



Typologies for Sustainable Water Use in Historical Japanese Towns

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Introduction

Since people started to live together, how to go along with water has been one of the most important issues. People had to come to live at certain places where they could get fresh water, for example locations nearby a river, a lake or areas where enough rainwater falls. In the course of time, because populations have increased at many places, their inhabitants needed to start to manage the supply and drainage of water for a bigger area.

This study focuses on historical towns with special water systems since it is expected to suggest a new insight into sustainable water use because of several reasons. First of all, in former times, most of water systems were regulated with simple or low technology, often without complicated infrastructure or electricity. Thus, most of the cases required less energy. People utilized natural stream or spring water by inventing technique to obtain and transfer by gravity or by underground pressure. The second reason was that people were more aware of water systems, especially in terms of quality and quantity. It was an unstable resource depending on the season and the weather, and people often had to share water. Some water systems had structures which were





more directly influenced by discharged water, so people could not help being careful about the effects on water quality and quantity exerted by their own activities. That is why they had the knowledge of where water came and went. At last, before modern administrative service emerged, inhabitants had been responsible for their own water systems and they maintained the systems by themselves. To summarize, it can be assumed that historical water systems required less energy, and people had more knowledge of the quality and quantity of water and how to live with it. These points are relevant for sustainable water use in present times.

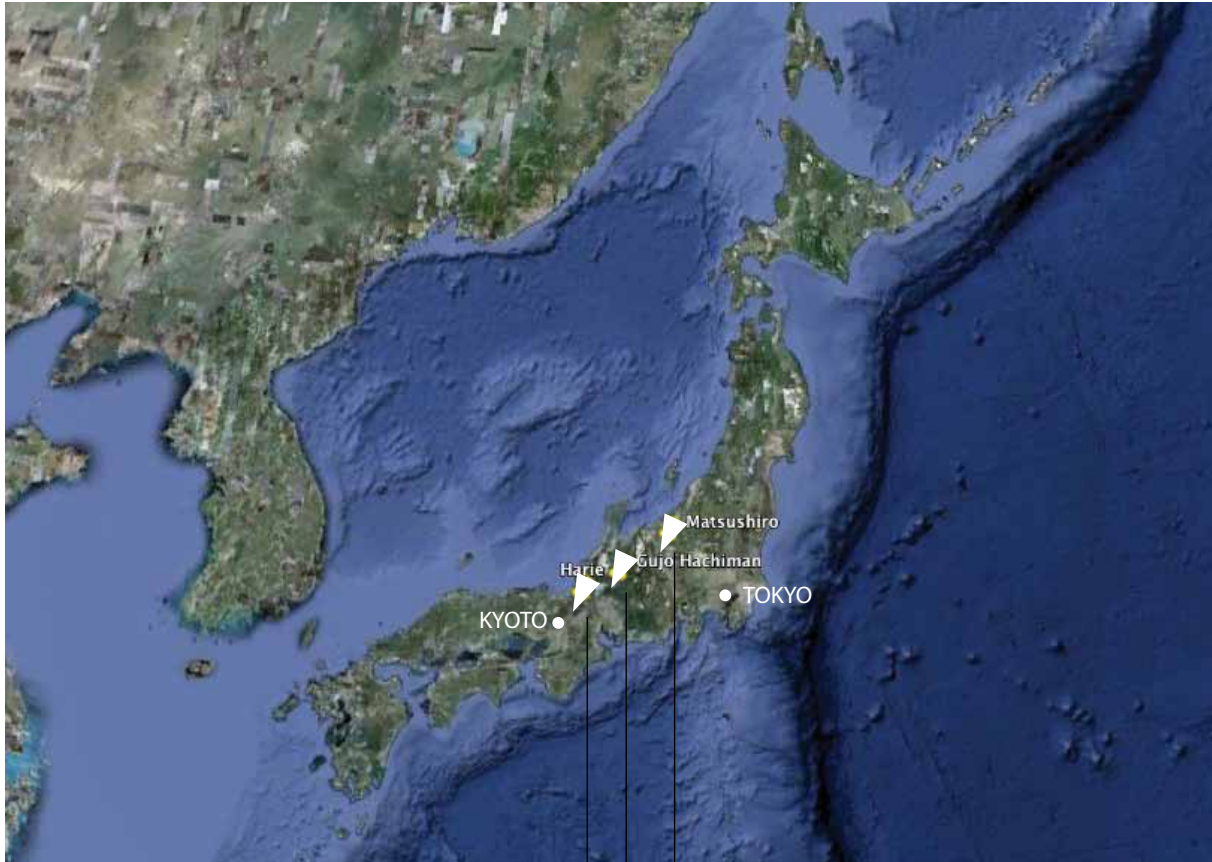
Nowadays, water issues are highly urgent on our social and political agenda. Urban designers and architects have an important role in contributing to the approach to climate change adaptation, especially in the field of water management. This is because water needs space to stream, to store and to drain. For this challenge, the variety and the knowledge of spaces associated with water in sustainable ways are more important than ever. By looking back in history, as has been argued above, we can find rich collections of typologies on these scales for sustainable water use. Then, the following question can be raised:

How can we derive new typologies for sustainable water use from the historical water systems for applications in the present living environment?

To answer this question, this study aims to propose a method to derive the typologies for sustainable water use from historical examples.

As the first step, Japanese historical towns with significant water systems are chosen as cases for the further studies in Asian countries. In the Netherlands, typologies for sustainable water use on district and architecture scales, such as 'wadi' and 'waterplein', are still limited, in spite of having a great tradition of water works on a civil engineering scale. Therefore, more alternatives should be proposed in order to diffuse sustainable water systems in a living environment. On the other hand, in some Asian countries with a large amount of precipitation due to the monsoon climate (more than about 1000 mm per year), water systems have more variety in form, quality and life style associated with water. In their history, people had to develop ways to regulate and utilize the large amount of rainwater and different types of water resources, such as wells, springs, and rivers. These conditions made the water systems in a living environment richer.





underground map: google earth

MATSUSHIRO, Nagano city, Nagano
inhabitants: 19,000 people
precipitation: 800mm / year

GUJO HACHIMAN, Gujo city, Gifu
inhabitants: 15,000 people
precipitation: 2,600mm / year

HARIE, Takashima city, Shiga
inhabitants: 600 people
precipitation: 1,800mm / year

These water systems consist of a unique spatial feature for supply and drainage, for instance a water basin with different water qualities or a parcelling with a spring for each plot. To support these systems, local rules are important: at what places people are allowed to drink or wash, and where they can drain water. In this study, water systems can be defined as a combination of the following three aspects: physical forms (structure of network, shape for space to stream, store and discharge, etc.), quality and quantity of water (quality for drinking and washing, quantity in different drainage infrastructure, etc.) and social customs (local rules for use, organization for maintenance, etc.). The working method is as follows. Three water systems from Japanese towns; Harie, Gujo Hachiman and Matsushiro, are chosen. For each system drawings are made on an architecture and urban scale to investigate water systems focusing on the three aspects mentioned above: physical form, quality and quantity, and use and maintenance. Furthermore, in order to study the relationship between these aspects, concrete drawings are transformed into abstract diagrams, which show the essence of the systems. In conclusion, the diagrams are once more elaborated to deliver typologies, which can contribute to design of sustainable water systems.

