A Study on Traditional Asian Gardens as Parts of Water Network

Hybrid System with Ornamental Garden Ponds and Functional Water System in Historical Cities in Japan

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Abstract

This research is aimed to reveal how to work hybrid system with ornamental garden ponds and functional water system in historical Japanese gardens cities through researching old maps, documents and measuring canals and garden ponds in three historical cities (Edo/Tokyo, Kanra-Gunma, Kojirokuji-Nagasaki). As a result, the following things are revealed. (1) If over 50% of canals runs through private land, canals are divided complicatedly to reducing risk to stop and pollute. (2) Lord of these cities lived in end of the system to check whether water quality of whole water network is good or not. (3) In most of cases, canal are not directly connected to garden ponds. In only cases which garden ponds have function to control amount of water in downstream or upper stream, garden ponds are directly connected.(4) Garden design variety get rich with topographical situation.(5) In gardens, canals are divied to different use; ornamental use and functional use for daily life.

Keywords

landscape architecture, traditional garden, water network, historical aqueduct, green infrastructure, Japanese gardens, garden design

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Introduction

This paper aims to understand the cultural landscape of water infrastructure to discover a new principle for sus-tainable green infrastructures. Today, green infrastructure is more important for cities considering the current ab-normal climate and global warming. It is essential to discuss how to solve and live together with likely future natural disasters. In particular in Japan, with the experience of deca-centennial Tsunamis with earthquakes, such as that of 11th of March, 2011, there is the realisation that it is impossible to protect cities from disasters completely. From different points of view, for the past 50 years or so, Japan's infrastructures have been constructed in such a way that they can be mended or replaced due to aging and overestimated lifespan. However, under sluggish economic growth, and consequently lower budgets, it is impossible to maintain the same quality of infrastructures by repairing and reconstructing. Under these situations, we need to replace some infrastructures to new principles of infra-structures to sustain with a low cost such as green infrastructures. The comprehension of historical green infra-structures gives hints that may provide an answer to this difficult challenge.

Asian countries have many gardens constructed in cities. Some gardens are connected with a view, water, and life cycle. Kyoto in Japan and Suzhou in China are very famous garden cities. However, most research focuses on the specific gardens in terms of their histories, spaces, stories, and decorations, while few comment on the relationship between gardens and cities. So, this research focuses on gardens as a cultural landscape with water networks, starting with a very simple question: "What is the role of gardens in the water network?".

Visible connections between gardens and cities are famous techniques; the concept of "borrowing scen-ery" in Asian gardens is a familiar topic for researchers. Yamaguchi, Nakashima, and Kawasaki (2009) reveal a visi-ble area from each famous garden as borrowing scenery in Kyoto, Japan, and also points out the relationship be-tween garden design and "borrowing scenery" by view-shed analyses of GIS. The relationship between garden de-sign and topography is clearly described with three-dimensional diagrams of European gardens by Steenbergen and Reh (2003). Their research has productive suggestions for garden preservation by combining three-dimensional spa-tial data with internal and external gardens. This paper addresses the combination of the garden plan with sur-rounding geographical information to analyse the relationship between gardens and cities with water networks.

A water connection is an essential component in the analysis of the relationship between gardens and ur-ban structures for the Asian gardens because garden ponds are one of the main structures in Asian gardens (Inatsugi, 1990). Even in enclosed gardens, garden ponds must be spatially connected to the water network. In cit-ies, the use of water networks connected to gardens for specific functions such as drinking water supply, daily life use, and factory use need appropriate planning and design. This research reveals actual connections between wa-ter networks and garden ponds. Since ancient times, Japanese gardeners have paid special attention to water sup-ply. Mori (1962) pointed out that in ancient Kyoto, the imperial city "Heiankyo", in the 8th century, garden placement was influenced by topography and water resources. After the Edo period (1603 - 1868), many garden cities with water networks were constructed. One of famous examples is Matsushiro, Nagano, for which Sasaki and Nagai (2016) have revealed the entire network and design of garden ponds in the city. In the Meiji period (1868-1912), the industrial canal from Biwa lake to Kyoto was used for the water network of gardens in Higashiyama, Kyoto, devel-oped as villa and temple gardens. Amasaki (1984) reveals the whole network and system. The survey by Sosuke and Morimoto (2003) of Kyoto's water system shows incredible facts about the water network in Higashiyama, Kyoto. Their biological survey reveals garden ponds that are connected to the water network have preserved distinct fish species in Biwa lake (the original water source of the water network). It means that garden ponds with water networks can be refuges and sanctuaries for flora and fauna as a hybrid cultural green infrastructure. These

authors develop an understanding of whole images of gardens in water networks in Japan. However, it is not clear what the relationship between garden design and water network systems specifically is. The objective of this paper is to understand how to realise ornamental gardens and practical water systems in the same network as multifunctional traditional green infrastructures.

