, salt, and sand damage. This method is also considered to have protected the land against tsunami and tides. When the March 11, 2011 Tohoku Earthquake occurred,

Image 1. Niji-no-matsubara

Photo 2. *Shoro* and *shoro manju*

Photo 3. Inside Niji-no-matsubara

it was reported that the Kujukurihama beach and the pine forest protected it against tsunami-inflicted damage.

Nijinomatsubara also serves to function as a health protection forest. Although it is near the main streets of Karatsu City, this pine grove cleans the air and blocks out noise to protect the living environment of the local people and provides nature recreation in the forest and sea.

(3) The Blessings of the Groves

The lumber, fallen needles, and pine resin harvested from pine forests are all very useful. In particular, fallen pine needles are easily obtained by using a pine needle rake; and during the early modern times, they were treasured as a source of fuel in daily life. During World War 2, ship building materials and pine oil were harvested here. Moreover, *shoro* mushrooms are only found in such black pine forests, thus this area is famous for its *shoro manju*, which imitates the shape of these mushrooms.

Having been designated a Special Place of Scenic Beauty; Niji-no-matsubara is highly valued for its scenery. The contrast between the white decomposed granite soil formed by the weathered granite and the pine trees bent by the northwest seasonal winds, called "white sand, green pines," has been appreciated by people since ancient times as an example of beautiful oceanside scenery.

(4) Preservation Activities

Although there are pine forests throughout Japan, most of them are man made because such forests cannot be maintained without human intervention. These forests are established on soil that is lacking in nutrients, (similar to that of beaches) however, this soil develops nutrients from fallen pine needles. Other plants then gradually grow when these nutrients become available. When this occurs, if there are trees that grow taller than the pines, the pine trees can no longer absorb sunlight and end up decreasing in number and disappearing. This phenomenon is called succession. Black pines resist salt damage and also grow well in wastelands. During winter, they keep their needles which allows them to maintain their ecological function. We should preserve coastal black pine forests in order to preserve their natural disaster reduction function. To control succession, people rake fallen pine needles to maintain pine forest functioning, which prevents fertilization of the soil and ensures that other vegetation does not grow. Pine needles were used as fuel in the past; therefore, the fallen needles were collected. In recent years, however, this raking has been insufficient, and many pine trees have withered and died due to pine weevils.

Due to these circumstances, local civil society organizations were formed to revitalize and preserve Niji-no-matsubara, and they have remained active in restoring the white sands and green pines of this pine grove.

Works cited

Saga Prefecture History Committee. *Saga Prefecture History Middle Volume* (early modern period) 1968

Okazaki, Hiroko; Ooki, Junichi. *Survey Report on Kujukurihama Tsunami Sedimentation and Coastal Topography Changes, Report of the Journal of the Natural History Museum and Institute, Chiba* (J. Nat. Hist. Inst. Chiba) 12(1) : 1-15. March 2012.

Watanabe, Taiki; Yokouchi, Norihisa; Okada, Tomohide; Mimizo, Hiroyuki. *Niji-no-matsubara Landscape Management Research: The Relationship between Changes in Management Details and Landscape Evaluation, compilation of landscape and design research and lectures.* No.1 December 2005.

【Future traditional and local knowledge and Azamenose】

Photo: Kitamura Keita

The Restored Floodplain Wetlands of the Matsuura River: Efforts at Azamenose

Kyushu University Hayashi Hironori

(1) Matsuura River Overview and Azamenose Nature Revitalization Projects

The source of the Matsuura River is in the Kurokamiyama system in the Kishima District of Saga Prefecture. The river flows north through mountains, the Karatsu plains, and into the Genkai Sea. The Matsuura River has a river basin area of 446 km^2 and a river channel length of 47 kms. The main branches of this river are the Kyuragi and Tokusue rivers. Approximately 84 % of the Matsuura River basin is mountainous, and roughly 70 % of this mountainous area is covered by coniferous forests. Natural stretches of rapids and deep pools have remained in the middle and upper reaches of the basin, including the two aforementioned branches. Most of the riverbed downstream is occupied by medake (*Pleioblastus Simonii*) and Amur silvergrass (*Miscanthus sacchariflorus*) clusters, with mostly common reeds and Korean willows in the middle and upper reaches. There are nearly 1 million people living in and around the river basin, with most of the population concentrated in Karatsu City downstream. Observing the changes over time in the floodplain and the former riverbed of the river, the Matsuura River used to have a floodplain of approximately 12.1 km^2 and a former riverbed of nearly 2.0 km^2 for a total of 14.1 km^2 in floodplain wetlands. However, only approximately 1.1 km^2 of this environment has remained (26 km upstream from the main stretch of the river), thus nearly 92 % of the original wetlands have disappeared. The causes for their disappearance include; direct loss of wetlands due to rice paddy development, loss of continuity caused by flood control from river improvements and lower water levels, concrete water channels for land cultivation, and decreased river continuity. The decreased functioning of rice paddies, which have a compensatory function for floodplain wetlands, is considered to have a significant negative impact (Shimatani 2003). In the Matsuura River, a centered approach to revitalizing such wetlands involves making efforts for the recovery of animals that rely on this terrain and improving the river environment. The center of this activity is the Azamenose area, wherein a project is being conducted to revitalize the wetlands. Due to the enactment of the Nature Revitalization Promotion Act in 2003, increased efforts have been made toward this end across Japan, and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has also started revitalization work. Among the first of these is the Azamenose Nature Revitalization Project.

Azamenose is situated in the middle reaches of the Matsuura River. There are strong embankments on its left bank, whereas no such structures are featured on the right side, thus leading this area to become flooded annually. On the Matsuura River, approximately three km upstream from here, there is a narrow, long meandering section called Komanaki. A project to create a shortcut flood control channel through this stretch was completed when studies for the Azamenose area started. Upstream from this narrow section is a stretch that is prone to flooding, but the shortcut has decreased water levels one to two meters on the river upstream from Komanaki, thereby significantly reducing flooding damage. Therefore, this channel at Komanaki was a key flood control project in the upstream reaches of the Matsuura River. Due to this project, however, there was an increased risk of flood damage downstream,