KABATA

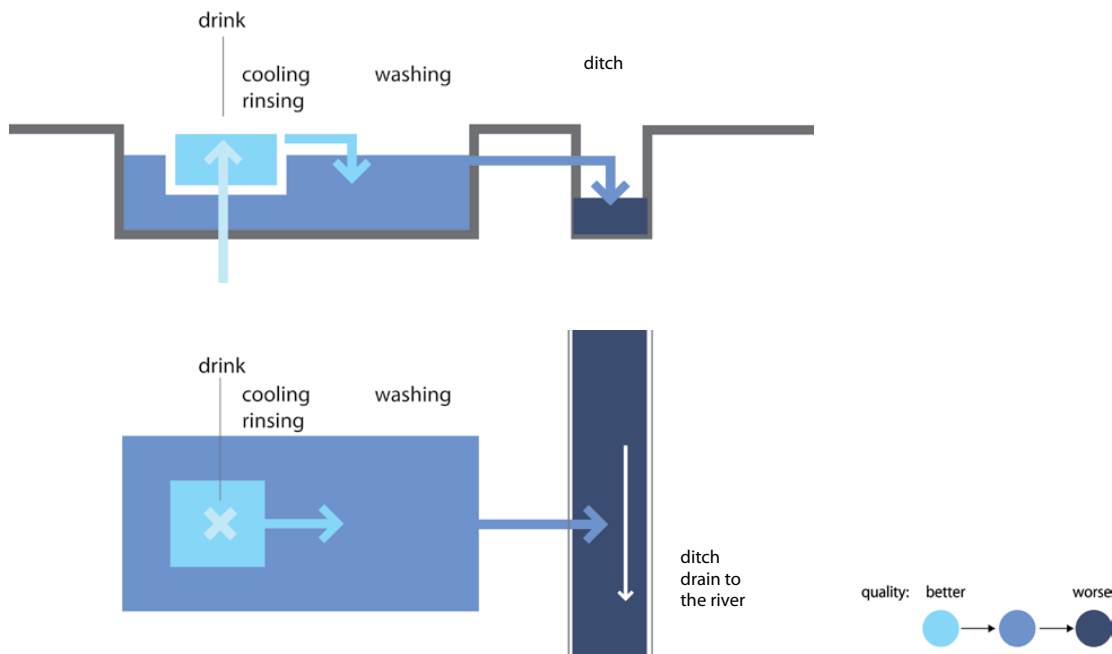
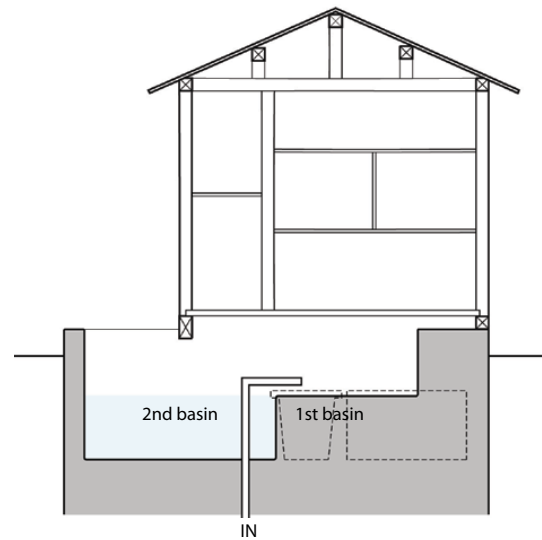
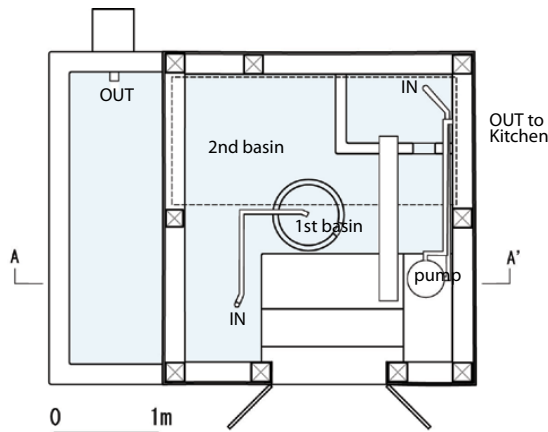
Harie, Takashima city, Shiga Prefecture

Kabata is a system with spring water, which has been used for at least more than a century in the area on the west side of Lake Biwa in the Shiga prefecture. Although many towns had similar systems in this region, the number of systems has been drastically decreased due to the supply of municipal drinkwater. However, only Harie town with about 600 inhabitants has more than 100 houses with Kabata. Harie is located at the edge of an alluvial fan, where confined groundwater comes close to the surface. By hammering a pipe into the ground with the length of 10 to 25 meters, the upwelling of groundwater takes place. Although the quantity of upwelling water can be affected by the amount of precipitation and by the season, Kabata has kept supplying water throughout history.

Architecture Scale

Kabata is a name of the unique system with a spring per housing plot, which is separated into several water basins for different purposes in a space inside a building. This building made of a wooden structure with a roof, in most cases two to four meters in length of a footprint. It can be a part of a main house or separated, each having a special name: Uchi(inside)-Kabata or Soto(outside)-Kabata. In this building, basins are constructed under the ground level in concrete together with its foundation. Spring underground water comes out from the bottom (or from a pipe sticking out above the water surface) into the first basin, and overflowed water goes into the second basin. The first basin is either round or rectangular with





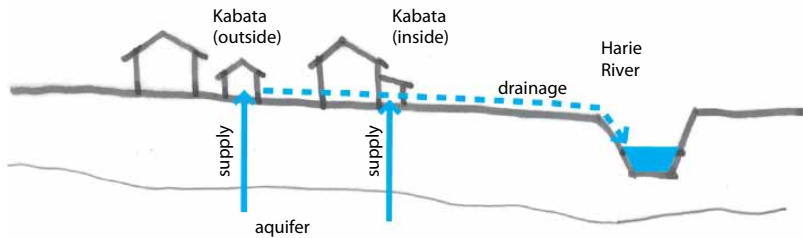
60 centimeters in diameter or length and positioned in the second basin, which often uses about half to two thirds of an area of the building.

People use the water from this system for several purposes. First of all, the water from the pipe is used as drinking water. In the past, people had to carry water to the main house by hand, but since 1950s most of the houses have been equipped with an electrical pump to send water to the kitchen or to other places. The first basin is used for cooling and rinsing. The temperature of ground water stays between 13 and 15 degrees Celsius throughout the whole year. Therefore, in summer, people store vegetables in the water, such as tomatoes, cucumbers and watermelons, as well as warm tea to cool down. The second basin is used to wash big pans or other slightly dirty utensils. In the second basin, most of the houses have carps or other fishes, which were meant to be eaten eventually in the past, but now they are called “cleaner” because they eat food particles on the pans, so that the left pans in the second basin are cleaned up by them. After cleaning in the second basin, people rinse pans or other utensils with the water from the first basin. Because of this separated-by-space use, water quality can be kept as the water from the pipe is cleaner than the one in the first basin, and the same happens for the first basin and the second one, thus cascade use is applied here. According to the users, they do not use certain synthetic detergents but no-detergent soap for fishes in the second basin and for the main river. The quality of spring water is so high that the water from the pipe passes the standard test for drinking water. Later on, particles from washing or streets go into the ditches and it affects water quality and it gets less good, but the water in the main river is also of very high quality, namely the first class of the Japanese standard norm for an open-water body.