Water network

Garden Design

FIGURE 1 Digitalized map for the analysis.

Digitalised old maps and measuring gardens and canals

The research method is based in mapping. The historical map of Edo from the early Meiji period is used to read water networks or garden design. However, these maps are distorted because of inaccurate measuring techniques, so adjustment or modification to digital data is necessary to be able to analyse with GIS. The first step is to cali-brate old maps and old drawings of gardens to understand the original situation of gardens and water networks that were demolished or modified. In some of these maps, design details are missing, a deficiency that is solved by field surveys and measuring with a laser measuring system (Fig.1). Both water network maps and garden plan drawings are connected with one digitalised map used to analyse their relationship. In some cases, stakeholders were interviewed to understand how the network worked previously.

In this research, cities to analyse were selected using the following criteria:

- Several garden ponds exist/existed in one city.
- Historical maps or drawings to describe both water networks and gardens were in existence.

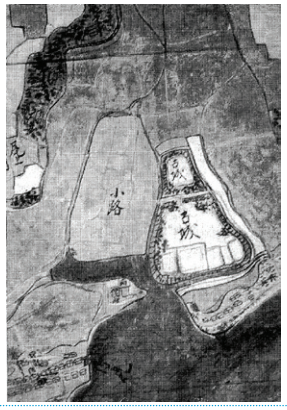
WATER NETWORKS WITH GARDENS, EDO, KOJIRO-KUJI, KANRA.			
City	**Edo**	**Kojiro-Kuji**	**Kanra**
Description	Water Resource: river, sea water, spring water, canals Over 1,000 gardens are constructed in the city Rich topographical situation from sea to plateau Rich historical documents Most of Garden style in Edo are circuit garden style, which distinct Japanese garden style in history Remain first measured map of Tokyo published in 1883-1884,scaled 1 to 5,000 which is clear to read design of gardens	Water resource: river 11 gardens remain Remain both water system and garden ponds Canals flow through one garden to another garden (not flow in public area) House of principal of the village is located downstream of the network	Water resource: canal Over 10 gardens remain Remain both water system and garden ponds Hybrid system with garden ponds and drinking water system Three branches from main canals flow south to north on the plateau with gentle slope Rich documents about gardens and water system in Edo Rich historical documents Remain illustrated map published in Edo period which is clear to read water network
Period	Edo	Edo	Edo
Topography	Plateau-Lowland	Lowland	Plateau
Water network	Natural resource: river, sea, spring water Canal: Drinking water, Irrigation water, Daily use	Natural resource: river, sea Canal: Daily use	Natural resource: river Canal: Daily use, Irrigation
Garden type	Circuit garden Garden for view from house	Garden for view from house	Circuit garden Garden for view from house
Owners of gardens	Buddism monk Warrior / Lord	Warrior	Warrior / Lord
Historical map			
Map	First measured map scale 1:5000 in early meiji era (五千分一東京図測量原図)	Map drawing of Kojiro village in Edo (神代村図)	Map of Obata area in Edo (小幡藩陣屋内絵図)
Water network	Unclear	Clear	Clear
Garden design	Clear	Unclear	Unclear
Remain water network	Not remain	Almost remain	Not remain
Remain garden ponds	Few garden ponds	Almost remain	Almost remain
Analysis	*Analysis based only on the old map*	*Analysis based on the map and field survey with measuring*	*Analysis based on the map and field survey with measuring*

TABLE 1 Water networks with gardens, Edo, Kojiro-kuji, Kanra.

Finally, three sites, Edo (old name of Tokyo), Obata, and Kojirokuji, were selected to research, as they are all garden cities constructed around the Edo period, with existing old maps from which to read the original situation of the water networks. The relationship between big cities and gardens can be understood through the topography between the plateau and the lowland through the city analysis of Edo. However, most gardens and water networks were demolished and changed. Obata and Kojirokuji, which remain both water networks and gardens, are the best examples of such analysis. Obata is located on a plateau with the canal for daily use and irrigation. Kojirokuji is located in a lowland near the sea with the canal accessible for daily use (Table 1).