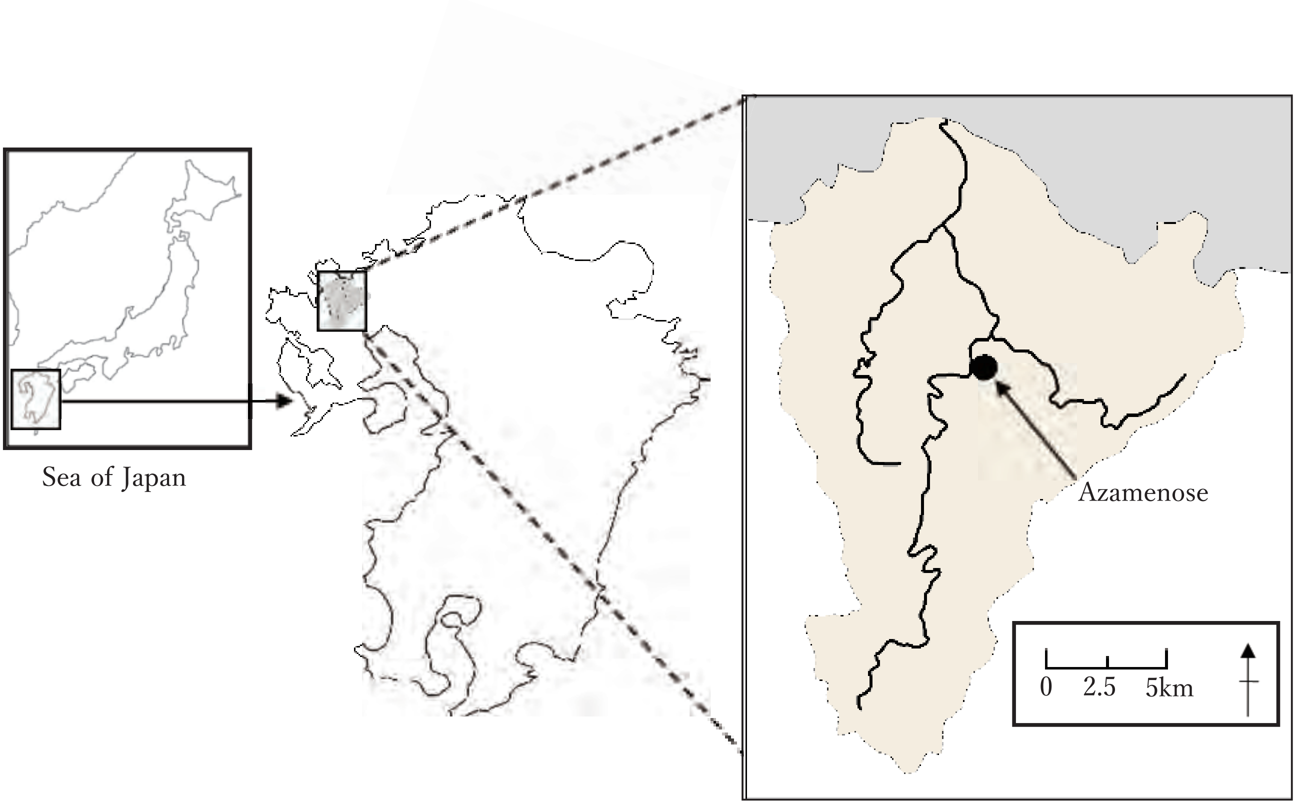


Image 1. Azamenose location

and reaching an agreement to start the project took over 20 years. The Azamenose area vicinity is the last remaining downstream area that is prone to flooding, thus when flood control measures started in this area, it became possible to discharge water from the new Komanaki channel. Although numerous flood control measures, including embankments and land acquisition, were considered for Azamenose, it was ultimately decided to work on a detention basin in the riverbed by acquiring land. The MLIT River Bureau at the time expressed the following intent; "We will do nature revitalization projects if the local people want them, so the focus in doing this will be on their motivation while we engage them in discussion." This is how the Azamenose nature revitalization project started.

The Azamenose project is not based on the Nature Revitalization Promotion Act; it is an MLIT endeavor. There was a voluntary review committee, with participants from academia serving as outside advisors (not in the primary decision-making body). There were no authorized planning documents, such as nature revitalization plans; the project proceeded with the committee discussing and altering plans. The project was conducted in this style because the subject area was relatively small, thus the project only involved one town, and the only agency of

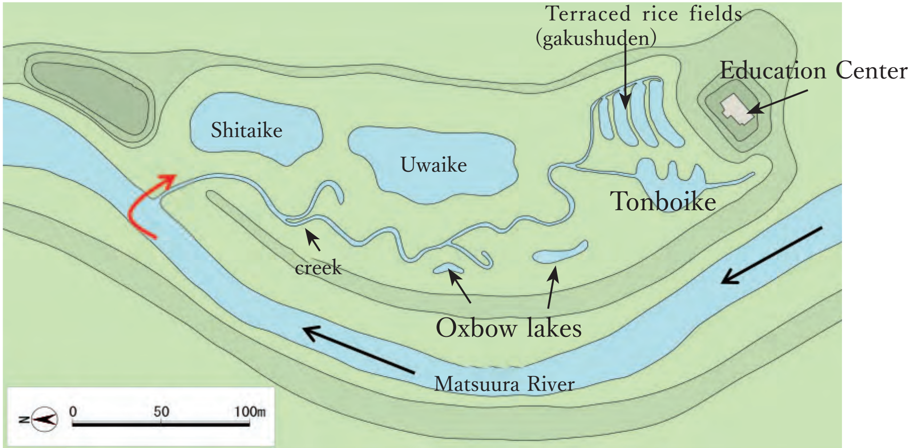


Image 2. Map of Azamenose

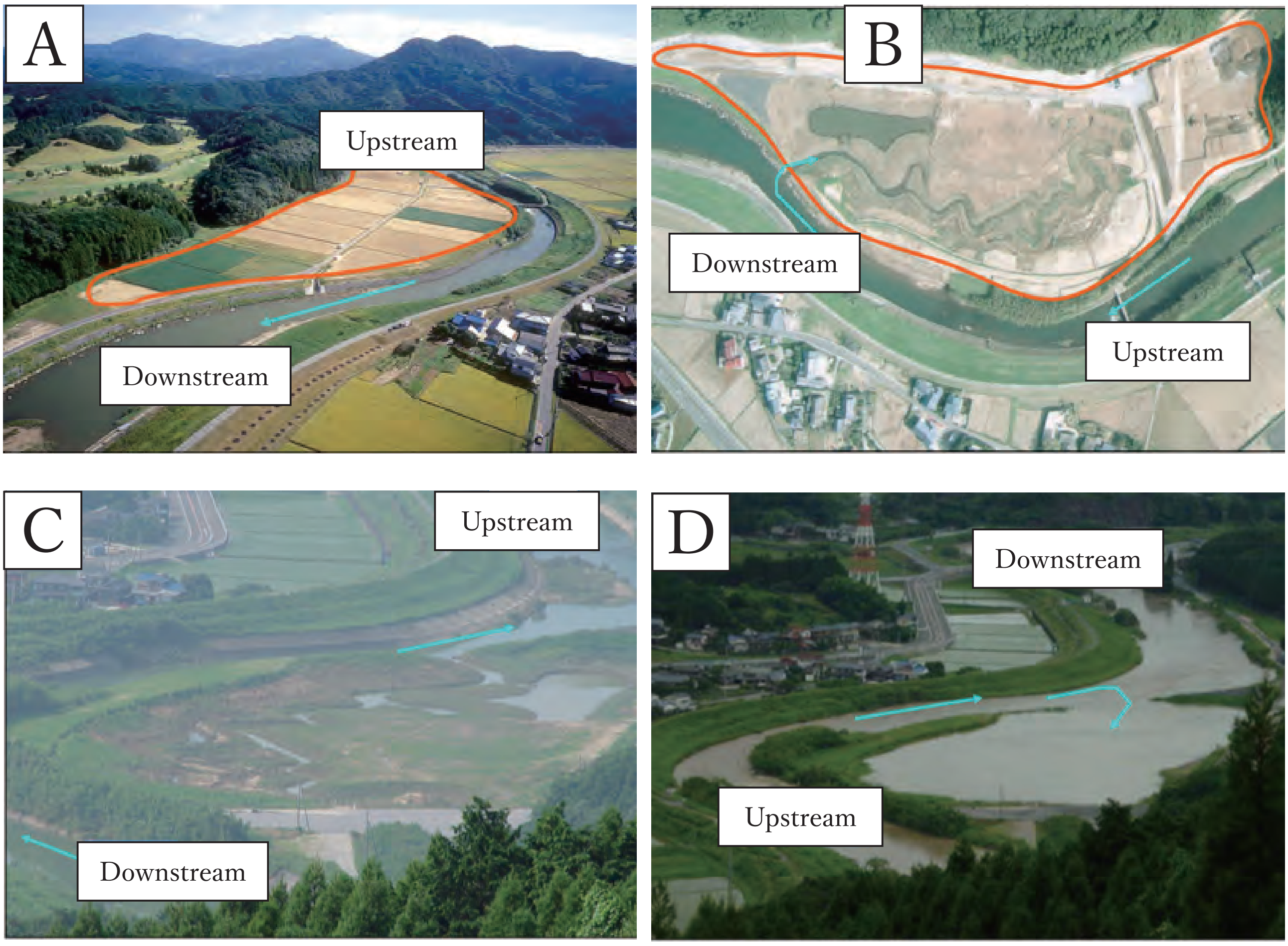


Photo 1. Azamenose scenery: (A) Before work started (B) After nature revitalization (C) Under normal conditions (D) During flooding

the national government that was involved was the MLIT. Discussions regarding the project occurred in the Azamenose Review Committee. The issues regarding goal setting and accommodative management methods were discussed and decided by this committee.