Town Scale

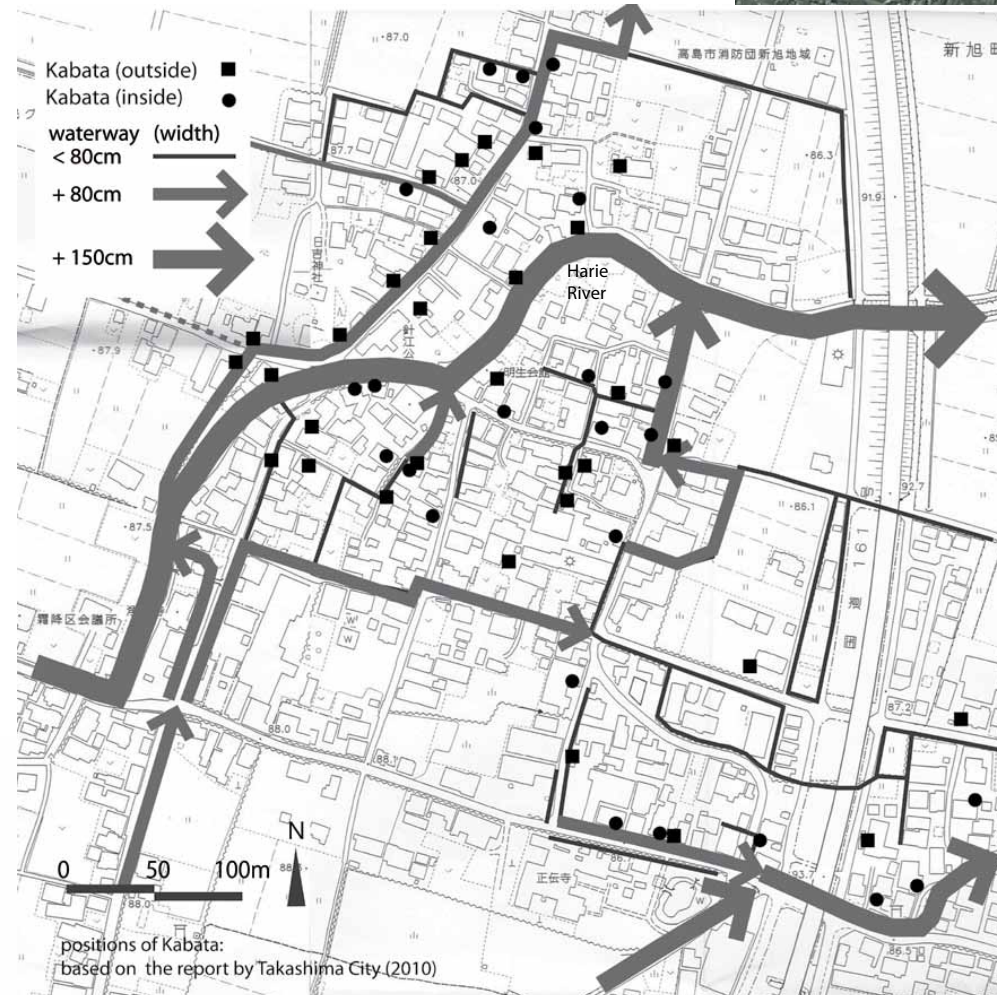
Kabata as a geographical position is widely and equally spread throughout the whole town and there seem to be no particular conditions. It has significant features in relationship with the distance to the river and other waterways and with the direction of slightly slope down from the west to the east. All Kabata has to have a connection to waterways for drainage because a spring in Kabata provides water constantly. In general, the water from Kabata flows first through narrow ditches and then through wider waterways, and it finally reaches one of the two rivers in the town. As an exception, some Kabata has direct drainage to the wider waterways or the river and as they are located very close to it. Because of this, the whole system has a tree structure due to which the quantity of water has increased in the course of time.

Supply and Drainage

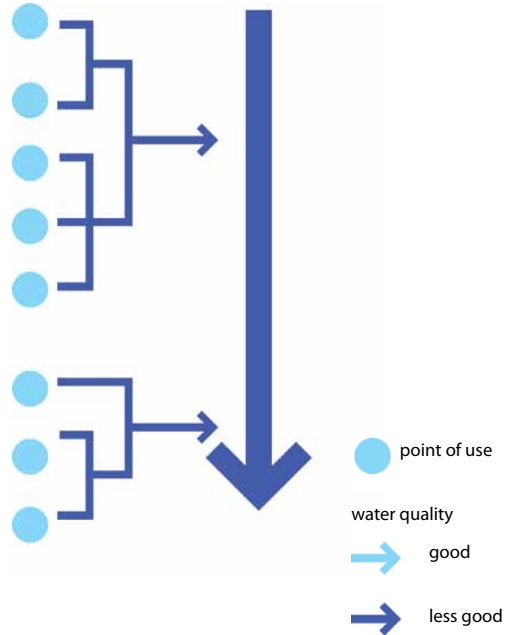


source: google earth

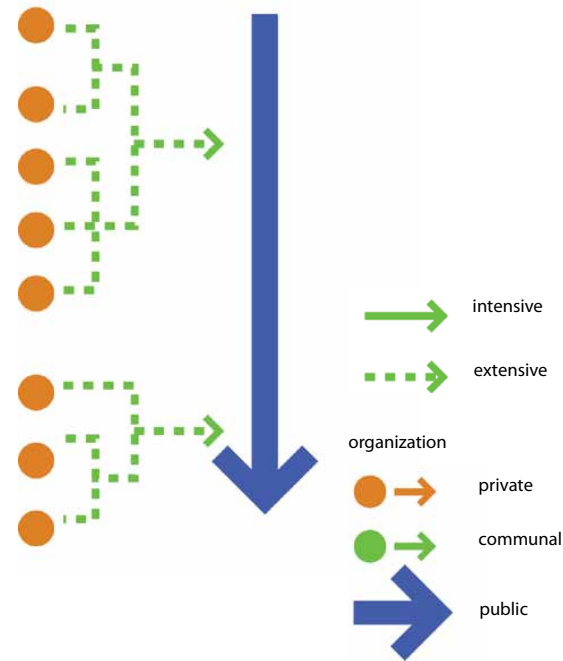
Quantity



Quality



Maintenance



Basically, Kabata is situated in a private plot and it is privately owned and used; thus, an owner and a user are the same and they maintain their own Kabata. Recently, owners have established a group to improve and to protect the environment in their town, and to work actively together. One of their collective actions is a water quality test of their own Kabata once a year. Another collective activity has a long tradition: collective cleaning. Although Kabata is privately regulated, some users of Kabata take care of the seasonal cleaning of the waterways close to their own houses collectively. The most central activity is that, four times per year, all the family gather in the main river Harie Okawa for so-called “river cleaning” to remove algae, which makes water drainage less smooth.



