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Water Resources Development in Taoyuan Tableland; Special Reference to the Word of "Transfer" and "Comparison" between Taiwan and Japan

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Water Resources Development in Taoyuan Tableland;

Special reference to the word of “transfer” and “comparison” between Taiwan and Japan

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Abstract:

Taoyuan tableland, located in the northern part of Taiwan, is well known as the most tank (pond)-dominated area in the world. The purpose of this study is to clarify water resources development in Taoyuan tableland specially focusing to historical significances and contemporary task of irrigation facilities (mainly tanks). With the achievements of previous studies as the foundation, tanks in Taoyuan tableland are reconsidered through the following approaches: 1) utilization of topographic maps from multiple times in history, 2) involvement of urbanization and industrialization, 3) abolishment of tanks and subsequent use of tank sites, and 4) the present condition of the existing tanks and their usage. In addition above approaches, I attempt to use “transfer” and “comparison” between Taiwan and Japan.

The reorganization of tanks through the Taoyuan canal project was quite thorough. However, in command areas, not all tanks were reorganized, and some remained in their original conditions. In addition, a large number of tanks remained outside command areas. The abolishment of tanks in recent years’ experiences more impact from urbanization and industrialization than irrigation projects such as Taoyuan canal project. Therefore, it is clear that tank trend were different between rural areas and urban areas. The new land after the abolishment of tanks is used for public spaces, including schools, public offices, and parks. This trend is the same in Japan. In this research I compared the Taoyuan tableland and the Inamino tableland, it finds that there is similar progress of water resource development. Initially they constructed many tanks, then introduced canal, the Taoyuan canal and the Tanzan canal, furthermore constructed dams. The concept of the Taoyuan

canal project and the Tanzan canal project is same. That is to connect river and tanks. The Tanzan canal project was ahead of the Taoyuan canal project. It might be transferred civil engineering technologies and knowledge. The number of tanks decreased in the Taoyuan tableland at the time of the Taoyuan canal project. On the other hand, the case of the Tanzan canal project bought to increase tanks. Recently, the both are influenced under urbanization and industrialization. Then the number of tanks has been decreased in the both area. These two area still the most tank dominated area, and there are many tanks. In Taiwan, surveys and studies of tanks are active with governmental support. Tanks are considered regional cultural assets, and attempts are made to use them as a tourism resource. These activities and concepts will probably be good references for community development in Japan. It is useful to transfer these idea. Therefor the researches and interchanges between Taiwan and Japan on this topics should be required more and more.

1. Introduction

1) Monsoon and tank

In rice cultivating areas of Monsoon Asia, to supplement seasonal and irregular precipitation, various irrigation means have been used. Tanks are one of the older measures used, with some of them over 1,000 years old[1)]. In the twentieth century, large-scale water resources development took place that used dams, such as those of the Tennessee Valley Authority under the New Deal Policy. In Asia, over 12,000 dams were constructed since the l950s in Japan, India, and China[2)]. These developments contributed significantly to increasing irrigated areas, stability, and food production. However, since the late 1980s, there were criticisms against dams and large-scale water resources developments (Pearce, 1995), and sustainable water use and development are now desired. Under such a climate, tanks with a long history that had been maintained by local people were reevaluated, and some attempted to use tanks in urban development planning (Agarwal and Narain, eds., 1997; Inamino Tank Museum Board of Operation, 2012).

This research especially focuses tanks in Monsoon Asia. Tanks are known to be common in Sri Lanka and India in addition to Japan (Minamino, 2014); however, Taiwan also has a lot of tanks. The Taoyuan tableland in Taiwan, where I discuss in this paper, is known as the area in the world with the highest concentration of tanks (Takeuchi, 1971).

2) Taoyuan tableland

The Taoyuan tableland is located in northwestern Taiwan, and it is bound by the Dahan river to the east and south, the Fengshan river to the west and south, and the Taiwan Strait to the northwest. It is a tableland with a mean elevation of about 100 m (Figure 1). It stretches about 35 km from east to west and about 30 km from north to south. The tableland spreads in a fan-shape and presents a gentle slope from the southeast to the northwest with the 551 m of Shimen Mountain at vertex of the fan. Terraces have formed in the edges, therfore its water system is isolated. The longest river that flows on the tableland is 44 km long, while all of its other rivers are small to medium length at 30 km or less. Their catchment areas are also limited. Annual precipitation is from 1,500 to 2,000 mm, but, due to the impact of monsoons, fluctuations between years are significant; in this natural environment, securing a stable supply of water is difficult (Pan, ed., 2010). To overcome such a natural environment, water resources development was

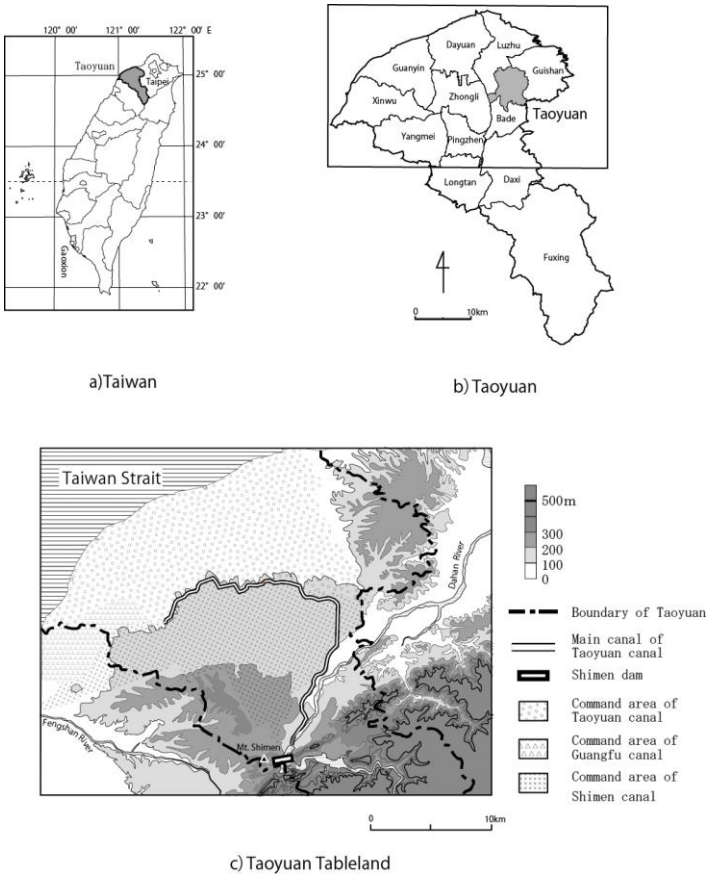


Figure 1. Research

undertaken, and as a measure of this, a large number of tanks was built.