(2) Azamenose Overview

Azamenose is located 15.6 km from the mouth of the Matsuura River (Image 1). The riverbed slope of the main river here is 1/1350, which is classified as segment 2 (Yamamoto 2004). This wetland has a length of 1,000 m and a width of approximately 400 m, for a total area of roughly 6.0 ha. It is composed of six ponds (Uwaike, Shitaike, Tonboike, oxbow lakes, etc.), terraced rice fields, and creeks that connect to the main Matsuura River (Image 2).

The Azamenose area was used for rice paddies before being developed into a floodplain wetland (Photo 1A). During that time, the height difference between the river surface and rice paddies was over 5 m, thus water was supplied to the paddies by pumping from reservoirs and the Matsuura River. To restore the wetland environment, hydrological continuity with the river and a flow rate changing dynamic system were recreated by lowering the ground level approximately 5 m. As a result, the wetland environment is maintained as usual, and floodwaters can enter during floods (Photo 1B). To maintain moisture in the wetlands, the new ground level was T.P. 2.5 m, approximately the sameto that of the Matsuura River in normal conditions. Moreover, the wetland creek riverbank elevation was set at T.P. 3.5–4.0, referencing water levels from the past April floods, to ensure that floodwaters during spring–summer can inundate the wetlands. To maintain this environment, the ground was adaptively excavated to ensure that in March 2006, the creekbank elevation (elevation of the banks of Shitaike and Uwaike) reached a depth of T.P. 3.0 m. Moreover, Photo 2 shows changes in the Azamenose landscape over time. Vegetation was not being actively planted here, thus when work started, the land was barren. Floods, however, brought various seeds (Hayashi et al. 2011), thus in 2012, eight years later, wetland vegetation, including willow trees over five meters tall, had naturally recovered.

In Azamenose, it is necessary to prevent direct inflow of floodwater and sediment from upstream to maintain the back marsh environment; thus, during floods, the water flows in from an inlet located downstream (backwater method; the red arrow in Image 2). There is also a creek in the wetland for drainage and to allow floodwater in. During a flood, water enters from an inlet through the creek, and as the water level rises, the floodwater spreads across the wetland (Photos 1C, D). During these events, various matter and living creatures enter Azamenose (Image 3).

Table 1 presents the results of calculating the frequency and number of days of flooding by elevation, based on the results (Image 6) of observing water levels here for one year. One

September 2001 There was a broad expanse of fertile fields. The Azamenose Review Committee was inaugurated in November 2001.

March 2004 Immediately after work: The body of water in the foreground is Shitaike. When excavation started, the land was barren without any vegetation.

April 2008 Four years after work: The body of water in the distance is Uwaike (completed in 2006). Flooding delivered various seeds, and herbaceous vegetation is recovering.

May 2010 Six years after work: There is herbaceous vegetation, and willow trees have started to grow around Shitaike.

June 2011 Azamenose during flooding: Floodwaters have flowed in from the main Matsuura River, and the entire area has become a pond.

Azamenose in August 2012: The willow trees have grown, with the tallest tree exceeding five meters in height. The scenery is approaching the level of improvement imagined by the Committee when planning started. Currently, Azamenose is lush with valuable flora and fauna.

Photo 2. Azamenose scenery over the years

Table 1 Frequency and number of days of flooding by elevation at Azamenose

Elevation	Flood frequency (times/year)	Flood number of days (days/year)	Bodies of water at each elevation (embankment height)
TP 7.0	3	0.6	
TP 6.0	5	1.4	
TP 5.0	7	2.8	Tonboike
TP 4.0	9	6.1	
TP 3.0	21	20.1	Creek, Shitaike, Uwaike
TP 2.5	27	106.0	

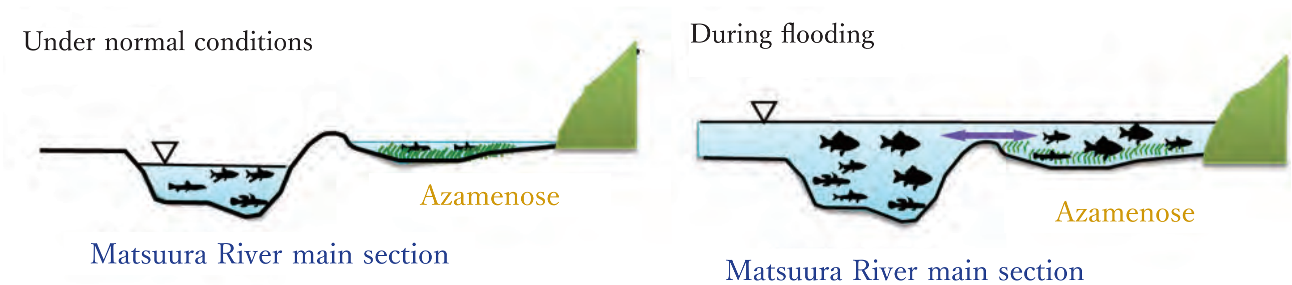


Image 3. Azamenose is an independent body of water under normal conditions, but flooding delivers various objects and living creatures onto the land.

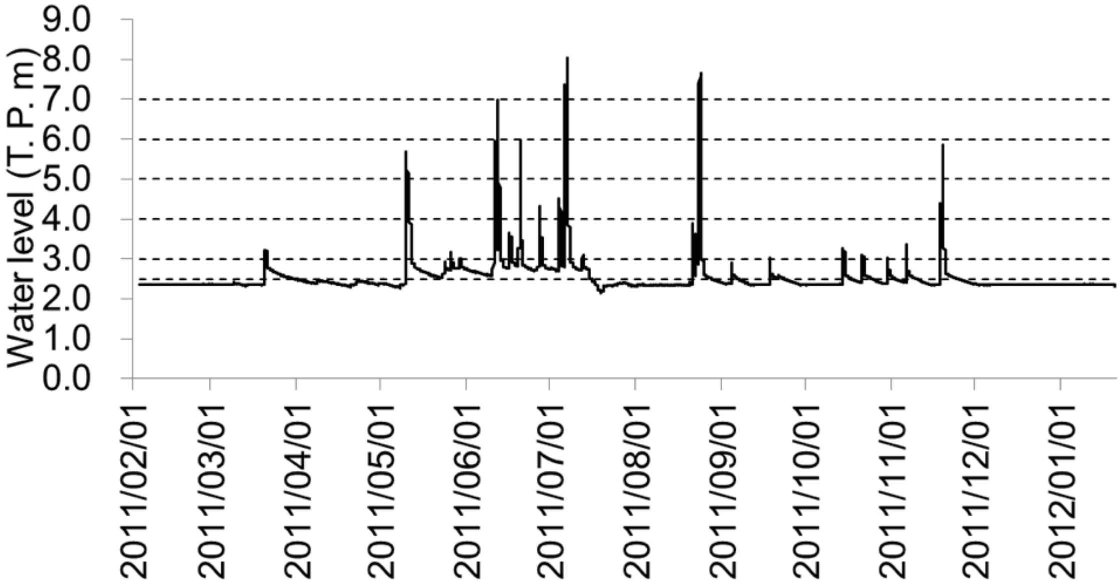


Image 4. Changes in water level at Azamenose (February 2011 to January 2012)

significant characteristic of Azamenose is that varied wetlands are formed and maintained by the gradient of such an environment and the terrain that it creates.

(3) Azamenose Nature Revitalization Project Goal Setting

On the Matsuura River, 92 % of the floodplain wetlands have disappeared (Shimatani 2003), and most rice paddies (which played an alternative role to wetlands) have ceased to provide such a function. As a result, the numbers of catfish and koi, which rely on these wetlands, have decreased along with opportunities for humans living along the river to encounter these fish. Adopting a centered approach to revitalize the floodplain has led to efforts to restore wildlife that rely on this habitat, thereby improving the river environment. The Azamenose nature revitalization project has been part of this initiative.

Two goals were set for the Azamenose nature revitalization project;

1) Revitalize the river floodplain wetlands
2) Revitalize interactions between people and other living things

The most significant characteristic of goal 1 is not that it set specific revitalization goals, but that it set as a target the revitalization of a habitat for common species that rely on a floodplain environment. For example, as seen with the Japanese crane on the Kushiro marsh and the stork on the Maruyama River, in nature revitalization projects, endangered species sometimes become indicators or symbols of progress. However, for the Azamenose, the goal was the revitalization of a habitat of all species, including koi, crucian carp, catfish, and loach, that used to be common.