outlet from Kabata to a ditch for drainage



waterway



Harie Okawa in summer

variety of Kabata



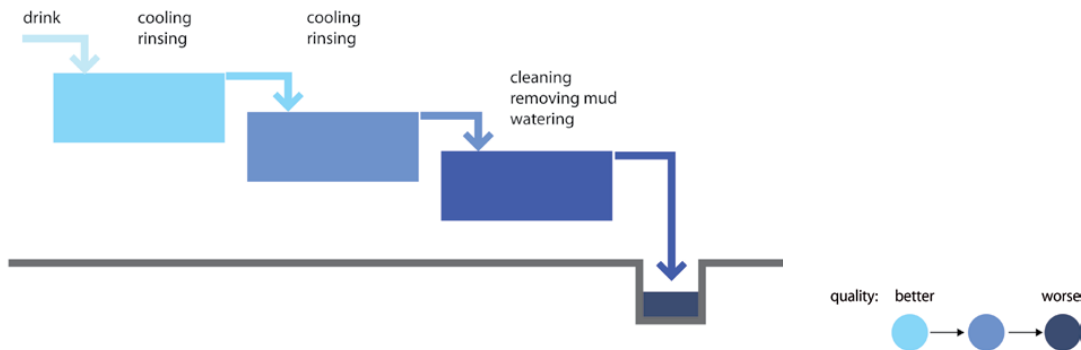
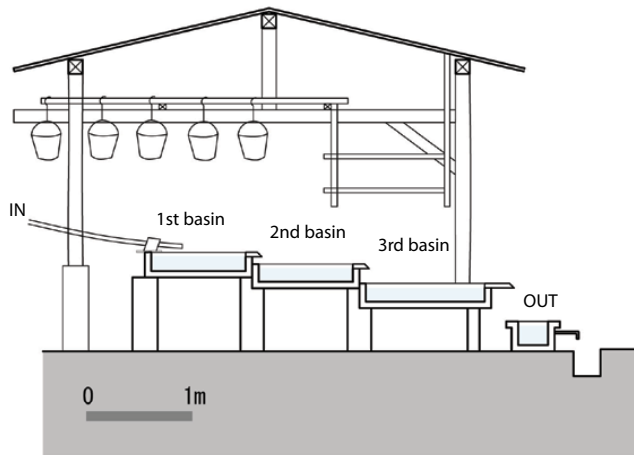
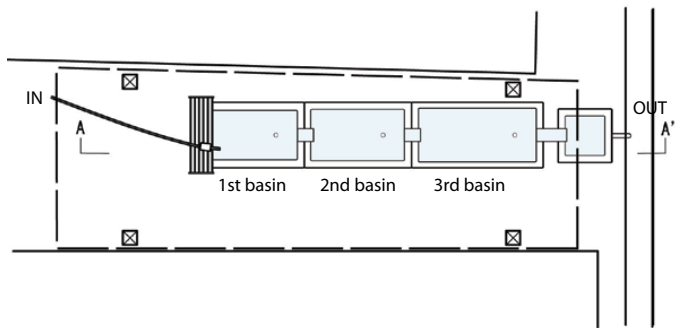


MIZUBUNE

Gujo Hachiman, Gujo city, Gifu Prefecture

Gujo Hachiman is located inland between the mountains in the Gifu prefecture in the middle of Japan. The town has developed within a small flat area along the rivers since the 17th century, and now the population of this area is 15,000. This town has a special water network in which different systems have been incorporated in a complicated manner. Mizubune is one of these systems, developed exclusively on a certain geographical condition. Although other systems, such as washing places along rivers and wells in public spaces, started to be abandoned relatively early due to the supply of a municipal water service, many Mizubune survived and now 14 systems have remained (this number is exclusive of a Mizubune newly made as a touristic attraction in the center of the town). Many cases are used collectively by a few to less than ten families. Mizubune is located along the steep foot of the mountains on the western side of the River Odara and on the northern side of the River Yoshida, because it uses the water gathered at the valley of the mountain. A pipe leads water from the upper part of the valley to the point of use close to the houses. It contains underflow water, running water and rainwater, but throughout history people have had no problems drinking it without boiling (at present, they boil it before drinking). It has been used for at least a hundred years in the face of evidence, and probably longer than that.





Architecture Scale

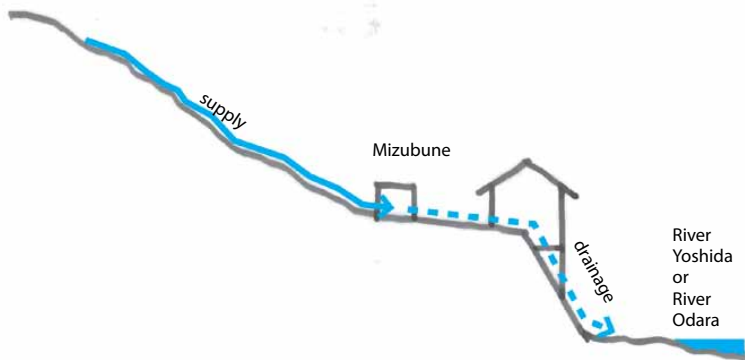
Mizubune means literally “water ships”, maybe because of open water basins and its longer shape. Most of Mizubune has three basins next to each other and of different height, so that water streams by gravity. The basins are lifted up by the legs to the height of a table, which makes them easy to use while standing. By positioning the three basins in one line, the whole thing has a longer rectangular shape, one meter wide and three to four meters long. It often has no wall but a roof to prevent rain from getting into it. It is often located between houses or beside a rather wide sidewalk. The water from the mountains is led to the first basin by a pipe, and it overflows to the second one and then to the third one.

As its form indicates, cascade use is applied to Mizubune. As has been mentioned before, in the past, people could drink water from a pipe without boiling. Nowadays, they find water quality lower and the municipal drinkwater network has been installed. So, most users do not drink it anymore, but some users still take water from the pipe to their house and drink it after boiling. In the past, there was a more clear difference in the use of each basin. Recently, however, the first and second basin are used for almost the same purposes, such as cooling vegetables and tea as well as rinsing vegetables. Cut flowers are often put let them drink water. The third basin is used for removing mud from the vegetables from your own garden, as well as for cleaning and for watering plants. By keeping this use per basin, water quality of the upper parts is better than of the lower ones, for example the water from the pipe is better than from the first basin, and the water from the first basin is better than the water from the second one. People do not bring things which need soap or cleanser here.