3) Review of previous studies

These tanks and characteristic of the landscape in the Taoyuan tableland and have garnered the attention of Japanese researchers. During the Japanese rule (1895–1945), Watanabe (1939) and Nou (1935) reported their studies on tanks in Zhongli. During the Republic of China Rule, Takeuchi (1971) and Hatate (1986) presented their discussions. In recent years, analyses have been conducted using GIS (Kobayashi et al., 2012; 2014; Morino et al., 2012). On the other hand, among Taiwanese researchers, Chen (1961) studied the Taoyuan tableland from the view point of regional geography, and Chen (1978) carefully discussed the reorganization of the irrigation system in the Taoyuan tableland. In recent years, Chen (2003) examined the water use in Taiwan in its entirety, and the Taiwan Literature Committee, ed. (2000; 2001), also discussed and outlined water resources development in the Taoyuan tableland.

In the previous studies, based on literature, the historical facts of tank construction in the Taoyuan tableland, water resources development since the Japanese rule, and the effects of said development were discussed. As for the existence of tanks, the discussion are unique in their use of topographic maps. In addition, changes in agriculture and the abolishment of tanks due to further urbanization and industrialization are discussed.

4) Way of approach

In the present study, based on maps (topographic maps), trends in tanks are reexamined. Analysis based on topographic maps is a method that has been

used by Takeuchi (1971), Kobayashi et al. (2012; 2014), and Morino et al. (2012). In this research, by using multiple topographic maps, I conduct a detailed analysis of each era. Next, I conduct an examination with a focus on urbanization and industrialization. Takeuchi (1971) and Hatate (1986) examined the stage where urbanization and industrialization had just started in the Taoyuan tableland, and there is insufficient discussion regarding the effects of both since the 1980s. In addition, Kobayashi et al. (2012; 2014) and Morino et al. (2012) examined rural areas; however, in the research, I target Taoyuan district in Taoyuan city, and these examinations are focused on trends in urban and suburb areas. In addition to the literature, this research is based on fieldwork and interviews conducted at related organizations on site; I examine the abolishment of tanks and the subsequent use of these lands, which were not discussed in previous studies. At the same time, I discuss the situation and use of surviving tanks. Furthermore I try to compare between the Taoyuan tableland and the Inamino tableland from the view of water resource developmet.

2. Water resources development in the Taoyuan tableland and regional changes

First, I summarize the progress of water resources development in the Taoyuan tableland based on previous studies.

1) Water resources development

i) Qing dynasty period

Development of the Taoyuan tableland was limited for a long time, as the previously described severe natural environment created obstacles. The turning point in its development occurred during the eighteenth century, brought on by immigrants from Mainland China (Minnan people from Fujian province and Hakka people from Guangdong province). These immigrants from the Mainland secured water through irrigation[3)], with its water source in the small to medium rivers of the tableland and several tanks[4)], and started farming, gradually expanding their settlements and industries.

The number of tanks at the end of the Qing dynasty was believed to have exceeded 8,000 (Pan, ed., 2010), creating the world's leading tank area on the

Taoyuan tableland.

ii) Japanese rule period

Based on the 1895 Treaty of Shimonoseki, Taiwan was placed under Japanese rule, where it remained for over 50 years. The construction of the Taoyuan canal was begun in 1916 and completed in 1928. It was a water use project of Taiwan's Governor (Taoyuan Irrigation Association of Taiwan, 2004). The Taoyuan canal, which uses the Dahan river, the largest river in northern Taiwan[5], as its water source, has its main canal built at an elevation of 110 m and irrigates 22,000 hectares of mid- to low-lying areas at elevations of 100 m or lower (Taoyuan Irrigation Association of Taiwan, 2004) (see Figure 1).

In this irrigation project, tanks were reorganized. Inefficient tanks were abolished, and out of 2,326 tanks, 244 efficient tanks were reorganized (Hatate, 1986).

iii) Republic of China period

After Japan withdrew, Taiwan was governed by the Kuomintang party, and since the late 1980s, democratization has been promoted, leading to today. To increase food production, the Guangfu canal dug to irrigate areas downstream from the Taoyuan main canal at the point of Shetzu river. "Rotational irrigation" is a water management technique unique to Taiwan[6] (Kan, 1981; Harada and Yamazaki, 1991). Water use was made efficient through rotational irrigation, and excess water was allocated to the Guangfu canal.