Garden ponds as water reservoirs

The results of the analysis of the three cities' water networks with garden ponds show that garden ponds have a function as water reservoirs for the water network. The water network in Edo (historical name of Tokyo), which has over 1,000 garden ponds, shows many examples of how garden ponds are connected to water networks. Edo, placed between the plateau and the lowland, has many small rivers that flow from the plateau's edge and also fac-es the sea (Edo bay). These water resources are used for garden ponds. The first measured map from 1883 shows this clearly, and over 1,454 garden ponds are revealed from the map (today, only 18 gardens are preserved as offi-cial heritage). These garden ponds resulted from city expansion after the big fire in 1657. Edo city was located in the only seafront area in the lowlands before the fire, and there were fewer than 277 garden ponds. After the fire, the government forced its citizens to move outside of the Edo area, which has good topography and water re-sources from the edge of the plateau and seawater. Analyses of Edo's first maps show that garden ponds quadru-pled in number and increased by 150 % in area after the fire. So, the city expansion that resulted from the recovery from the fire diversified the water resources and garden designs (Fig. 2). Through analyses of Edo's first measured map, it reveals that different connection types depended on the location upstream or downstream in rivers. Most of the gardens upstream had spring water points inside the gardens and directly connected to garden ponds with dykes as small dams. These gardens are located alongside the edges of the plateau from which water springs; this controls an amount of water downstream. A similar structure is found in the imperial garden "Shugakuin Rikyu" in Kyoto, where a dyke was constructed to store water for rice fields in the garden area. Most gardens downstream or at the seafront have one water connection - ditch to rivers - to pull water into garden ponds. Water is controlled with gates to intake and drain. The gate can be seen between the garden and the sea in the garden "Hamarikyu". These examples upstream and downstream show that garden ponds are not connected directly to main streams, but placed as water reservoirs of the water network, which allow for the adjustment of the amount of water (Fig. 3 and Fig. 4).

The water network in Obata, Kanra, Gunma, has eleven garden ponds and shows the combined system for daily uses and garden uses. Obata, placed on the plateau alongside the river (Ogawa), has many small canals that run from the main canal (Ogawazeki) to the rice fields area. Each house has at least one garden pond, which is used not only for garden uses but also for daily life as a water reservoir. Eight gardens in Obata have deeper ponds which have rectangular shapes that are most useful for daily life.

The water network in Kojirokuji, Nagasaki, in which eleven garden ponds remain, shows the combined system for dykes for flooding and garden uses. Kojirokuji, located on the lowlands alongside the river (Minotsuru river) and facing the sea (Ariakekai), has four main canals with garden ponds. Each house has a series of piled stone walls alongside the main canal to prevent flood water from the river reaching the houses. Garden ponds are also used for daily life and are strategically placed behind the stone walls to provide continuous access even during times when the river floods.