Town Scale

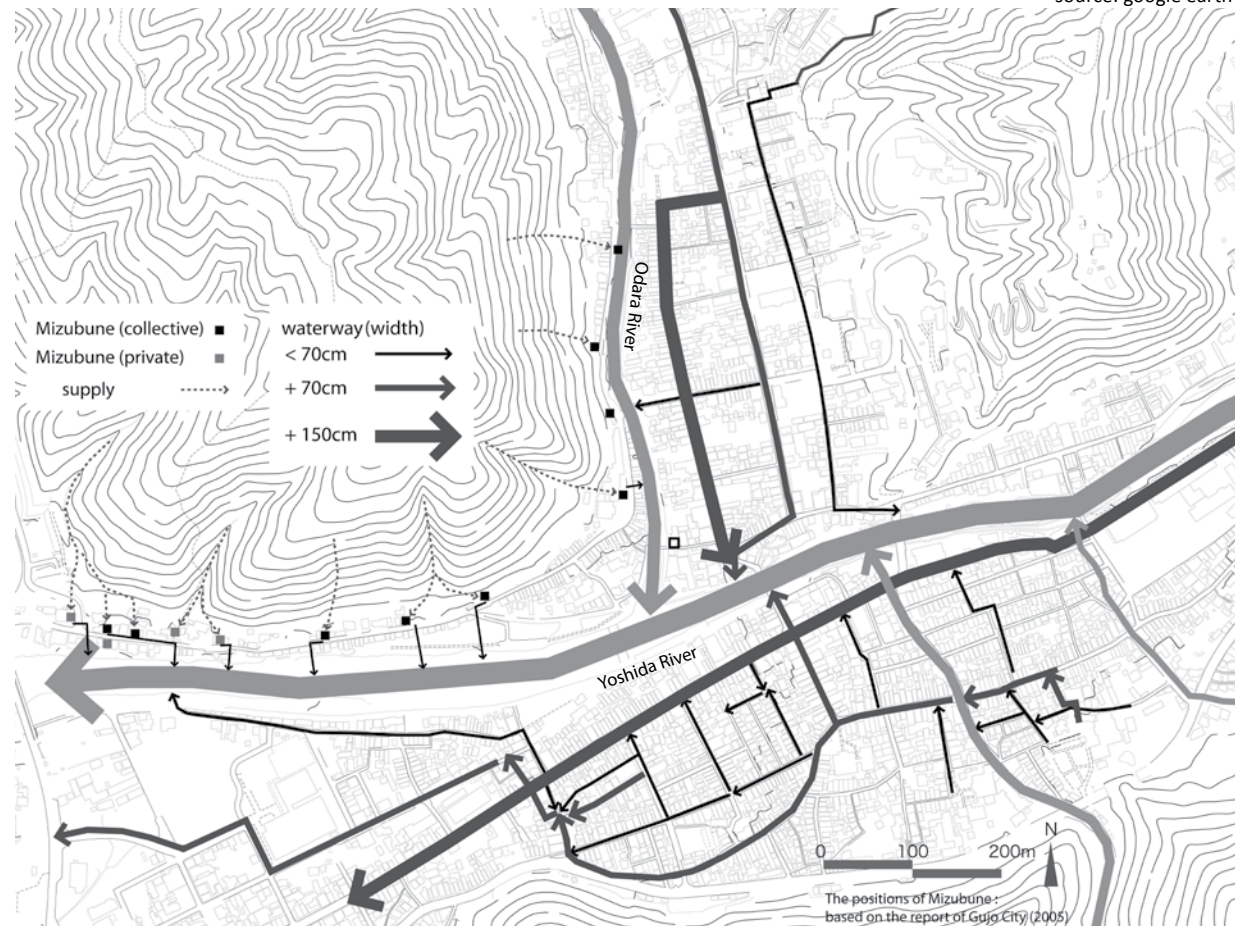
The distribution of Mizubune is strongly related to the geographical condition. They are located on a narrow band between the foot of a steep mountain and the major rivers. It is necessary to obtain water of good quality directly from the mountain. Water keeps running and its constant overflow from the third basin goes to a gutter along the street for a short time, and it is subsequently discharged to the River Yoshida or the River Odara. Sometimes, water from a few Mizubune is gathered into the same ditch and then it gets released. However, basically drained water goes down directly from Mizubune to the rivers. So, its form resembles a comb in which small streams lead to the big final stream of drainage.

Supply and Drainage

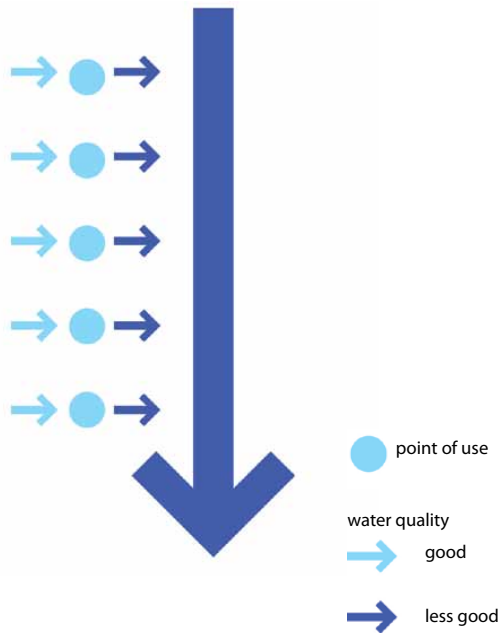


source: google earth

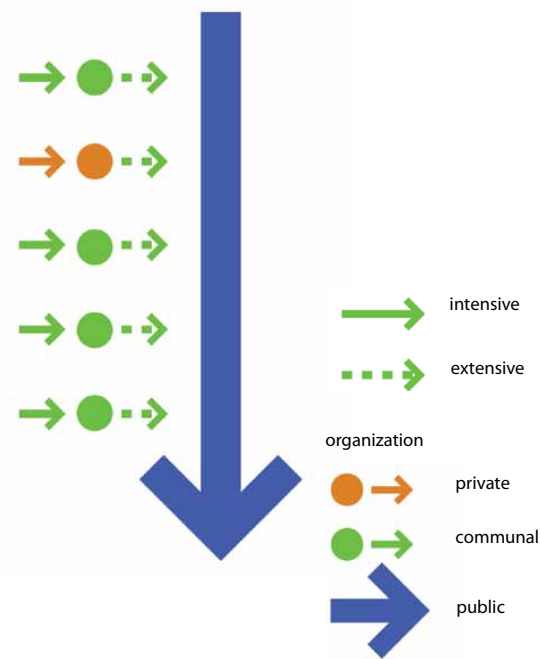
Quantity



Quality



Maintenance



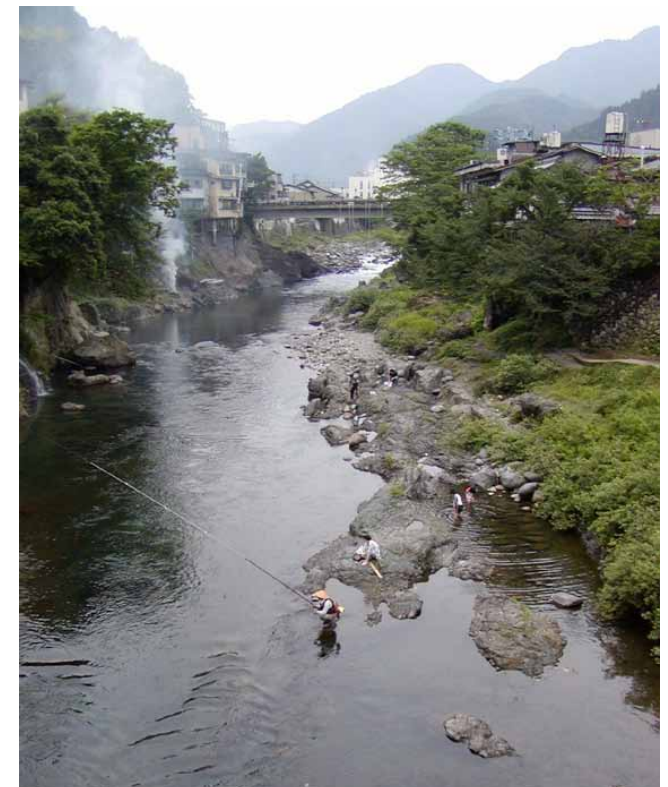
Although there is private Mizubune used by one family, Mizubune is often shared among a few to less than ten families. In some cases users form a group and members have to pay a certain amount of money per month to cover the costs of electricity and future maintenance. The cleaning of Mizubune takes place on an irregular basis, when a user sees the necessity. Normally, Mizubune user groups take care of an intake point of water in a valley in the mountains, and their representatives carry out maintenance together. Some groups clean the ditches collectively once per year.