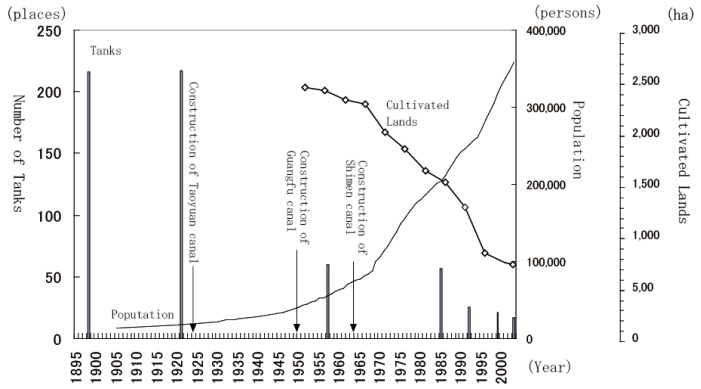
In 1963, the Shimen dam was completed on the Dahan river. The Shimen dam is a rock-fill dam of 133 m in height, and its capacity is 310 million cubic meter. In addition to the provision of agricultural irrigation water, the purpose of this dam is diverse and includes water supply, industrial water, power generation, and flood control (Northern Region Water Resources Office, Water Resources Agency Ministry of Economic Affairs, 2003). With the completion of the Shimen dam, the Taoyuan canal was provided with a stable water flow because its water intake was moved to immediately below it. This strengthened the water source significantly. In addition, the Shimen canal was newly dug from the Shimen dam, and it came into operation in 1964. With the Shimen canal, areas in the Taoyuan tableland with elevations of 100 m or more could be irrigated (see Figure 1).

2) Urbanization and industrialization of Taoyuan district

The Taoyuan tableland mostly falls under the administration of Taoyuan

City. Taoyuan City consists of seven districts. Out of those, in this paper, I focus on Taoyuan district, where the city capital is located.

Taoyuan district is located about 20 km west of central Taipei. The Taoyuan station is connected to Taipei station through the TRA West Line, which is the main rail line of Taiwan. With a regular train, it takes 35 minutes to travel between them. In addition to its proximity to Taipei, the Taoyuan international airport—the largest international airport in Taiwan—opened in the north of Taoyuan district in 1979, and highway networks have been established. At present, (2014) Taoyuan district has the largest ratio of foreigners in Taiwan along with foreign capital investment and factories[7].



The population of Taoyuan district 13,439 in 1905, and had increased to 105,841 in 1970. In contrast to this population increase of 100,000 over 65 years, the population exceeded 200,000 in 1984, a mere 14 years later. Furthermore, the passing of another 14 years (1998) saw the population increase to exceed 300,000 (Figure 2). As of 2014, the population has increased to 415,431. As such, the population has continuously shown significant increase in the 1970s, 1980s, 1990s, and 2000s. Looking at land usage, the cultivated area decreased from 2,469 ha (2,374 ha of rice paddy and 95 ha of farm fields) in 1951 to 769 ha (766 ha of rice paddy and 3 ha of farm fields) in 2001, a reduction down to one-third (see Figure 2). Starting with the building of the Keishan industrial area in northern Taoyuan, the number of factories built within the city is rapidly increasing. Farmlands are being changed to plants and factories along with residential areas to accommodate the increasing population.

Figure 2. Transition of tanks and

Source: Center for GIS, RCHSS, Academia Sinica (中央研究院人社中心地理資訊科学研究専題中心「台湾百年歴史地図」(http://gissrv4.sinica.edu.tw/gis/twhgis/), Pan(2010).

3. Trends of tanks in Taoyuan district

1) Topo-sheets and summary of trends of tanks

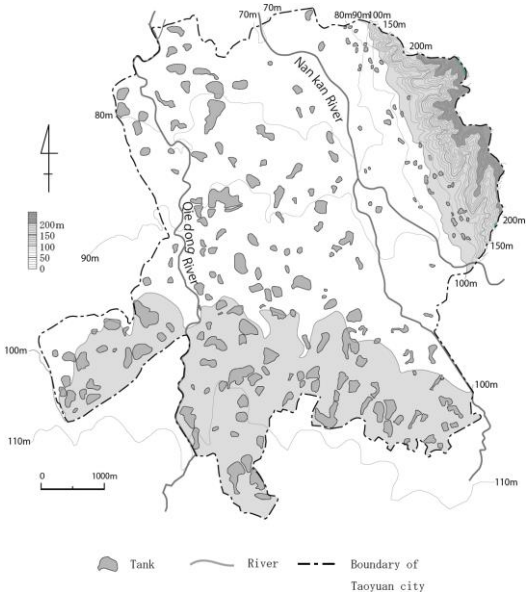


Figure 3. Distribution of

Source: Center for GIS, RCHSS, Academia Sinica (中央研究院人社中心地理資訊科学研究專題中心「台湾百年歴史地図」

In this research, I used the "Taiwan Historical Maps in the Last One Hundred Years" operated on the website of the Center for GIS, RCHSS, Academia Sinica (GIS Center), as well as topographic maps stored in the Academia Sinica library, as the original materials for analysis. Specifically, I used the following seven maps: "Taiwan Baotu," (the "Maps of Taiwan" produced in the colonial era) shown in Table 1[8], "Land Survey Topographic Maps[9]," "Union General Headquarters Survey Office Topographic Maps[10]," "CEPD Topographic Maps (First Edition)," "CEPD Topographic Maps (Second Edition), "CEPD Topographic Maps (Third Edition)," and "CEPD Topographic Maps (Fourth Edition) [11]." In each map, we target the sheets that include the Taoyuan district area. In all of these maps, the Taoyuan area encompasses multiple sheets. In this research, instead of the year the target sheets were created or surveyed, we use the year indicated in the "Taiwan Historical Maps in the Last One Hundred Years," excluding "Union General Headquarters Survey Office Topographic Maps." For "Union General Headquarters Survey Office Topographic Maps," we use the most recent of the two map sheets. In addition, the scales of the original map sheets are 1/20,000 for "Taiwan Baotu" and 1/25,000 for the others, as shown in Table 1. On "Taiwan Historical Maps in the Last One Hundred Years," Taiwan is processed to make it consistent with other map sheets.