In the Azamenose nature revitalization project, the planning review was conducted through local participation. In this process, many Review Committee participants shared their opinions; “We used to be able to catch creatures like loach, crucian carp, koi, catfish and river shrimp in the rice paddies and rivers, so we came into contact with animals every day,” and “Azamenose should be a place where people can encounter other living organisms.” Goal 2 was established based on this opinion.

(4) Accommodative Management and Local Knowledge

In this project, accommodative management is conducted to change ground elevation and terrain gradient, along with monitoring the results of habitat and breeding circumstances of the local flora and fauna as well as groundwater levels after work was completed. After the first phase of work, intermediate monitoring was conducted from 2004 to 2005, and this revealed the following issues.

1. The creek and Shitaike ground elevation were T.P. 3.5 m, and when in dry conditions and at the relatively high elevation of T.P. 3.2 m or more, exotic Canadian goldenrod grows in thickets.

2. Increasing aridization was noted on the roadside (near town) of Shitaike, and there are clusters of vegetation primarily including wasteland-like weeds, thus the ecotone from the body of water to dry land wherein submerged and emergent plants thrive is poor.

3. Clusters of single plants, such as the exotic humectant Paspalum distichum, dominate the water's edge at Shitaike.

4. Due to the establishment of willow trees brought by floods and the expanded distribution of water pepper, the creek has been covered in vegetation and open water is disappearing.

In response to these issues from 2005 to 2006, the following changes were made to the project plans (Image 5).

1. Decrease the ground elevation of the creek banks from T.P. 3.5 m to T.P. 3.0 m to make the area surrounding the creek into a wetland. (flooding frequency of 15–20 times/year)

2. To restrain the strong growth of terrestrial exotic vegetation and expand the wetland vegetation area, change the slope gradient of Shitaike and the east side of Uwaike from a steep slope of 50–70 % to 20 % to expand the frequently flooded surface area.

3. Plant willow trees to control the increase in wetland water temperatures and the strong growth of exotic herbaceous plants.

4. Build wooden fences on the creekbank to secure the water surface width and control bank collapse upstream.

Moreover, in the Azamenose design process, the Review Committee received the following proposals from local residents: “During floods, you should allow overflow from downstream,” and “Just in case, you should plant a bamboo grove on the upstream embankment.” Therefore, the present form was designed while referencing these comments.

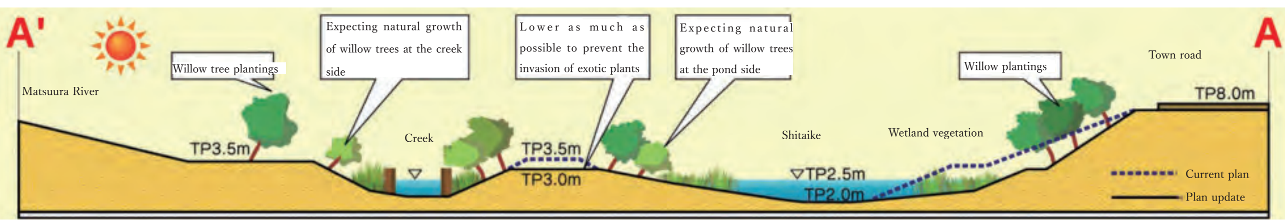


Image 5. Cross-section image at the initial and plan change stages (cited from the MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011)

*This paper was written by making significant adjustments to the existing paper by Hayashi et al. 2012b *A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose Wetland Studies*, pps. 2, 27-38.

Works cited

Shimatani, Yukihiro; Imamura, Masashi; Otsuka, Kenji; Nakayama, Masafumi; Tomari, Koichi (2003): *A Nature Revitalization Plan for Azamenose on the Matsuura River Advances in River Engineering* 14, 451-456

Yamamoto, Koichi (2004): *Structural Offshore River Studies*, Sankaido

MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011): *Azamenose Records (Azamenose Area Environmental Survey Report)*

Hayashi, H.; Shimatani, Y.; Shigematsu, K.; Nishihiro, J.; Ikematsu, S. and Kawaguchi, Y. (2012): *A Study of Seed Dispersal by Flood Flow in an Artificially Restored Floodplain Landscape and Ecological Engineering* 8, 2, 129-143

Hayashi, Hironori; Shimatani, Yukihiro; Ozaki, Ken; Ikematsu, Shinya; Tsujimoto, Yotaku; Miyajima, Yasushi; Agata, Masahiro; Masahiro; Suzuki, Taro; Soeda, Masashi; Kawahara, Teruhisa (2012b): *A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose. Wetland Studies* pps. 2, 27-38.

Watanabe, Norisuke; Hirakawa, Ryuichi (2007): *Flow Characteristics of the Matsuura River Azamenose and its Impact on the Main River, Annual Journal of Hydraulic Engineering* 51, 673-678

Yamaguchi, Hirofumi; Mukai, Emi; Nakayama, Yuichiro (2005): *Research on Nature Suitability at Azamenose in the Initial Stage of the Azamenose Nature Revitalization Project. Osaka Prefecture University Agrobiology Bulletin pps.* 57, 25-32

Nature Revitalization Plan. *Advances in River Engineering* 14, 451-456

Yoshitomi, Tomoyasu (2008): *Proposal for a Nature Interpretation Model in the Azamenose Nature Revitalization Project Area, Civil Engineering Journal pps.* 50(7), 40-45

Collaboration with local society

Kyushu University Hayashi Hironori

(1) Local Resident Participation and Forming Agreement

Planning consideration for the Azamenose nature revitalization project was primarily driven by the Azamenose Review Committee (Image 1). Local residents, persons from academia, and government officials participated in monthly meetings to discuss plan proposals, and maintenance and management systems. Image 1 presents the Committee's structure. Although nature revitalization projects typically proceed based on scientific studies conducted in academia, in the Azamenose Review Committee, persons from this sector served as advisors. The decision-making body comprised the local residents who participated in the Committee, which was inaugurated in November 2001, and held over 150 meetings as of 2020. Moreover, the Committee has the following seven rules for forming agreements, as well as an autonomous organization, which is called the Azame Association, is led by the local people to support Azamenose activities, and continues to function independently.

[1] Membership is not permanently fixed; participation is voluntary.

[2] Discussions are conducted on a monthly basis (Even matters wherein decisions have already been made shall be re-discussed based on the accumulation of knowledge and changes in circumstances).

[3] All participants shall discuss and determine how the Review Committee shall proceed.

[4] The Senior Citizens Association and the Women's Association shall actively participate to work toward taking in various local opinions and knowledge.

[5] Meetings shall be conducted in multiple venues; there shall be no fixed location.

[6] The basic attitude shall be “Let's do this!” and not “Do it!”

[7] Persons from academia shall serve as advisors; the main body shall consist only of the local residents.