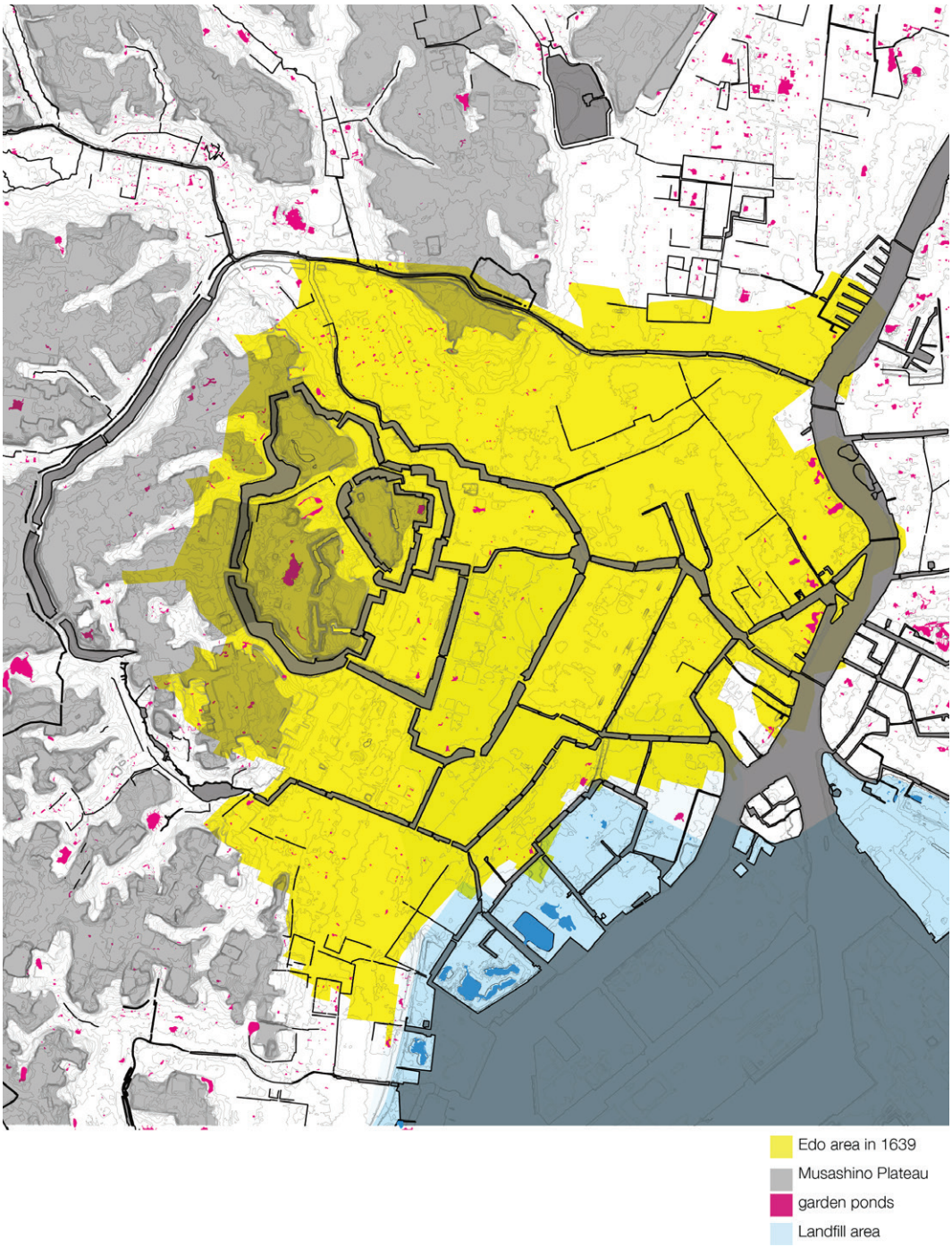
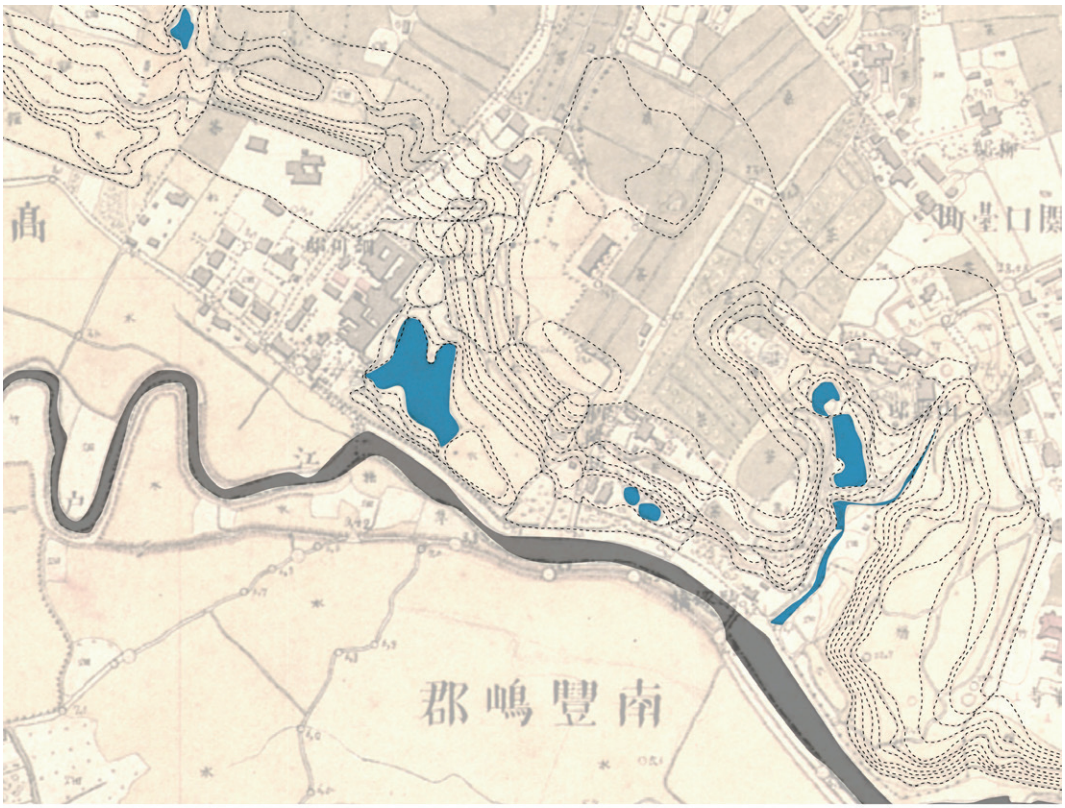


FIGURE 2 Garden ponds and city expansion in Edo.



*based on map in 1883

FIGURE 3 Garden ponds in upper stream and topography *based on map in 1883.

Main river
Garden ponds
Contour line

*based on map in 1883

FIGURE 4 Garden ponds in down stream *based on map in 1883.