Table 1. Number of tanks

Maps	Scale	Published Year	Tanks related without Taoyuan canal	Tanks related without Taoyuan canal	Tanks Total
Taiwan Baotu (台湾堡図)	1/20,000	1898	216		216
Land Survey Topographic Map (日本陸地測量部地形図)	1/25,000	1921	235		235
Union General Headquatoers Survey Office Topographic Map (連合勤務総司令部測量所)	1/25,000	1957	60	17	77
CEPD Topographic Map Ver.1 (経建版第1版)	1/25,000	1985	57	12	69
CEPD Topographic Map Ver.1 経建版第2版	1/25,000	1992	25	11	36
CEPD Topographic Map Ver.1 経建版第3版	1/25,000	1999	21	9	30
CEPD Topographic Map Ver.1 経建版第4版	1/25,000	2003	17	9	26

Source： Center for GIS, RCHSS, Academia Sinica (中央研究院人社中心地理資訊科学研究専題中心、「台湾百年歴史地図」

The tanks were identified from the topographic maps, and the results are shown in Figures 3 and 4 as well as in Table 1. The overall trend shows that the number of tanks in 1898 according to “Taiwan Baotu” was 216. In the 1921 “Land Survey Topographic Maps,” the number of tanks had increased to 235. In the 1957 “Labor Union General Headquarters Survey Office Topographic Maps,” the numbers had decreased significantly to 77, or about one-third. In the 1985 “CEPD Topographic Maps (First Edition),” the number had decreased to 69, but the decreasing trend had slowed down since 1957, and not many tanks were abolished. In the 1992 “CEPD Topographic Maps (Second Edition),” the number has been halved, down to 36, and in the 1999 “CEPD Topographic Maps (Third Edition),” it was down to 30. In the 2003 “CEPD Topographic Maps (Fourth Edition),” it was down to 26, about one-tenth of when tanks were most prolific.

In previous studies, trends in the tanks were explained in association with the changes in the water use system that accompanied irrigation projects (Chen, 1978; Morino et al., 2012). Since many tanks were built during the Qing dynasty, the subsequent development of the Taoyuan canal, the Guangfu canal, and the Shimen canal (Figures 1 and 2) led to the reorganization of the water use system, the building of new tanks, and the abolishment of old ones. Compared to the period of water resources development in the Taoyuan tableland indicated by the other maps, “Taiwan Baotu” (1898) indicates the time period prior to the development of

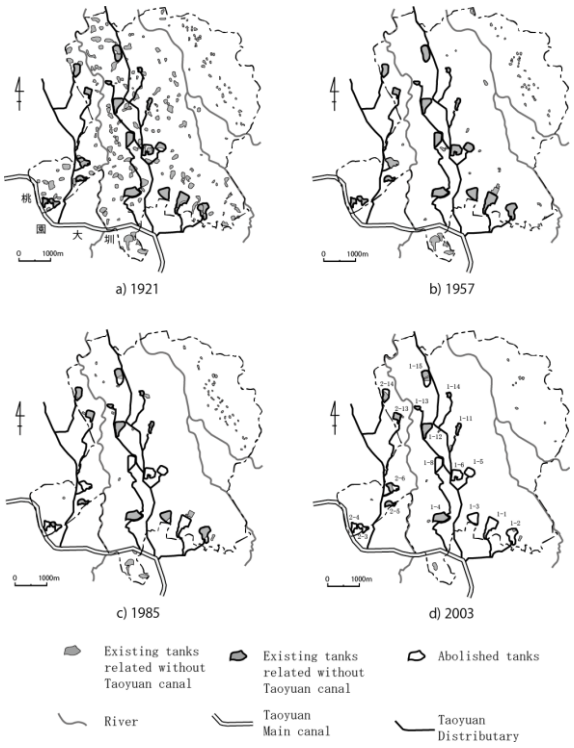


Figure 4. Transition of tanks

The numbers on d) are related with Table 2. 1-1 is tank'name and indicate order number on earch distributary.The situation of earch tanks are shown in Table 2

the Taoyuan canal. Next, in the Japanese "Land Survey Topographic Maps" (1921), the construction process of the Taoyuan canal is shown. In addition, the "Union General Headquarters Survey Office Topographic Maps (1957) showed the completion of the Taoyuan canal construction under the governance of the Republic of China. Following this, the Shimen dam was completed in 1963, and the Shimen canal was completed in 1964 (Figure 2). Much of Taoyuan district is the command area of the Taoyuan canal, while only the south side of main canal of the Taoyuan canal aqueduct benefited from the Shimen canal (Figure 4). As mentioned earlier, with the completion of the Shimen dam, the intake of the Taoyuan canal

was changed, which realized a more powerful water source and stable water supply. Therefore, the command area of the Taoyuan canal were positively affected by the completion of the Shimen dam. The "CEPD Topographic Maps (First Edition)" (1985) reflects the effects of the Shimen dam and the Shimen canal. Based on the above history of water resources development and the related facts, we next confirm the distribution and trends of tanks at each spatial point.

2) Distribution of tanks in each era

i) Taiwan Baotu (1898)

As shown in Figure 3, tanks in the Taoyuan district area include those with both relatively large and small areas. Much of Taoyuan district spreads on flat planes with an elevation of 70 to 110 m. In the northeast part, there is a hill that connects to the Linkou tableland. The flat plane gently slopes from south to north, and the Nankan river flows on the east side of the tableland while its tributary, the Jiadong river, flows to the west. Both rivers flow north.

On the flat part of this tableland, there are relatively large tanks. On the other hand, the foothills east of the Nankan river have small tanks.

ii) Land Survey Topographic Maps (1921)

Construction of the Taoyuan canal started in 1916. In the Taoyuan canal project, tanks were reorganized. Ineffective tanks were abolished to increase the arable lands, while some of the tanks were maintained as subsidiaries. Through the raising of the dike, digging of the tank bottoms, and combining multiple tanks, the capacity was increased. Near Taoyuan district, the main canal of the Taoyuon canal is dug at an elevation of 110 m, and irrigation water is provided to related tanks from the main canal through distributaries (Figure 4). The command area of the Taoyuan canal is the north side of the main canal and the west side of the Nankan river. Related tanks between the Nankan river and Jiadong rivers receive water from the no.1 distributary, and related tanks to the west of the Qiedong river receive water from the no.2 distributary.