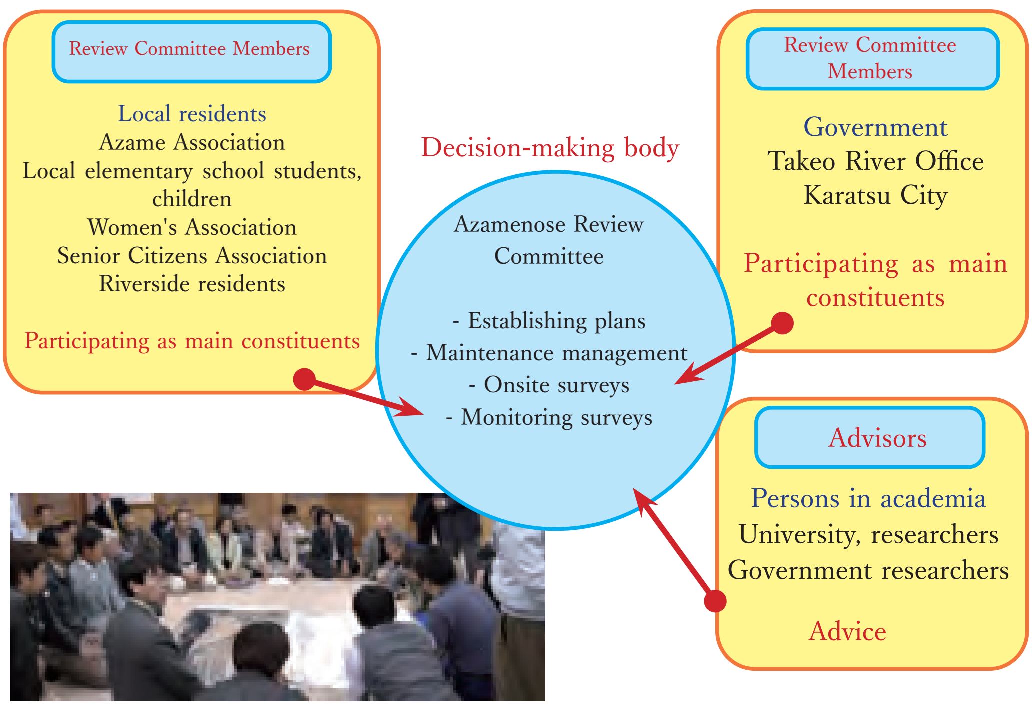


Image 1. Azamenose Review Committee structure (added to MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011))

(2) Local Resident-led maintenance and management efforts

As previously stated, at Azamenose, work was driven through the participation of local residents. Even after a project was completed, the local people led maintenance and management initiatives discussed in the Review Committee. This work primarily consisted of (1) vegetation management (such as cutting grass and cleaning), (2) an environment education event was conducted for elementary school students, and (3) local traditional events. Although river managers and persons from academia jointly participated in these activities through auxiliary roles, these were all led by the NPO Azame Association, which consists of local residents (Hayashi et al. 2010). In item 2, the environment classroom was conducted for elementary school students; these students learned about flora, fauna and the natural environment at Azamenose. This led to the fulfillment of one of the initial Azamenose planning goals—revitalizing interactions between people and nature. Moreover, this activity motivated locals to undertake vegetation management, such as cutting grass and cleaning (Hayashi et al. 2010). These maintenance and management activities put into practice the "wise use" clause which is stated in the Ramsar Convention. Since 2011 the project has received social collaboration project funding from Kyushu University; through which locals, the University, and the MLIT have collaborated to outsource fixed point photography and other work, install rainwater tanks, create Azamenose maps, and develop the lotus pond for viewing, among other initiatives. In particular, the lotus pond (Photo 2) completed in 2014 marks the fulfillment of a proposal by the Azamenose Women's Association (a review committee consisting of the local women, MLIT officers, female Karatsu City employees, and female students from Kyushu University) to improve the attractiveness of the area from the perspective of women. After completion, the lotus pond became a popular topic on social media and as well as a new attraction at Azamenose.

Furthermore, the Azamenose summer vacation environment classroom started in 2007 has been conducted continuously for 13 years until now (2019). With many participants coming from outside areas (primarily the Fukuoka metropolitan area) in recent years, activities at Azamenose are picking up speed.

*This paper was written by making significant adjustments to the existing paper by Hayashi et al. 2012b A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose Wetland Studies, pps. 2, 27-38.

Works cited

MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011): *Azamenose Records* (Azamenose Area Environmental Survey Report)

Hayashi, Hironori; Shimatani, Yukihiro; Tomari, Koichi (2010): *Observations on Nature Revitalization Project Maintenance and Management Structure. Advances in River Engineering* 16, 535-540

Hayashi, Hironori; Shimatani, Yukihiro; Ozaki, Ken; Ikematsu, Shinya; Tsujimoto, Yotaku; Miyajima, Yasushi; Masahiro; Suzuki, Taro; Soeda, Masashi; Kawahara, Teruhisa (2012b): *A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose Wetland Studies pps.* 2, 27-38.

Tomita, Ryoto (2010): *The Possibility of Temporary Agreement in Natural Environment Collaboration, with the Azamenose Nature Revitalization Project as an Example. Journal of Environmental Sociology* pps. 16, 79-92

Watanabe, Atsuko; Washitani, Izumi (2006): *Generational Differences as seen in Riparian Environment Biodiversity Awareness and Desire for Project Participation in the Region surrounding the Azamenose Nature Revitalization Project. Ecology and Civil Engineering* 9 (1), 31-45

Photo 1. The environment classroom

Photo 2. The Azamenose lotus pond

The Environment of Azamenose

Kyushu University Hayashi Hironori

(1) Changes in Flora

Based on the results of a monitoring study (MLIT 2011), Azamenose flora are divided into the following clusters; wetland plants (e.g., water caltrops (*Trapa japonica*), water pepper (*Persicaria hydropiper*), and mizosoba (*Polygonum thunbergii*)), quasi-wetland plants (e.g., fall panicum seeds (*Panicum dichotomiflorum Michx.*) and *Salix pierotii*), and wasteland plants (e.g., Canada goldenrod and Ambrosia trifida(*Solidago altissima*)). At points lower than the T.P. 3.0 m that one would expect in a wetland, the share of wetland plants increased and then stabilized. Functioning as a breeding ground for wetland vegetation, one of the initial planning goals, is thus considered to be mostly achieved.

(2) Changes in Fish Fauna

Seven years of monitoring have led to the confirmation of 11 families and 35 species of fish. Image 1 presents yearly trends in the number of species confirmed through this monitoring. In 2003, when only the creek was completed, monitoring only confirmed 12 species. From 2004, when Shitaike was completed, although there were some variations, 24–28 species were confirmed each year. A total of 19 species, including cyprinid fishes, catfish (*Silurus asotus*), loach (*Misgurnus anguillicaudatus*) and medaka (*Oryzias*) have been confirmed over time. In particular, cyprinid fishes, catfish, loach, and others were species mentioned in the planning revitalization goals because they require a floodplain wetland environment during spawning season. Based on these facts, Azamenose is considered to possess a certain advantage as a habitat for such species.

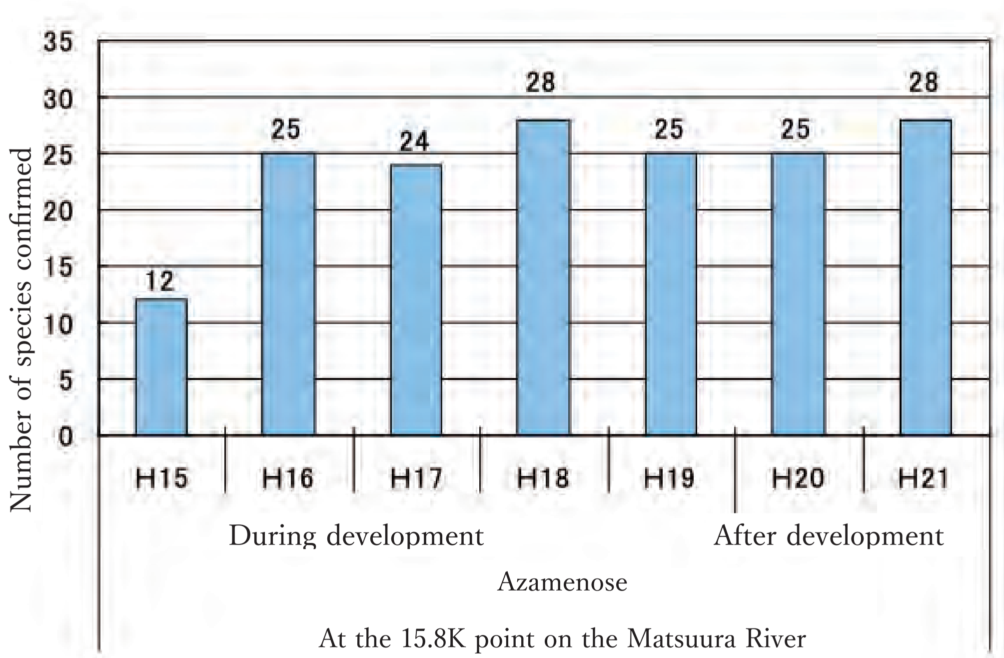


Image 1. Changes over time in the number of fish species confirmed at Azamenose (cited from MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011))