Mizubune (private owned)



Collective cleaning



Yoshida River

variety of Mizubune

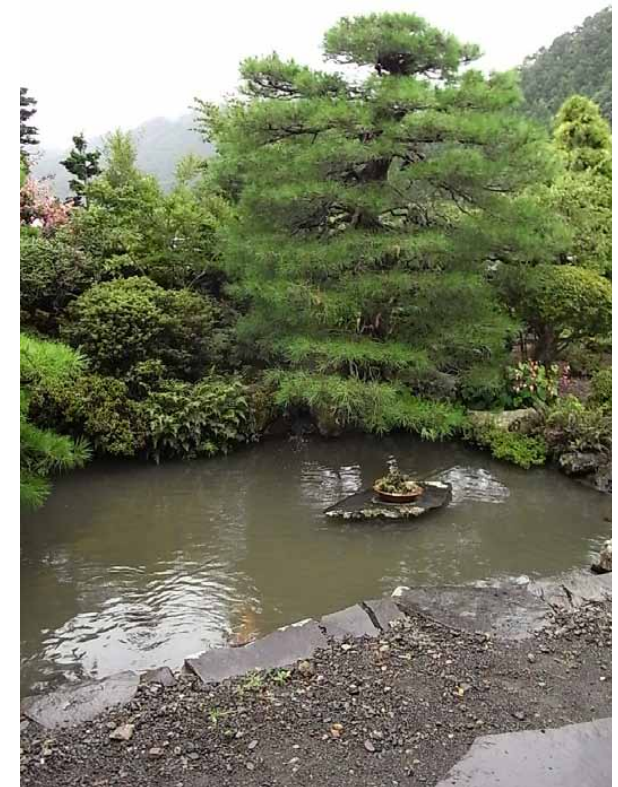


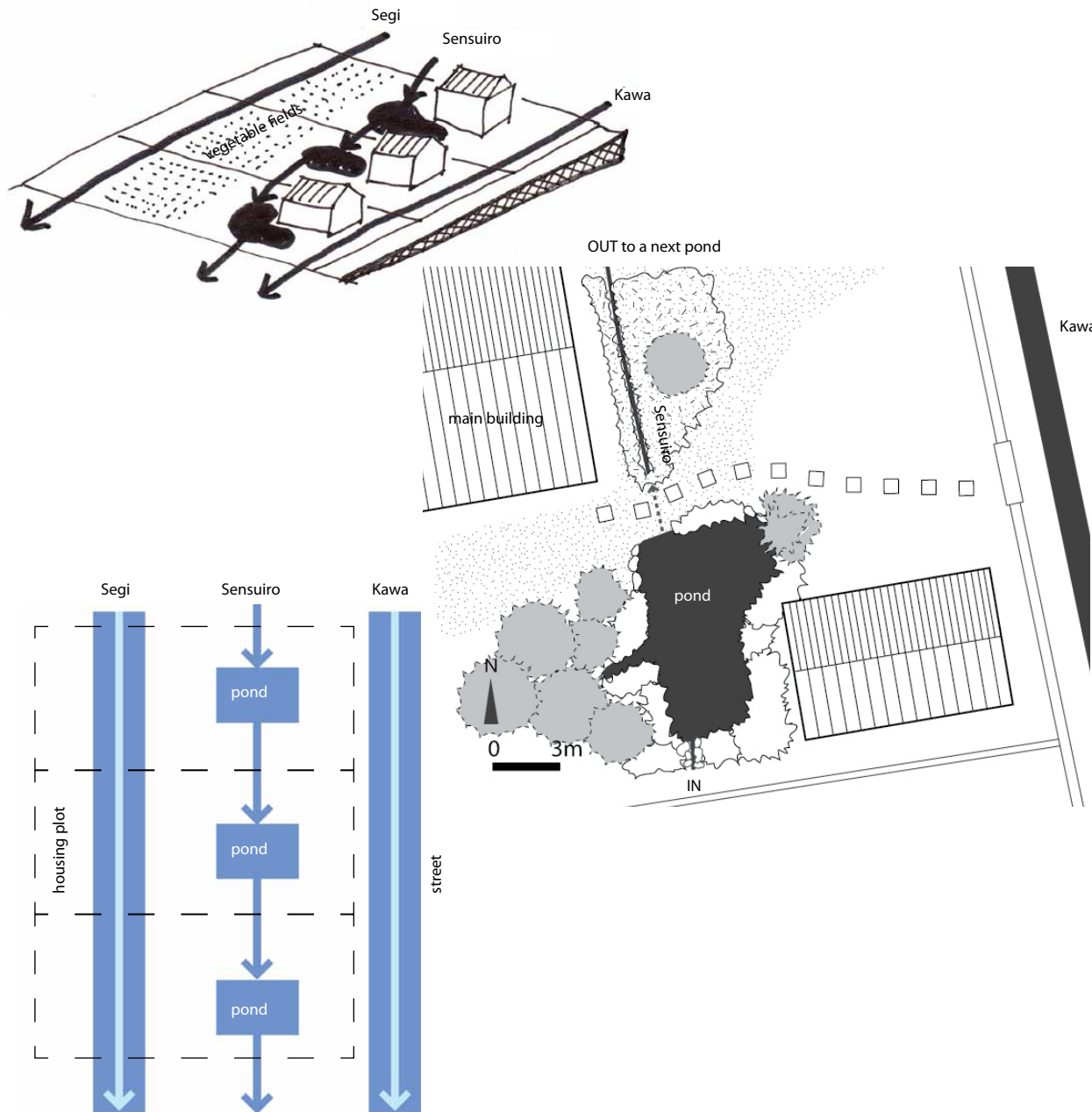


SENSUIRO

Matsushiro Town, Nagano City, Nagano pref.

Matsushiro is a small town with 19,000 inhabitants in the Nagano prefecture. It is located on an alluvial fan which is surrounded by mountains on three sides and by a river on one side. This town has a special system, the so-called Sensuiro, literally “pond water way”, named by the professor who made the first major survey in 1984. Nowadays, its inhabitants use this name as well. It is a very unique system exist since the latest 18th century in which three water ways stream parallel to one another in one plot. This can happen due to a special layout of the plot, that is streets on the short side of long rectangular plots are located perpendicularly to the contour lines. Kawa streams along the street in front of the housing plot, while Sensuiro and Segi flow through the plots. Sensuiro, which is the name of the whole system but also of one of the three streams which joins the ponds in the middle of the plots, while Segi streams on the back side of the house for the irrigation of your own vegetable patches. Water is taken from a river or supplied from a spring at the upper side of the alluvial fan and immediately separated into the three streams. This system has existed since the 18th century at the latest, and it has been transformed throughout history, but nowadays because of the trend for dividing plots, the system is to be less consistent. The area with three parallel streams as its principle is quite rare, and often ponds are not connected by Sensuiro anymore, but obtain water from a well in their own plots or from another source. However, the number of ponds, including the ponds without Sensuiro, is about 150 and maybe half of them are still connected by the stream.





Architecture Scale

Kawa and Segi are straight streams in their form. Kawa is mostly wider and deeper than Segi and Sensuiro and it has more quantity as a water stream. Sensuiro connects ponds. Because ponds are meant to be viewed from a house in a garden, the shape of a pond varies greatly from a sort of rectangular to an organic form, and their positions are decided in relationship to a house. Therefore, the course of Sensuiro is sometimes bent in order to flow around a house.