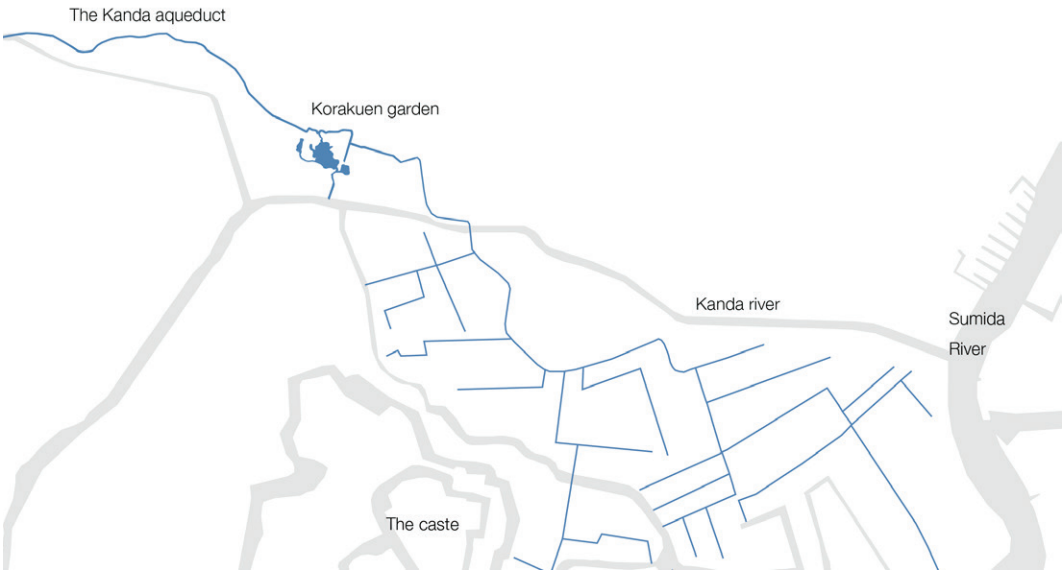


FIGURE 5 Korakuen garden as parts of the aqueduct network in Edo.

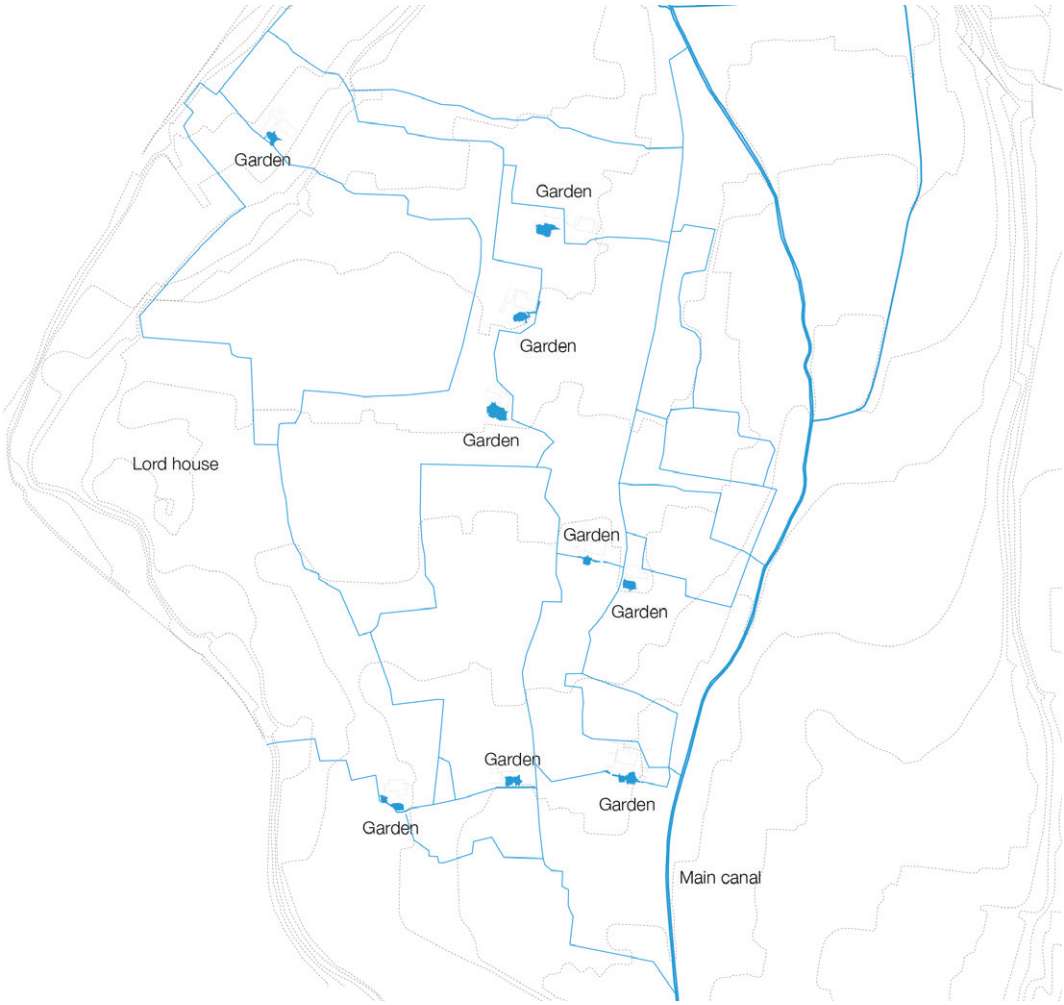


FIGURE 6 Water network and garden ponds in Obata, Kanra, Gunma, Japan.