Figure 4a shows the construction condition of the Taoyuan canal. Compared to that of 1898, the number of tanks has increased. Prior to the implementation of the Taoyuan canal project, tanks were being constructed. In addition, many of the related tanks from the Taoyuan canal project were maintained by combining the existing tanks. The maximum water surface area of the fourth tank of the no.1 distributary (1-4 in Figure 4d) was 11.7 ha, while it's capacity was 257.2 cubic meter, water depth was 2.2 m, and the irrigated area was 74.3 ha. The shape is that of a

typical plate.

iii) Union General Headquarters Survey Office Topographic Maps (1957)

Figure 4b shows the condition in 1957, after the completion of the Taoyuan canal and governance has changed from Japan to the Republic of China. Tanks in the command area of the Taoyuan canal had been abolished, and many unrelated tanks had disappeared. On the other hand, outside of the beneficiary area of the Taoyuan canal, in other words, the south side of the Taoyuan canal main aqueduct and east side of the Nankan river, there were still a lot of tanks.

As such, reorganization of tanks made progress in areas where the new water use system had been introduced through the Taoyuan canal; outside of the new water use system, a system that is centered on tanks continues to exist. The changes in the water use system due to development are strongly reflected in the continued existence of tanks. This was before the urbanization and industrialization of Taoyuan district (Figure 2).

iv) CEPD Topographic Maps (1985–2003)

Figure 4c shows the distribution of tanks in 1985, when some progress had been made in the urbanization and industrialization of Taoyuan district. Since 1957, the Shimen dam and the Shimen canal have been built and put into operation for irrigation. In Taoyuan district, the south side of the main canal of Taoyuan canal is the command area of the Shimen canal, and the command area of the Taoyuan canal had its water supply stabilized. As a result, while tanks on the south side of the main canal of Taoyuan canal were abolished, many tanks remained on the east side of the Nankan River.

Significant changes had been seen in the command area of the Taoyuan canal. Even related tanks maintained through the Taoyuan canal project had been abolished. Tanks were abolished, especially those located at the center of cities, and they were converted to sites for schools, public offices and so on.

Changes in tanks shown on the first (1985) through fourth editions (2003) of the CEPD Topographic Maps include the abolishment of a large number of tanks on the east side of the Nankan River from 1985 to 1992. The topographic maps show that, in 1985, plants were established in the northern part of the same area, and, in 1992, plants were established in the southern part, as well. Meanwhile, urban areas spread concurrently. From 1999 to 2003, industrial plants and urban areas expanded even further, and more tanks were abolished.

When comparing 2003 (Figure 4d) and 1957 (Figure 4b), a large distribution of tanks was found in 1957 in the area outside of the command area of the Taoyuan canal, in other words, the south side of main canal of Taoyuan canal and the east side of the Nankan River. In 2003, even in these areas, tanks had been abolished. A factor in this abolishment is the introduction of a new water use system: the completion of the Shimen canal on the south side of main canal of Taoyuan canal. On the east side of the Nankan River, urbanization and industrialization were the major factors.

Cultivated land decreased with the urbanization and industrialization of the command area of the Taoyuan canal, and the related tanks of the Taoyuan canal were abolished. In 1957, there was only one related tank that was abolished. In 1985, six related tanks[12] were confirmed to have been abolished. Since then, each time the topographic map has been renewed, abolishment of related tanks were confirmed. In 2003, out of eighteen related tanks, only nine remained.

3. Existence of tanks in Taoyuan district: Abolishment and usage

1) Land use after abolishment of tanks

Table 2 organizes the related tanks of the Taoyuan Main Canal and abolishment conditions. In Taoyuan district, there are twelve tanks in the first branch aqueduct and six tanks in the second branch aqueduct, for a total of eighteen related tanks.

In the field survey, the present conditions of the related tanks and the land use after abolishment were confirmed. Compared to the 2003 "CEPD Topographic Maps (Fourth Edition)," two more tanks had been abolished. On the other hand, it was confirmed that the fourth tank of the second branch aqueduct continued to be present[13] .

According to the data in the literature data, abolishment of tanks peaked around 1980 (Chung Yuan Christian University (Department of Architecture), 1996). As Figure 2 shows, in the 1970s, the cultivated area started to decrease, and the population increased quickly. These conditions are reflected in the abolishment of tanks.

Land use after abolishment was as follows: five schools, two government agencies, such as city hall, one park, one hospital, one farm, one waste disposal site, and one urban planning site. This is similar to Japan (Fukuda, 1973; Minamino,

2006). The site of the twelfth tank in no.1 distributary (1-12) is vacant at the time of this study, but there are plans to build a government agency building.

Table 2. Situation of tanks and land use patterns after

Distributary	Tank	1957	1985	1992	1999	2003	2017	Year of abolishment	Land use after abolishment
No.1 Distributary	1-1	○	△	△	×	×	×	1976	High school Cmmunity center
	1-2	○	○						
	1-3	○	○						
No.2 Distributary									

Photograph 1 .

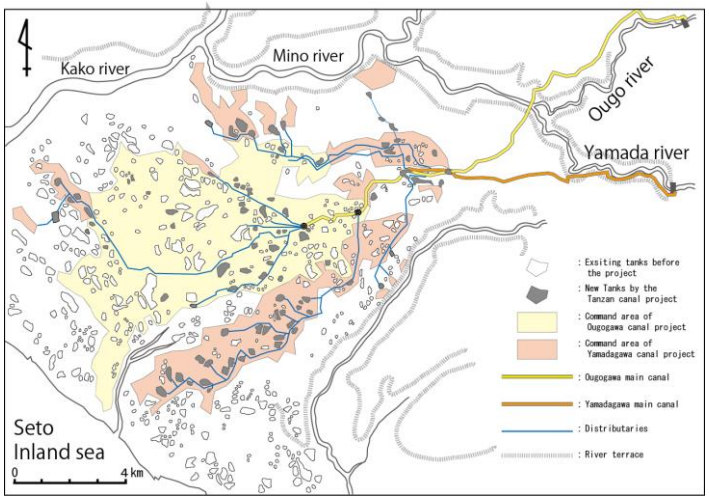
○:

So...