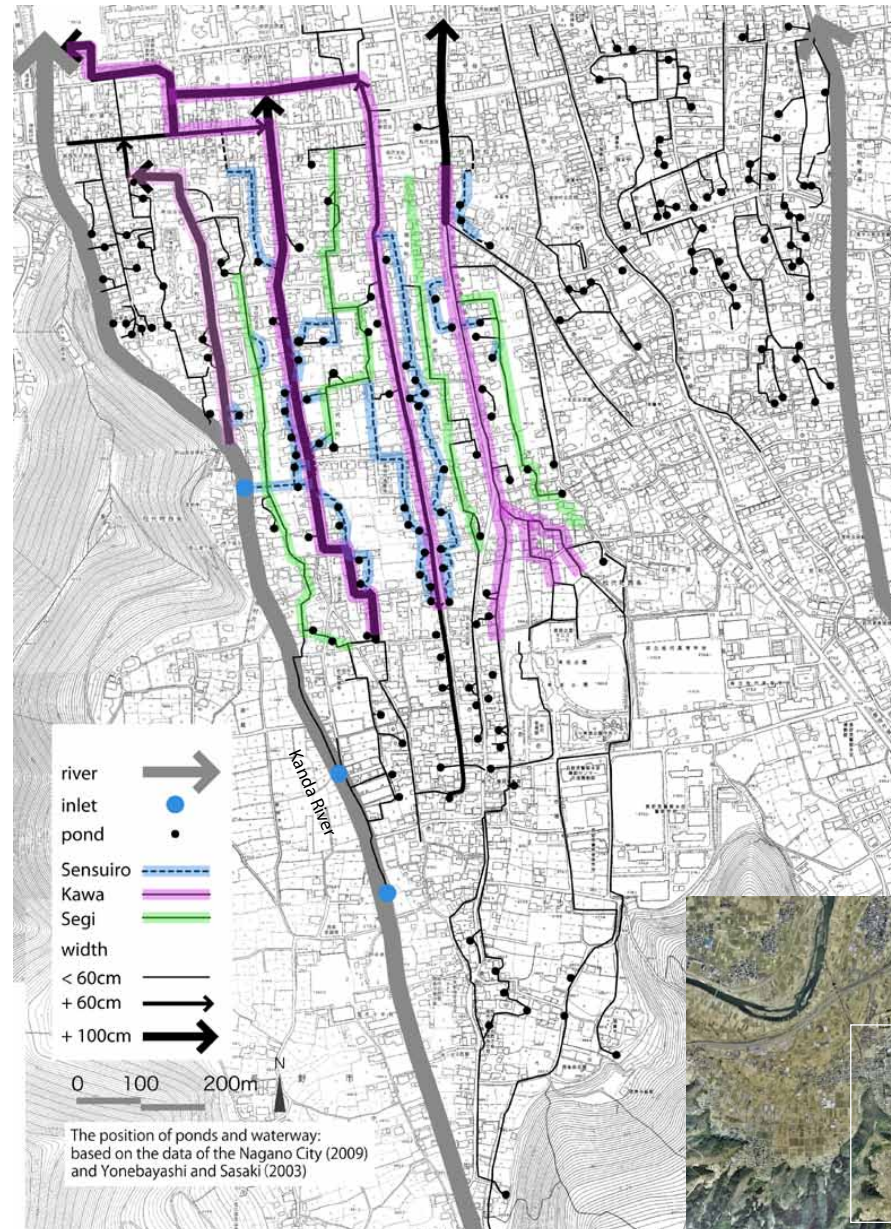
It seems that around the 18th century one of streams (either Kawa or Sensuiro) was used for drinking water. At the beginning of the 20th century, drinking water started to be supplied, so both Sensuiro and Kawa were used for a limited washing purpose (dirty washing was done separately and drain water was not discharged into Kawa or Sensuiro). Since the beginning of the construction of this system, Segi has served an irrigation purpose and now it is still used for the same purpose although the area of vegetable fields has become smaller. The water from Sensuiro is sometimes used for watering plants and for taking mud away from the tools, but its main purpose is being viewed as a scenery from a living room of the main house and often carps live there for esthetic reasons. Therefore, the water from the three streams does not show much difference in quality. Throughout history, Sensuiro has been used for washing faces and dishes, while Kawa has been used for washing clothes. It suggests that there was a period when each stream might have had different quality of water.

Town Scale

The issue of placing Sensuiro and the other two streams so that they run down by gravity is very strategic. In order to run down from the south to the north, the three parallel streams are set perpendicularly to the contour lines, so basically that they do not cross one another till the end. This layout is used only for the western part of the town, where only the upper side has spring water. The eastern part of the town has a more complicated pattern because a spring is upwelling in many ponds to supply water.

Sensuiro and Segi run through private plots, from one to another. Therefore, they are owned as private assets and maintenance activities take place individually. However, water runs through the plots, so users inform one another about water-related activities. For example, when one user starts to dredge up and water has to be detoured to Kawa for a while. For this activity, the user informs the neighbour on the down side that no water is supplied temporarily. Kawa runs along the streets and it is a public domain. However, each district observes the custom of doing collective cleaning once in a while (twice per month till twice per year). In addition, some users also maintain the inlet from the river collectively.

Supply and Drainage

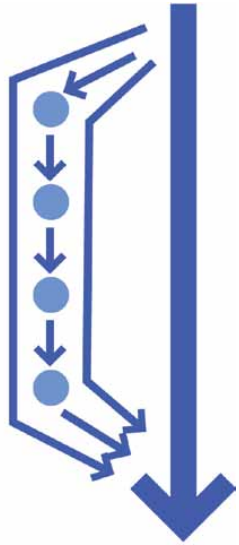


Quantity

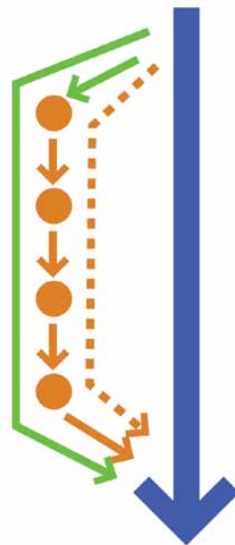
source: google earth








Quality



Maintenance



-  intensive
-  extensive
- organization
-  private
-  communal
-  public



Kawa

Segi

Self made dredge system by a user



variety of Sensuiro



Conclusion

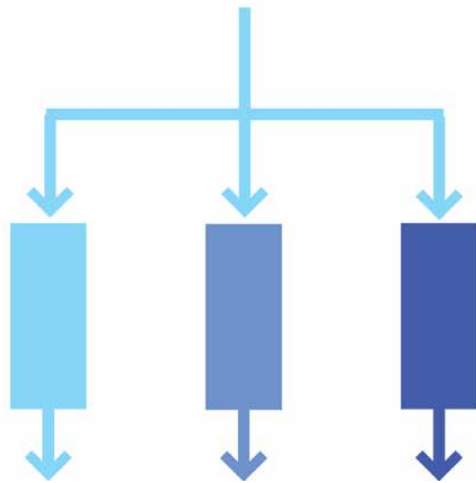
How system sustainable?

From the sustainable point of view, the examined historical water systems show the following features. First of all, the purposes of use are distributed to the separated space, according to water quality, so that water use becomes economic in quantity. Second, water is transported by gravity or by natural pressure, thus it needs less energy. These two features are made possible by the combination of geographical conditions and constant stream of water. Third, the users carry out a considerable part of maintenance. Although the municipal water system has been installed, by taking care of their own historical system inhabitants are quite aware of water quality and quantity. An important point is that the quality and quantity of water is quite visible from the waterway. In addition, self-maintenance, often carried out collectively, makes people aware of where water comes and goes and which of their activities can affect it. Thanks to this visible water system and self-maintenance, people still have a good knowledge of the flow of the water systems, and of how to live with water.