Photo 1. Confirmed eggs and larval fish

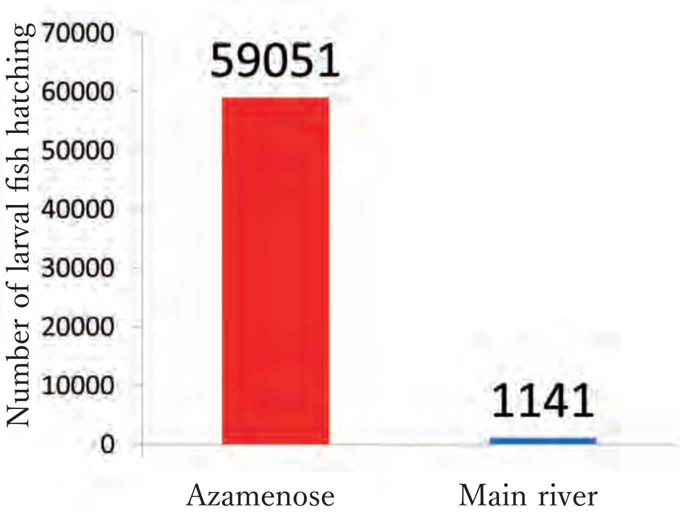


Image 2. Comparing cyprinid fish spawning potential at Azamenose and on the main Matsuura River

(3) Revitalization of Fish Spawning Habitat

Many cyprinid fishes, and catfish have been confirmed to spawn in Azamenose (Photo 1). These species primarily do so in water grass and emergent plants near the shore. In the initial project planning, these fish were identified as species that may spawn here. Moreover, as explained in the following section, numerous mussels have been confirmed in Azamenose.Among these mussels, spawning has been confirmed for Acheilognathus. In addition, a total of 22 species of larvae and juvenile fish, including the freshwater minnow, dark chub, Acheilognathus rhombeus, Tanakia lanceolata, Japanese dace, Sarcocheilichthys variegatus, Biwia zezera, and loach, have been confirmed. Given their existence, it is possible for Azamenose to function as a spawning ground for these fish as well. According to a study by Ozaki et al. (2010), the number of eggs spawned by cyprinid fishes at Azamenose is 50 times higher than those on the main stretch of the Matsuura River (Image 2). Therefore, we can assume that this wetland plays a key role as a spawning ground for fish on the Matsuura River.

(4) Bivalve Habitat Revitalization

In initial project planning, mussels were not assumed to be a revitalization goal. However, it became clear in 2007 that approximately 1,500 of them lived in Shitaike (Hayashi et al. 2009). The three species confirmed were Sinanodonta lauta, Unio douglasiae, and Lanceolaria grayana (Photo 2). Among the 1,500 such creatures, 98 % were Sinanodonta lauta (Hayashi et al. 2009). Azamenose is, therefore, considered a particularly favorable habitat for these mussels. However, due to the confirmation of a water caltrops invasion in 2008, and this vegetation entirely covering Shitaike in the following year, an oxygen deficiency was noted in this body of water. This caused the death of the majority of mussels in Shitaike. However, a 2014 survey confirmed that a large number (estimated 1,000) of mussels (mostly Sinanodonta lauta and Unio douglasiae) continued to inhabit Uwaike and Tonboike. The causes of this are considered lower levels of nutrient salt and organic matter supplied during flooding, compared to Shitaike because these areas are somewhat removed from the inlet (about 150 m) as well as the invasion of water caltrops seeds (Lie et al. (2014)).

It is also clear that Sinanodonta lauta is distributed only in limited locations on the main Matsuura River (Hayashi et al. 2011), thus Azamenose functions as an important habitat for thesemussels in the river system.

(5) Issues at Azamenose

Two Azamenose nature restoration project goals (1. restoration of the river floodplain wetlands, 2. revitalization of interactions between people and other living things) have mostly been achieved, thus the project can be deemed a success. However, significant issues related to Azamenose continue to persist. One future issue regarding vegetation is developing countermeasures against exotic flora represented by the Canada goldenrod and Ambrosia trifida, which grow prolifically in areas with low flooding frequency. In particular, the cover provided by tall trees, such as willows, has led to methods of controlling and removing exotic fauna into view, and in the future, we will need to respond to these issues. Furthermore, in wetlands, where elevation is relatively low, the strong growth of willow trees is remarkable. This plays a key role in maintaining

Photo 2-1. Mussels of the order Unionoida confirmed at Azamenose (Sinanodonta lauta)

Photo 2-2. Mussels of the order Unionoida confirmed at Azamenose (Unio douglasiae)

Photo 2-3. Mussels of the order Unionoida confirmed at Azamenose (Lanceolaria grayana)

Photo 3. Comparison before and after felling willow trees (left: before, right: after)

the wetland environment and in providing a habitat for fauna. Moreover, there were concerns regarding trapping garbage and sediment. As a result, after discussion by the Review Committee, it was decided to periodically thin the willows on a large scale (Photo 3). Although both functions of providing a reasonable scenic view and a habitat for fauna are being maintained, it has been determined that the continued observation of transitions in flora and to conduct discussions is appropriate.

Maintenance and management activities at Azamenose are led by the NPO Azame Association. Although there is currently a strong structure for this, the participating members have become fixed, and the people involved are aging. Developing their successors is, therefore, an urgent issue. Currently, an active intergenerational exchange is conducted between the senior citizens and elementary school students through environment classrooms and other activities, but the parents of the children rarely participate in any such initiatives. The primary reason for this is thought to be due to a busy, middle-aged lifestyle with little free time. For these activities pertaining to developing successors, each generation is continuously involved in order to create maintenance and management systems. Establishing a mechanism that enables this to develop successors is the most important issue for the future. Moreover, because some items used to maintain and manage the terraced rice fields for environmental study require payments for expenses, such as fuel for tractors and insect repellent, some fundraising is also required. Although funding from the national government and local authorities currently covers these expenses, this funding is not guaranteed to continue. Acquiring the minimum amount of funds required for maintenance and management is a significant issue.

*This paper was written by making significant adjustments to the existing paper by Hayashi et al. 2012b A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose Wetland Studies, pps. 2, 27-38.

Works cited

Hayashi, Hironori; Tsujimoto, Yotaku; Shimatani, Yukihiro, Kawaguchi, Yoichi (2009): *A Case Study on the Anodonta Genus Ecology and Invasive Systems in Revitalized Wetlands. Annual Journal of Hydraulic Engineering* 53, 1141-1146

Hayashi, Hironori; Shimatani, Yukihiro; Ozaki, Ken; Ikematsu, Shinya; Tsujimoto, Yotaku (2011): *Research on Flow Characteristics of Order Unionoida Mussels. Annual Journal of Hydraulic Engineering* 55, 1393-1398

Hayashi, Hironori; Imaguma, Yusuke; Shimatani, Yukihiro (2012a): *An Investigation of the Physical Control Factors of Canada Goldenrod Clusters in Floodplain Wetlands. Advances in River Engineering* 18-29, 34

Hayashi, Hironori; Shimatani, Yukihiro; Ozaki, Ken; Ikematsu, Shinya; Tsujimoto, Yotaku; Miyajima, Yasushi; Agata, Masahiro; Masahiro; Suzuki, Taro; Soeda, Masashi; Kawahara, Teruhisa (2012b): *A Comprehensive Report and Operational Evaluation of the Revitalized Floodplain Azamenose. Wetland Studies* pps. 2, 27-38.