2) Current condition of tanks and usage

Looking at existing tanks, as discussed earlier, the fourth tank in no.2 distributary (2-4) was not confirmed using topographic maps. This related tank was used for fishing and fish-breeding tanks. As Takeuchi (1971) pointed out, in Taiwan, to provide economic support to war veterans, fish farming business in tanks was promoted. According to the Taoyuan irrigation association that manages related tanks, 261 out of 285 related tanks have a fish-farming contract. Of the related tanks in Taoyuan district, all ten tanks have fish-farming contracts. The Taoyuan irrigation association has a rental income from these contracts. However, the actual revenue is not significant for the Taoyuan irrigation association. The mowing around tanks is done by fish-farming businesses, which saves the labor required for maintenance, providing an advantage. At each tank, one can find fertilizer tanks or water stirrers for fish farming. In the fifth tank in no.2 distributary (2-5), a water circulation device was

Photograph 2 .



installed. In the thirteenth tank in no.1 Distributary (1-13), in addition to fish-farming facilities, it was operated as a leisure facility that provided fishing and barbequing services for the catch (see Photograph 1).

It was also confirmed that tanks are being used as water-friendly spaces. In the fourth tank of no.1 distributary (1-4), the local government manages the water amenity facilities and takes responsibility for maintenance, such as mowing. Tanks that are surrounded by rural farmlands may have "No Trespassing" signs, etc., while related tanks in suburban areas have fences that do not interfere with the landscape and view.

Figure 5. Distribution of tanks and the

Although the sixteenth tank in no.1 distributary (1-16) located in outside of city area, the whole tank is maintained as a park. In this park, there is a sign that says, "Introduction to Taoyuan Tank Culture" (see Photograph 2). Taoyuan local government promote cultural activities centered on tanks. Therefore, survey and research of these tanks are actively supported. For example, according to the Department of Architecture, Chung Yuan Christian University (1996), Council for Hakka Affairs edition (2003), and Cultural Affairs Bureau Taoyuan County Government (2007), in conjunction with the history of the Taoyuan tableland being reclaimed by immigrants from the Mainland, there is an attempt to consider tanks as local cultural assets. In addition, there are some attempts to use tanks as tourism resources (for example, Chen, 2006; Cultural Affairs Bureau Taoyuan County Government, 2007).

4. Comparison and transfer

Table 4. Outline of Taoyuan canal

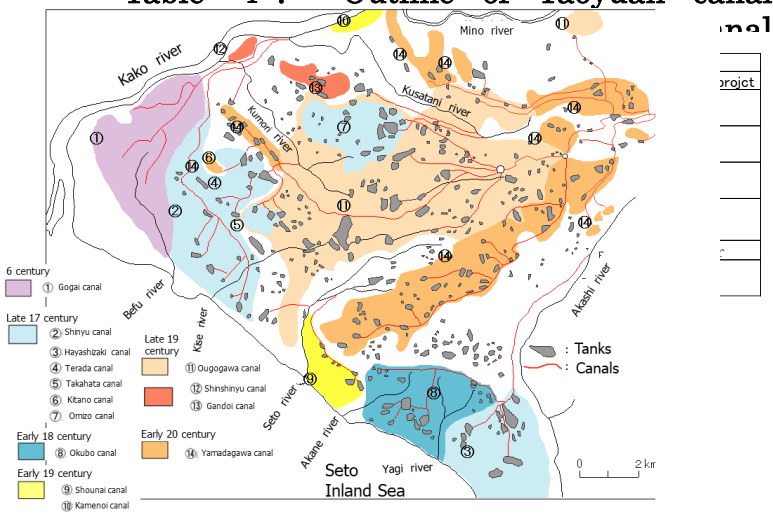


Figure 6. Canal projects in the

Table 3. Outline of canal project in Edo period in Inamino tableland

Name of canal	Year of construction	Source	distance from source (km)	Number of new tanks	Command area * (ha)	Intake water period
Shinyu canal	1655	Kako river	15.0	15	580.0	June, 20～Septenber 30
Hayashizaki canal	1658	Akashi river	13.5	13	235.0	October, 1 ～May, 31
Terada canal	1658/1672	Kumori river	5.8	14	289.2	May, 2～June, 23
Omizo canal	1669/1680	Kusatani river	8.2	17	345.0	September,1～May,1

Figure 5 shows the distribution of tanks and the Tanzan canal project, as we discuss later, in the the Inamino tableland in Japan. There are many tanks in the Inamino tableland. At first, the natural environments are cited in reason why these tanks were made. Annual rainfall is approximately 1,100mm to slightly exceed 1,000 mm to be required for rice cultivation. And the rainfall is unstable and unreliable because of the influence of monsoon. Although the Kako river that is biggest river in Hyogo prefecture flows near the region, they could not use the water of Kako river. Because the area is tableland, its altitude of tableland is higher than Kako river. Therefore most of this area was remained as wasteland and forest till late seventeen century.

The progress of the engineering technology such as the construction of castle and the economic reasons induced the development of the Inamino tableland. New canals using water from small and medium size river on the tableland were accomplished on this occasion (see Figure 6 and Table 3). A lot of tanks were made with these canals. Why were these tanks made? The water of those small and medium size river had been already used by people in downstream area. They did not permit to use water in irrigation period. But they permitted to use water after they use or during non-irrigation period. As Table 3 shows their intake water period is limited. Tank is required to store water in non-irrigation period, and to get stable water supply. As a result of these style of water resource development, the Inamino tableland became the most dominate tank irrigation region in Japan.