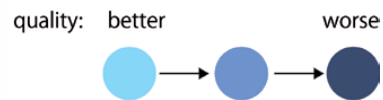




Cascade use



Separated and parallel streams



Delivered typologies

By considering the findings mentioned above, two groups of typologies regarding physical features of sustainable water use are delivered in relationship to the quality and drainage systems. The systems with these typologies are more sustainable to some extent in comparison with the modern systems in which people use potable water for any purpose of use, for example flushing the toilet and watering plants, and all drained water of any quality is mixed into the same sewage and treated together.

First, regarding the relationship between water quality and space, two typologies can be proposed, namely 1) cascade use in stream and 2) separated and parallel streams. The first typology, the cascade use, can be found in Kabata and Mizubune. It means that the course of the water stream from upper to lower is physically divided into several steps and each part has been designated for a particular purpose of use. The purposes of use are defined as follows: the use of the upper part requires that the water stays rather clean, while in the case of the lower part the needed water quality can be lower. Therefore, the water from the upper part is of better quality when it

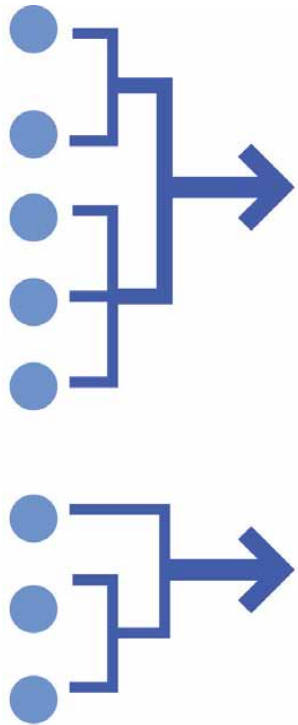
reaches the lower part. Thus, the same water is used several times and the quantity of used water can be diminished.

The second typology, the separated and parallel streams, can be found in the Sensuiro system, in which supplied water is divided at the beginning and it streams separately so that quality can stay different. If drained water is kept separated, and treated separately according to its quality, this system does not lead to the degradation of better quality water by mixing it up with lower quality water. The present Sensuiro does not have different quality anymore from Kawa and Segi, and it is drained into the same river. In the past, however, these three water streams had different ways of use, and it can be assumed that each had different quality. This system can be more effective in quantity if the same stream is used repetitively and it still happens in the present Sensuiro system. Because of this, the separated stream becomes long and then streams parallel to one another do not become mixed.

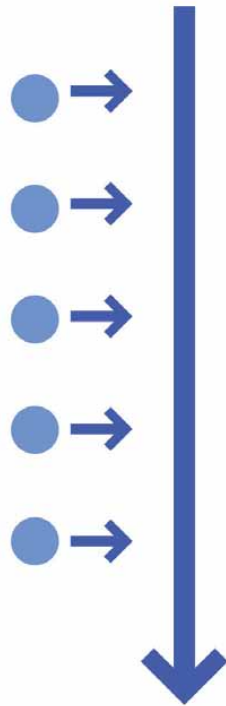
The second group of typology is about drainage structures, which is delivered by the relationship between the locations of points of use and the structure of a drainage water way.

Three typologies have been proposed: 1) a tree structure, 2) a comb structure and 3) a linear structure. All three examined systems, Kabata, Mizubune and Sensuiro, supply water constantly, and therefore they need own drainage systems on which geographical condition have great influence.

Kabata has a tree pattern to collect water from some points of use into one stream and these streams meet and finally they gather in a main river. Because the water source is an upwelling spring by natural pressure and it keeps supplying water 24 hours a day, water can be drained with a rather small degree of inclination. Due to this, a wider area on a relatively flat surface can be covered. Besides, water supply points spread, so this tree structure has the advantage of collecting water from a big area. In contrast, Mizubune is structured like a comb in which an individual point of use discharges into the main river almost directly by natural gravity. This system is made possible by special geographical features of points of use. They are located on a steep slope of the mountain near the river where the water can be drained directly into the main river within a relatively short distance. In addition, the points keep a certain distance in order to use water from a valley so that every Mizubune can get



Tree structure



Comb structure



Linear structure

● point of use

enough water. So, maybe to connect each other does not make much sense and better to drain into the main river directly. Sensuiro also has a drainage system with a slope by natural gravity but completely different from the structure of Mizubune. Its points of use are located in a drained water way; in other words, the points are connected by drainage. This means that the drained water of the upper user is supplied to the neighbour on downstream. In addition, a not very steep slope for a big surface is required this way to share the same water with many points of use.

Considering the aspect of quantity, the first pattern, a tree-structure, accumulates water in the course of time, so the quantity increases. The ditch for Kabata becomes obviously wider when it gets close to the main river. For Mizubune, the comb-structure water ditch stays the same wide and it suddenly pours into the huge river and it is added to the main stream from the upper area. For the linear structure of Sensuiro, there is no water input in the course of time, so quantity in the stream stays almost the same unless a big amount of water is taken away for irrigation or for other purposes.

From the qualitative aspect, the influence between points of

use is examined. In the tree system of Kabata, drained water is gathered in its structure so the quality of drained water affects water ways in the branches of the system. On the other hand, drained water from Mizubune goes to the main drainage directly so the quality of drained water does not have much influence, except for the big river. In the linear system of Sensuiro, drained water from an upper user has direct consequences for lower-side users.

From the maintenance point of view, first of all, the status of the assets shows a basic explanation of territory of private and communal maintenance. Furthermore, a drainage structure also effects especially the intensiveness of collective maintenance. At the Kabata system, the points of use are privately owned and maintained, while some of the ditches and the main river are communally maintained. For the main river as the final drainage waterway, all inhabitants (one person per family) has to take part in collective cleaning four times per year. Mizubune is often used and owned collectively, so maintenance is carried out collectively both for Mizubune itself and for the supply points in a valley, while a small waterway for drainage has less intensive collective activities. Sensuiro

Drainage pattern	Tree structure	Comb structure	Linear structure
	Kabata	Mizubune	Sensuiro
Transportation	By natural pressure (by an upwelling spring)	By inclination/a slope	By inclination/a slope
Change in quantity: during transportation	Accumulated in branches	Stay the same in a branch and all added directly to the main drainage	Stay the same in a branch
Influence on quality: between points of use	Influenced by accumulating in branches	No influence on each other (only on the main drainage)	Direct influence on a point of use for a neighbour
Collective maintenance	Branches for drainage	Not intensive for drainage (but intensive for supply point in a valley)	Branches for drainage



and Segi are owned and maintained privately, but the parallel stream of Kawa is collectively maintained very often, for example once a week or month. To summarize, the more influence of own use happens in the structure for drainages, the more intensive activities are performed.

Method

Through analysis and delivering typologies, it becomes obvious that the physical structures of typologies establish a significant relationship between water quality or quantity, and use and maintenance. Therefore, the method to consider the three aspects of physical form, and water quantity and quality, and use and maintenance, has a certain effect to make complicated systems in a clear and abstract structure, thus typologies, by using drawings. To deliver typologies in this way and to find significant points in process can suggest new insight for design of sustainable water system.

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