Kadoya, T.; Suda, S.I.; Nishihiro, J. and Washitani, I. (2007): *Procedure for Predicting the Trajectory of Species Recovery based on the Nested Species Pool Information: Dragonflies in a Wetland Restoration Site as a Case Study. Restoration Ecology* 16, 397-406

MLIT Kyushu Regional Improvement Bureau, Takeo River Office (2011): *Azamenose Records* (Azamenose Area Environmental Survey Report)

Ozaki, Ken; Hayashi, Hironori; Nakajima, Jun; Ikematsu, Shinya; Shimatani, Yukihiro (2010): *Research on the Functioning of Revitalized Wetlands as Fish Spawning Sites. Ecology and Civil Engineering Society, Collection of Speeches from the 14th Presentation Symposium* 39-42

Liu, Jia; Hayashi, Hironori; Inaguma, Yusuke; Ikematsu, Shinya; Shimatani, Yukihiro; Minagawa, Tomoko (in press): *Factors of Water Quality and Feeding Environment for a Freshwater Mussel's (Anodonta lauta) Survival in a Restored. Wetland Society of Wetland Scientists*

Nakamura, Futoshi (2003): *Thinking, Studies and Plans concerning River and Wetland Nature Restoration, with the Restoration of the Wetlands, Floodplains and Meandering Waterways of the Kushiro Marshes as Examples. Ecology and Civil Engineering* 5(2), 217-232

Shimatani, Yukihiro; Inamura, Masashi; Otsuka, Kenji; Nakayama, Masafumi; Tomari, Koichi (2003): *The Azamenose Nature Restoration Plan Advances in River Engineering* 14, 451-456

Yoshitomi, Tomoyasu (2008): Proposal for a Nature Interpretation Model in the Azamenose Nature Revitalization Project Area. Civil Engineering Journal pps. 50(7), 40-45

The Flood Control Function of Azamenose

Kyushu University Kitamura Keita

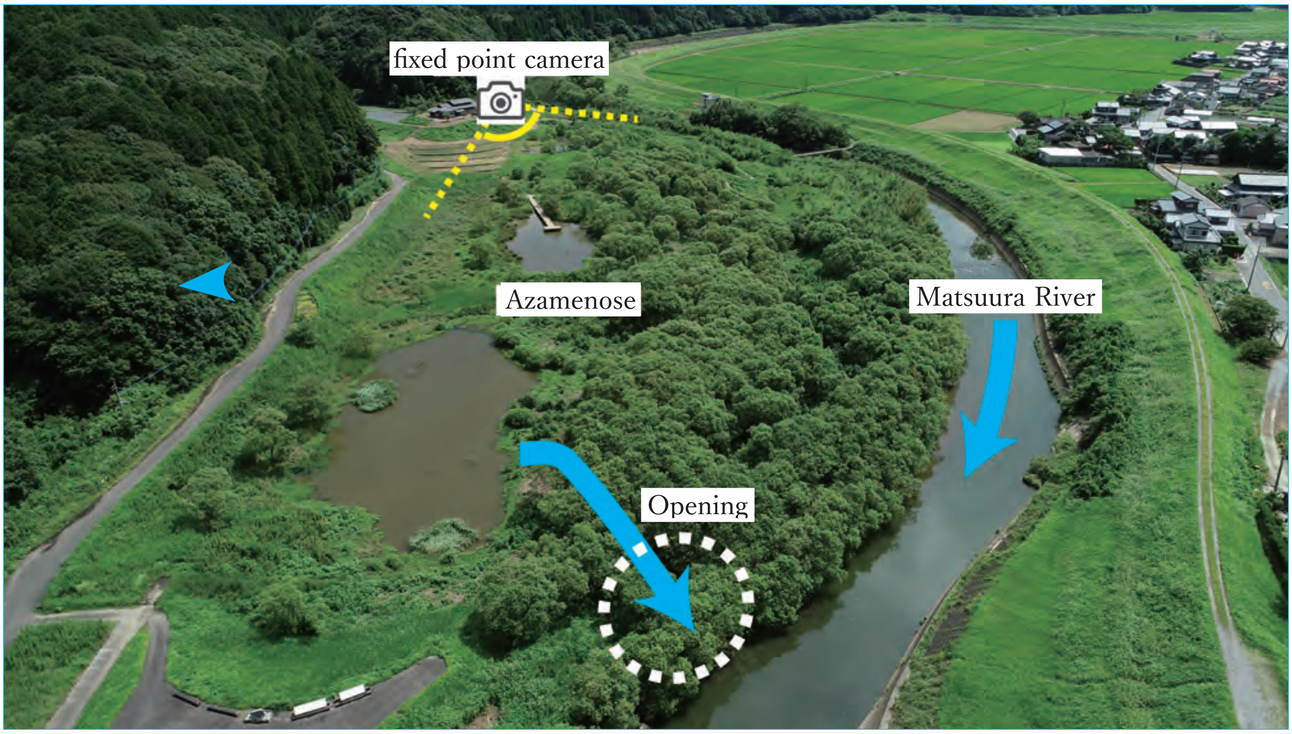


Photo 1. Azamenose

(1) Azamenose

Although Azamenose is a complete nature revitalization floodplain wetland project, it has the same structure as the floodplain open levees explained in the previous chapter. In other words, it has a creek drainage opening, situated downstream. Different from these open levees, however, the embankment upstream from the opening is five meters lower than the embankment on the opposite bank. I verified the type of flooding that occurs at Azamenose, which has such a structure, as well as the flood control effects using an onsite study of the flooding in the August 2019 torrential rains and a recreation simulation, similar to the Okawano floodplain open levee.

(2) Onsite Conditions During Flooding

I captured pictures of flooding conditions at regular intervals by using a fixed-point camera from the positions shown in Photo 1 during the August 2019 heavy rains (Photos 2–5). On the Matsuura River, the flow is from the left of the photo to the far right. The arrows in Photos 2–5 show the direction of the floodwater flow.

At 10:00 on August 27 (Photo 2), for the first time, flooding into Azamenose was caused by increased water levels in the downstream pond. Similar to the floodplain open levee type of flooding, the backwater phenomenon occurs from the opening due to increased water levels on the main stretch of the river. This supplies floodwaters to Shitaike and Uwaike. During that time, the floodwater current at Azamenose was extremely gentle.

Photo 2. Azamenose(10:00 on August 27, 2019)

Photo 4. Azamenose(9:00 on August 28, 2019)

Photo 3. Azamenose(18:20 on August 27, 2019)

Photo 5. Azamenose(13:40 on August 28, 2019)

Photo 6. Azamenose during a flood (11:30 on August 29, 2019)

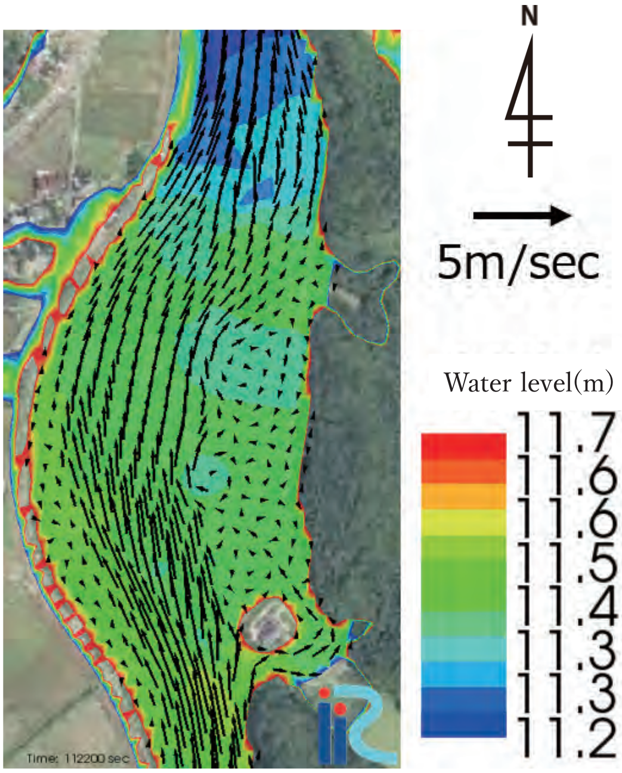


Image 1. Azamenose flowrate vector and water level contour images (at flowrate peak)

After 18:20 (around sunset; Photo 3), flow from upstream to downstream on the main part of the river was confirmed, even in the wetland.

After dawn, water levels were trending upward, and around 9:00 on August 28 (Photo 4) they approached their peak. Judging from the photo, I estimated the difference between the embankment crown on the left bank of the main river and the water level to be 1–2 m.