Western technology was introduced by the modernization of the Meiji and became able to carry water from a more far – off source of rivers. The Tanzan canal project could be implemented using western technologies, such as surveyor, steel products and so on. The Tanzan canal project is consisted two stage, those are the Ougogawa canal project and the Tamadagawa canal project. At this occasion, those intake water period were also limited. Therefore 27 tanks were constructed in the Ougogawa canal project and 64 tanks in the Yamadagawa canal project.

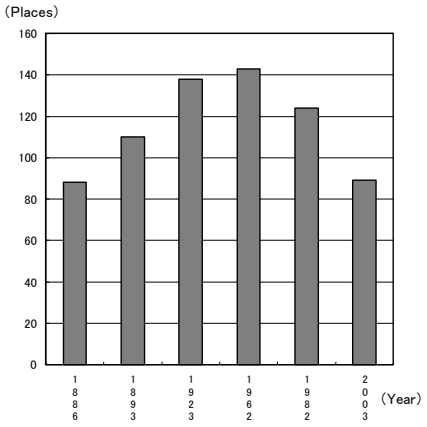


Figure 7. Transition of number of tanks

Source : topographic maps

Table 4 shows the outline of the Taoyuan canal project and the Tanzan canal project (the Ougogawa canal project and the Yamadagawa canal project). The Taoyuan canal project is quite large comparing with the Tanzan canal project from the view point of command area and design duty of water. But from the view point of design of water resource development, both are similar. That is idea of connection between river and tank. And those canal projects both were governed by Japan. The Tanzan canal project was carried out prior to the Taoyuan canal project.

The Inamino tableland mostly falls under the administration of Inami Town. Approximately 12% of total areas of Inami Town are occupied in tanks. Figure 7 shows the change of the number of tanks in Inami Town based on topographic maps in each times. 88 tanks existed in 1886. Then the tanks increase to 143 in 1962. However the tanks in Inamino Town decreased and became 89 tanks in 2003. And there are 88 in 2017.

To compare between tanks in the Taoyuan district and Inami Town, the number of the tanks increased till the Taoyuan canal project in the Taoyuan district, then a lot of tanks were abolished by the Taoyuan canal project. The number of tanks dramatically decreased. On the other hand, the number of tanks increased in Inami Town by the Tanzan canal project. After 1960's the number of tanks in both area decreased. What kind of reason is such a difference found in?

At first, the number of tanks increased together until these new canal project, the Taoyuan canal project and the Tanzan canal project. It means construction of tank was main way of water resources development. The condition of these canal projects different. In case of the Tanazan canal project, the intake water period was limited, mainly non-irrigation period. Therefore tank as a way of intermediate storage is required. In case of the Taoyuan canal, such function for tank is also required. But there many inefficient tanks. They should be re-organized from the view of water management and proper land use. Then the number of tanks became to decrease. On the other hand, the Shimen canal project initially planned to re-organized tanks, they could not implement it (Lee, 2016). After 1960's the construction of Shimen dam and the Shimen canal project was carried out in Taoyuan tableland in 1964 and the Toban canal project with three dams was carried out in Inamino tableland in 1992. These water resources developments make strengthen stability of water supply. The influence of urbanization and industrialization is commonly seen both area. This change of area has also been promoted to abolish tanks in two regions.

4. Conclusion

Our findings are summarized as follows. First, from the analysis of the topographic maps by years, it was shown that there is a clear relationship between water resources development and tank trends. Specifically, the reorganization of tanks through the Taoyuan canal project is quite thorough, as was pointed out by Takeuchi (1971) and Hatate (1986). However, as Kobayashi et al. (2014) indicated,

not all tanks in the command area were reorganized, and the existence of tanks other than those that were related was confirmed by our research. In addition, it was shown that tanks continued to exist even after the construction of the Taoyuan canal on the south side of its beneficiary area and the east side of the Nankan river. Since then, tanks on the south side of main canal of Taoyuan canal have become beneficiaries of the Shimen canal, and tanks on the east side of the Nankan river went through the building of plants and residential development. Thus, these tanks were abolished quickly. In addition, related tanks became abolished at the central part of command area of the Taoyuan canal. Abolishment of tanks is effected by not only irrigation projects, but also by the urbanization and industrialization of recent years. All of the tanks in the rural farm areas examined by Kobayashi et al. (2014) are still in existence, and the trends of tanks in rural areas and urban areas are different.

The new land use accompanying the abolishment of tanks includes public spaces, such as schools, government offices, and parks. This trend is similar to what we have observed in Japan. In addition, their usage as fish-farming tanks was pointed out by Takeuchi (1971), and this still continues.

Utilization of tanks includes cases in which they were converted into parks, water amenity spaces, and leisure facilities. In addition, there are attempts to utilize tanks as local cultural assets, and, furthermore, as tourism resources. In Japan, the activities at the "Inamino Tameike(=Tank) Museum" of Hyogo prefecture[14] are considered to use the cutting-edge approach. Compared to this approach, cases of the Taoyuan tableland are advanced.

Compared with the Taoyuan tableland and the Inamino tableland, it finds that there is similar progress of water resource development. Initially they constructed many tanks, then introduced canal, the Taoyuan canal and the Tanzan canal, furthermore constructed dams. The concept of the Taoyuan canal project and the Tanzan canal project is same. That is to connect river and tanks. The Tanzan canal project was ahead of the Taoyuan canal project. It might be transferred civil engineering technologies and knowledge. The number of tanks decreased in the Taoyuan tableland at the time of the Taoyuan canal project. On the other hand, the case of the Tanzan canal project bought to increase tanks. Recently, the both are influenced under urbanization and industrialization. Then the number of tanks has been decreased in the both area.