Connection between garden ponds and water networks

In most cases, in the three cities, the garden ponds are connected to water networks with diversions; the garden ponds are placed in branches that are separated from the main streams to remove risks to the main functionality of the canals.

Six aqueduct canals for drinking water and irrigation in Edo (Kanda, Tamagawa, Aoyama, Mita, Senkawa and Honjo) also connected to garden ponds with diversions.However, kanda aqueduct canal in Edo directly con-nected to lord's family (Tokugawa family in Mito 水戸徳川家上屋敷) gardens, "Korakuen(後楽園)", and the garden controlled an amount of water as the inlet point from Kanda river and adjusted the appropriate amount of water to meet the demand of the entire water network. However, by reconstructing the gardens, the garden ponds have be-come a part of the branch that is divided from the main streams. Other gardens ponds in other aqueducts (ex: Nai-to family in Takato 高遠藩内藤家下屋敷) also have similar functions to "Korakuen" in branches of the aqueducts (Fig. 5).

Another connection type to garden ponds from canals is found in Obata, Kanra, Gunma, Japan, as aque-duct system and garden uses are found together in the same network. This water network is complex and canals are divided many times in the village of Obata, Kanra, feeding directly to each house. 70.4% of canals in the net-work flow in private areas. This means that any route from upstream to downstream passes through a private area. However, there are many routes downstream with many diversions to reduce the risks of stopping the entire sys-tem through the activity (daily life use, having fishes for garden use) in each private area. 75 % of diversion points are placed in public areas to maintain overall control, and to prevent stopping or polluting that might be caused by errors made in a private area. This system can accept garden use with a direct connection from the canal (Fig. 6 and Fig. 11)

Connections between garden ponds and the water network in Kojirokuji is much simpler. Four main canals flow south to north, with branches to each garden that return water to the same canal. 68.1 % of canals in the network flow in public areas and canals in private areas are only parts of the downstream and upper stream. It means the main canals of the water system flow in a public area.

Diversion points to garden ponds in Edo are generally located in a private area. In Edo, 99.5% of garden ponds are connected to water networks with only one inlet, so that there is less flow in the garden ponds. Gates are only needed to control some water in gardens (closing and opening gates decreases the impact downstream). On the other hand, garden ponds in Obata and Kojirokuji are parts of the water network, closing and opening gates in gardens that influence the amount of water in the water network. So, most diversion points (78% of Obata, 100% of Kojirokuji) are placed in a public area to allow them to be managed from outside the gardens (Fig.7, Fig. 8, Fig. 9).

System for checking water quality in the network

The water quality in aqueduct systems needs to be checked daily for drinking and other uses. In old times, there were no machines to do so. The water network with gardens in Kojirokuji, a very simple network with two main streams and garden ponds, installed a water-checking system. The family who lived at the end of the network was one of the bureaucrats (Ito family), who would check water quality after it flowed through cities in garden ponds, a process that contributed to maintaining the high quality of public health in cities. A similar system is applied to Edo and Obata. The main castle of Tokugawa shogun (tycoon) family was placed almost at the end of the water network (Tamagawa aqueduct). The lord family (Oda family) also lived almost at the end of the water network (Table 2).

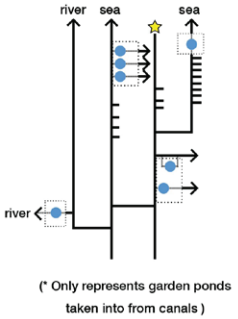
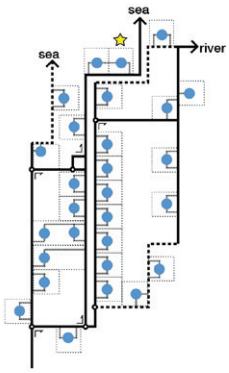
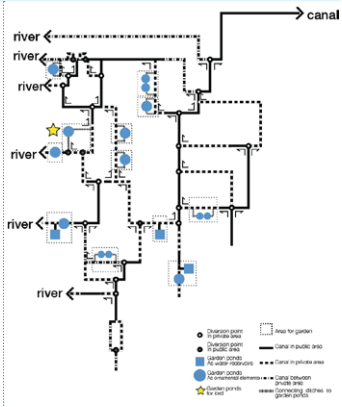
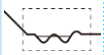
Diagram of water networks with gardens, Edo, Kojiro-kuji, Kanra.				
		Edo	Kojiro-Kuji	Kanra
	Diversion point In private area Diversion point In public area Garden ponds As water reservoirs Garden ponds As ornamental elements Garden ponds for lord Area for garden Canal in public area Canal in private area Canal between private area Connecting ditches to garden ponds			
Total length of canals (m)		-	1854	6020
Total length of canals, public ownership (m)		-	1263 (68,1 %)	1780 (29,6 %)
Total length of canals privare ownership (m)		-	591 (31,9 %)	4240 (70,4 %)
Division points of canals		-	6	16 (4 points in private area)
Confluent points of canals		-	3	18
Number of graden points		1454	28	17
Garden ponds and network				
Type 1 Divide and return to same canals		1	25	10
Type 2 Divide and return to another canals		0	2	1
Type 3 Divide and return at a some point		1447	1	3
Type 4 Direct connection to garden ponds		6	0	3
Garden ponds and topography				
Type A Garden ponds with slope		181	0	5
Type B Garden ponds alongside slopes		177	0	0
Type C Garden ponds without any slopes		1096	28	12