After the peak at around 9:00, although water levels trended downward, flood waste continued to flow. However, around 13:00 on the same day in Azamenose, the flow from upstream to downstream (from the left to the right in the photo) on the main stretch gradually weakened and completely stopped around 13:40 (Photo 5) leading to flood waste piling up. Inflow and outflow of this waste ceased, and the water levels gradually subsided.

Looking at the above time lapse images, between 18:20 on August 27 and 13:40 on August 28, the floodwater levels were higher than the Azamenose embankments, thus indicating that the flood flowed in from upstream.

The state of Azamenose after the flood is shown in Photo 6. Going downstream from upstream, groves of mixed trees, including bamboo and willows, fell in the direction of the flow (the trees being upset in this manner is called a "disturbance"). This indicates the magnitude of the disturbance from the flooding from upstream.

(3) Flood Recreation Simulation

I conducted a flood recreation simulation of the August 2019 torrential rains under the same conditions as the Okawano floodplain open levee mentioned above (Image 1).

For the Azamenose calculation results, the image shows a vector image expressing the magnitude and direction at the time of the highest floodwater flow (peak), and a contour image showing the floodwater levels in color. During this time, water levels are higher than the Azamenose embankments, meaning floodwater will flow downstream here. This led to the main riverbed expanding. As a riverbed expands, the flowrate subsequently decreases. At Azamenose, due to the water level on the main Matsuura River being higher than the embankments and the main stretch of riverbed widening, we can determine there is an overall decrease in the flowrate.

Image 2 changes over time in the cross-section flow rate 150 m downstream from Azamenose. The solid orange line indicates the current allowance of overflow from the embankments, and the green solid line indicates control of flooding from the embankments. Comparing these two lines, when overflow from these embankments was controlled, the peak flow rate significantly increased.

At Azamenose, when the main river water level is higher than the embankments, the main flow moves downstream, as if the riverbed had expanded. As a result, the riverbed flowrate decreases. This causes pooling here, which results in a significant flow rate peak cut effect.

Based on this, when a disturbance occurs in the floodplain due to the Azamenose embankments being low, we can observe that a significant flowrate adjustment effect occurs. Even in disaster reduction systems using the same floodplain, for rice paddies (which are the main land use in floodplain open levee areas), these disturbances are a major disadvantage. The primary purpose of rice paddies is for harvesting rice; therefore, such events may cause the rice plants to collapse or wither and die. In comparison, for Azamenose (i.e., floodplain wetlands), disturbances are actually a benefit because they maintain wetland ecosystems. A significant number of Acheilognathus rhombeus (*Acheilognathus genus*) were confirmed in this area after this flood. Azamenose also acts as a refuge for fish during floods.

Photo 7. Acheilognathus rhombeus confirmed after the flood

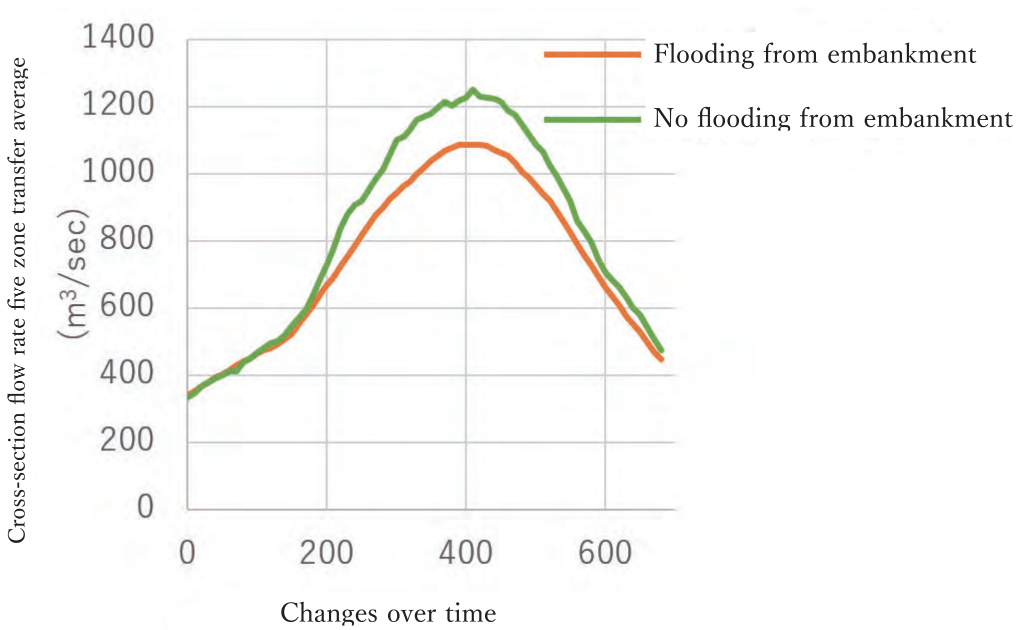


Image 2. Changes over time in the cross-section flow rate 150 m downstream from Azamenose (five zone transfer average)

【Traditional and Local Knowledge of the Matsuura River】

Photo: Shimauchi Risa

Traditional and Local Knowledge of the Matsuura River

Kyushu University Shimatani Yukihiro

This booklet was written with a focus on the Matsuura River as part of Eco-DDR (Ecosystem-based disaster risk reduction) research represented by Takehito Yoshida of the Graduate Program on Environmental Sciences. Although readers may not be familiar with Eco-DDR, it is a disaster risk reduction and prevention method that has gained global attention in recent years and uses ecosystems to respond to frequent natural disasters caused by global warming.

The concept of disaster risk reduction and prevention using ecosystems comprises both the philosophy that preserving ecosystems by reducing disasters through conserving natural environments (including broad wetlands, tidal flats, and forests) results in disaster prevention as well as the philosophy of humans actively using the power of ecosystems (such as coastal forests and flood damage prevention forests). In many cases, these philosophies are combined. There are also hybrid Eco-DDR combining ecosystems and man-made structures that have gained attention in recent years.

The Matsuura River, which is the primary focus of this booklet, is a treasure trove for these structures. The Matsuura River has various traditional structures that continue to be used, including Niji-no-matsubara, open levees, cross-levees, and *funagata yashiki*. In the Azamenose wetland revitalization project conducted by the MLIT, the primary objective was nature revitalization, but there is also a significant floodwater retention function. Such projects that adeptly use the power of nature can be called Eco-DDR or hybrid Eco-DDR that represent Japan based on traditional technology reaping the blessings of nature and surpassing disaster.

This booklet also presents a general history of the Matsuura River. The river has a gentle slope where boats can easily travel upstream. Karatsu City, which is located at the mouth of the river, has been on an important trading route since ancient times. The river basin is composed of a low ridge and crossing, transited by several small- and medium-length rivers that connect easily to the Ariake Sea, and the Omura and Imari Bays. In these areas, the upstream region is a source of obsidian, and the Matsuura River was an ancient artery connecting Japan to the Asian continent. In this booklet, we observed that there are 191 ruins situated along the Matsuura River. Among these, 172 sites were from the medieval period or earlier, thus this region was developed beginning in the prehistorical and Jomon periods.Rice farming was first introduced in Japan in the downstream reaches of the Matsuura River.

From the end of the medieval period, the ceramics industry started by Korean potters prospered there. In the Edo Period, the region was a source of coal, thus the Matsuura River was active as a transportation route.

Starting in the early modern period, flood control and irrigation projects became commonplace, with works including the Karatsu domain, the Niji-no-matsubara improvement, the joining of the Tokusue (Hatae River) and the Matsuura Rivers, the Daikoku Weir, and Umankashira under the Saga domain. Currently, many old stone Weirs can be found throughout the Matsuura River floodplain. Along with the domain's projects, local construction also accounted for various flood control and irrigation projects.

Several traditional Eco-DDR currently remain on the Matsuura River, with its extensive history, and thus serve as a museum. When dealing with climate change, the knowledge of our predecessors provides crucial suggestions. Please bring this book along when you visit the Matsuura River Eco-DDR.

Onsite survey scenery photos (December 16–17, 2019)

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Eco-DRR as Learned from Local History

Traditional and local knowledge of Eco-DRR in and around the Matsuura River

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