TABLE 2 Diagram of water networks with gardens, Edo, Kojiro-kuji, Kanra.

FIGURE 7 The inlet point of garden pond from the river, in old Yasuda garden, Ryogoku, Tokyo

FIGURE 8 The diversion point of garden pond, Kanra.

FIGURE 9 The diversion point of garden pond, Kojirokuji.

FIGURE 10 Relationship between micro-topography and garden ponds in Edo.

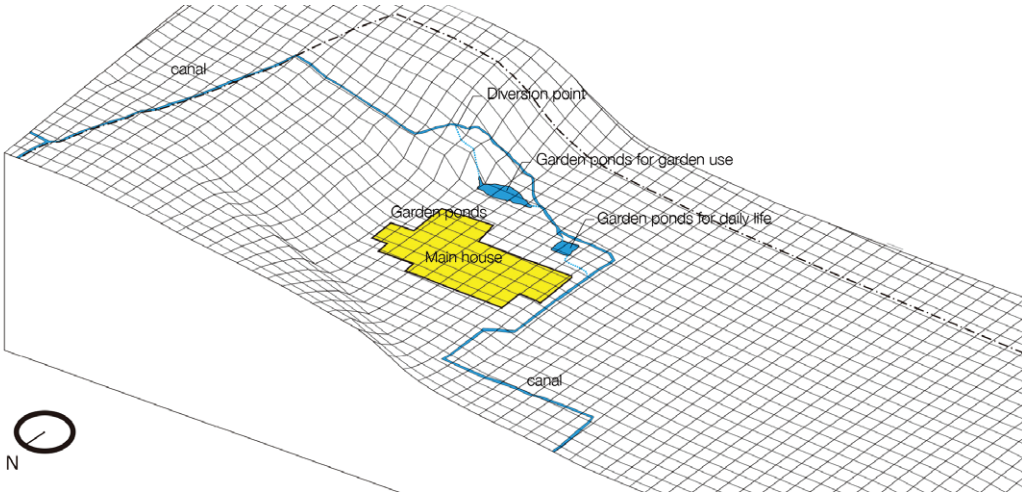


FIGURE 11 Relationship between micro-topography and garden ponds in Kanra.

FIGURE 12 Garden pond with piled stones wall to prevent to flooding.

Garden design as parts of water networks

Functional ponds and ornamental ponds in garden

Gardens ponds in Obata and Kojirokuji have two different needs: functional use and ornamental use in the same water network (Garden ponds in Edo are only used ornamentally with non-potable water). In five gardens in Obata, two garden ponds are set within one garden to realize both residential and ornamental functions. Garden ponds for ornamental use are shallow and horizontally spread with freeform shapes, located in front of the main house to be seen from the main guest room. On the other hand, practical ponds are deeper and rectangular-shaped, located near a kitchen and a toilet. Fish swim and eat remains of food, and then clean water in the functional ponds.

Design with micro-topography

The topography is not only important to the water network systems but also to the garden design. Micro topography is directly applied to garden design, such as a waterfall. Our measuring survey in Obata reveals the relationship between garden ponds in the water network and micro-topography. The entire village of Obata's has a gentle slope from north to south, and water networks were planned with the topography. Each garden has an average of 1 to 2 metre level difference; however, the large difference is applied to ornamental garden elements such as waterfalls, or mounds. It means that positions of garden ponds are defined with original micro- topography (Fig. 11). 24.6 % of gardens ponds in Edo, which has rich topography in the city area, are designed with micro-topography (Fig. 10). In Kojirokuji, the area is almost flat. However, walls of piled stones to prevent flooding are applied to garden designs (Fig. 12).

Conclusion

The aim of this research was to reveal the workings of hybrid systems with ornamental garden ponds and function-al water systems in historical Japanese garden cities of Edo/Tokyo, Kanra-Gunma and Kojirokuji-Nagasaki. This was done using the methods of researching old maps, documents, and measuring canals and garden ponds in three old cities and translating this into GIS data that could be analysed. This delivered the following important in-sights:

1. If over 50% of canals run through private land, canals are divided complicatedly to reduce the risk of stopping and polluting.
2. Lords of these cities lived at the end of the system to check whether the water quality of the whole water net-work was good or not.
3. In most cases, canals are not directly connected to garden ponds. In the few cases in which garden ponds have a function to control the amount of water downstream or upstream, garden ponds are directly connected.
4. Garden design variety increases with the topographical situation.
5. In gardens, canals are divided into different uses: ornamental use and functional use for daily life.

The gardens ponds that were part of the study all have access points to the water networks and were very much designed to be used in daily life by the people living around them. Diversions in a public area or garden

area to sep-arate main streams and garden streams are important to maintain water quality. On the other hand, garden ponds including inlet points or outlet points, can control flows in water networks with gates closing or opening. Lords also have a necessary role in checking water quality in downstream networks. These systems were operated only by the traditional community in the early modern period when local lords controlled the local community system. Though the modern water system has replaced these water systems, the role of garden ponds as adjustment points or access points suggests green infrastructure as a flexible water system. Maintenance of these water sys-tems through active management of gardens by each residence gives us hints on how to solve maintenance prob-lems for modern water systems managed by governments. So, to apply green infrastructure to cities, it is im-portant to simultaneously cultivate communities with cultural life through green infrastructure, beyond maintenance activities.

References

Amasaki, H. (1984). Water network and garden ponds in Nanzenji-temple. *The Journal of Kyoto College of Art,* Kyoto

Inatsugi, T. (1990). 庭園と住居の< ありやう> と< 見せかた・ 見えかた> ― 日本・中国・韓国― *[Space and design about garden and houses in Japan, China and Korea].* Tokyo: Sankaido

Ito, S. & Morimoto, Y. (2003). Garden Ponds as Wildlife Habitats for Fish from Lake Biwa into Kyoto City. *Journal of The Japanese Institute of Landscape Architecture* 66(5) 621-626, Tokyo

Kim, Y., Ono, A., Zhang, J., & Mitani, T. (2017). A Study of the Spatial Composition and Elements in Korean Byeol-Seo Garden. *Journal of The Japanese Institute of Landscape Architecture* 80(5) 599-602, Tokyo

Kim, Y., Ono, A., Zhang, J., & Mitani, T. (2018). A Study on Enclosing Characteristics of Topography around the Korean Byeol-Seo Garden. *Landscape Research Japan Online* 81(5) 559-564, Tokyo

Mori, O. (1962). 寝殿造系庭園の立地的考察 *[A geographical study on gardens for Shinden-zukuri style architectures].* Nara National Research Institute for Cultural Properties, Nara, Japan

Ohashi, M., Mizuuchi, Y., & Ono A. (2019). A Study on the Planting Design of Ginkgo trees and the Process of Ginkgo trees Landscape Formation in old Yamazaki village in Inazawa, Aichi prefecture, *Journal of The Japanese Institute of Landscape Architecture* 82(5) 469-474, Tokyo

Ono, A. (2016). A study on Revetment Design of Canals and Gardens in Suzhou, China. *11th International Symposium on Architectural Interchange in Asia* 950-953 Sep, Sendai, Japan

Ono, A., Li, K, Zhang, J., & Mitani, T. (2012). A Study on the Spatial Composition between Garden Architectures and Garden Ponds in Suzhou, China. *13th International Symposium of Landscape Architecture, Korea, China, and Japan* 49-53, Suncheon, Korea

Ono, A., Li, K, Zhang, J., & Mitani, T. (2013). A Study on the Relationship between the Pond Waterside and the Garden Pavilion as a United Space Design. *Journal of The Japanese Institute of Landscape Architecture* 76(5) 497-500, Tokyo.

Ono, A. & Mitani, T. (2010). A study on the Relationship between the Topography and Gardens in Edo. *UIA2011TOKYO Academic Program* 103-108, Tokyo.

Ono, A. & Kim, Y. (2018). Redefining an Abandoned Old Aqueduct System As Green Infrastructure: I*FLA World Congress,* Singapore.

Ono, A. & Kim, Y. (2018). A Study on Renovation of Historical Green Infrastructure in Tokyo, Japan. *The 12th ISAIA 2018 Pyeongchang Korea,* p2071-2074, Pyeongchang Korea.

Sasaki, K. & Nagai, Y. (2016). *Recent Changes of Watercourses Supporting the Pond of Garden at Matsushiro, Castle Town, in Nagano City.* The Academic Society of Japanese Garden, 1-10, Tokyo.

Steenbergen, C. & Reh, W. (2003). *Architecture and Landscape: The Design Experiment of the Great European Gardens and Landscapes,* The Netherlands, Birkhauser.

Yamaguchi, K., Nakashima, K., & Kawasaki, M. (2009). Characteristics of Scenic Views and Topographic Enclo-sure of the Traditional Gardens in Kyoto, Japan. *Society of Civil Engineers D* 65(3), 317-328.