In this research, I was able to grasp the summary by the comparison of both. About examination of the individual detail, it is a plan clarifying in a future study. In addition it, this research pointed out that the Taoyuan canal project and the

Tanzan canal project

Notes:

1) With Japan as an example, construction of the Sayama Pond was supposed to have taken place in the year 616. In China, Anhoutou in Anhui Province was built in the Eighth to Fifth Centuries B.C., while Korea's Byeokgolje Reservoir was built in the fourth century (Osaka Sayama Tameike Museum, 2010). In addition, Nuwara Wada of Sri Lanka was built in the first century (Brohier, 1934) while tanks were built in Southern India during the fourth and fifth centuries (Vaidynathan and Sivasubramaniyan, 2001).
2) Dam database prepared by the International Commission on Large Dams: "World Register of Dams" (the fourth edition, secondary update data).
3) In Taiwan, the expression "圳" is used as canal.
4) In Taiwan, tanks are called "陂(塘) bēi (táng)" or "埤(塘) pí (tang)."
5) The Dahan river is the largest river in northern Taiwan with a length of 178.5 km. The downstream part flows through the city of Taipei and is called the Tanshui river.
6) Rotational irrigation is an irrigation method that separates the beneficiary area into several units (rotation sections), and the time and discharge/supply are determined by the staff. In this manner, water is diverted into each rotation section until it reaches the intake (Kan, 1981).
7) Taoyuan homepage http://www.tycg.gov.tw/.
8) For "Taiwan Baotu," the survey was conducted from 1900 to 1902, and it was completed in 1904. The 1:1,200 cadastral maps were edited to 1:2,000, and again edited to 1:20,000 to create the original map.
9) Survey department topographic maps were prepared from 1921 to 1929.
10) The Labor Union General Headquarters is the logistics department of the Ministry of National Defense, Republic of China. It is the present day Combined Logistics Command.
11) "CEPD" is an abbreviation for the Council for Economic Planning and Development. It consists of the Ministry of the Interior as the administrator and the logistics department of the Ministry of National Defense (Combined Logistics Command).
12) However, part of one of them exists as a tank.
13) The fourth tank of the no.2 distributary is not shown as a tank (water) on a topographic map.
14) Please refer to the Inamino Tameike(=Tank) Museum Board of Operations

(2012) and Minamino (2011).

References

Agarwal, A., and Narain S, eds. (1997): Dying Wisdom. Center for Science and Environment. (in English)

Brohier, R. L. (1934): Ancient Irrigation Works in Ceylon. Ministry of Mahaweli Development Sri Lanka. (in English)

Chen Cheng-Siang (1961): "Taiwan Topography." Shikimei Industry Geography Research Center (augmented edition was published by SMC Publishing Inc. in 1997). (in Chinese)

Chen Chie-Peng (2006): "Walking Map of Taoyuan Tableland Tanks." Cultural Affairs Bureau Taoyuan County Government. (in Chinese)

Chen F.H (1978): The Development of the Irrigation System and the Change of the Structure of Rural Settlement in the Ko-Ko-Kang Area, Northern Taiwan. Japanese Journal of Human Geography 30, 65–79. (in Japanese)

Chen Hung-tu (2003): "Taiwan Water Use History." Wunan Book Co., Ltd. (in Chinese)

Chung Yuan Christian University (Department of Architecture) ed. (1996): "Taoyuan Tank Survey Study." Taoyuan Prefecture Cultural Center.(in Chinese)

Council for Hakka Affairs (2003): "The Taoyuan Main Canal and the Guangfu Canal System Tank Survey Study." Council for Hakka Affairs. (in Chinese)

Cultural Affairs Bureau Taoyuan County Government (2007): "Brochure for Taoyuan Prefecture Tank Tourism: Pondspapago." Cultural Affairs Bureau Taoyuan County Government. (in Chinese)

Fukuda K. (1973): Abolishment of Irrigation Reservoirs due to Urbanization: The Current Situation and Background. Geographical Review of Japan, 46(8), 554–560. (in Japanese)

Harada T. and Yamazaki K. (1991): Water Resources Development and Rotational Irrigation in Taiwan. Geography, 36(7), 48–56. (in Japanese)

Hatate I. (1986): Water Resources Development in Taiwan. The Journal of the Faculty of Law, Aichi University (Economics and Business Edition I), 111, 109–152. (in Japanese)

Inamino Tameike(=Tank) Museum Board of Operations (2012): "Inamino Tameike(=Tank) Museum: Ten-Year History." Inamino Pond Museum Board of Operations office. (in Japanese)

Ito K. (1993): "Taiwan: 400 Year History and Outlook." Chuko Shinsho. (in

Japanese)

Kan, C.E. (1981): Water Use in Rotational Irrigation of Taiwan. Agricultural and Forestry Survey, 31(10), 2–11. (in Japanese)

Kobayashi S,, Morino Y., Kadono H., Tadakuma K., Kojima A., and Namie A. (2012): Changes in Tanks due to Irrigation Water Use in the Taoyuan Tableland, Taiwan Since the Colonial Period: Analysis Incorporating GIS. 2012 The Human Geographical Society of Japan, Research Conference Presentation Summary, 62–63. (in Japanese)

Kobayashi S., Morino Y., Kadono H., Tadakuma K., Kojima A., and Namie A. (2014): Development of Irrigation Water Use in the Taoyuan Tableland, Taiwan and Changes in Land Use: Analysis Incorporating GIS. E-journal GEO, 9, 172–193. http://jstage.jst.go.jp/article/ejgeo/9/2/9_172/_pdf (in Japanese)

Lee Liyung (2016): From canal to dam: Construction of Shimen dam and land use. Taoyuan reference, 1, 79-88. (in Chinese)

Nou T. (1935): Tanks on the Tableland in Zhongli District, Taiwan. Journal of Geography, 554, 33–37. (in Japanese)

Northern Region Water Resources Office, Water Resources Agency Ministry of Economic Affairs (2003): "Shimen Reservoir Operation 40th Anniversary Issue." Northern Region Water Resources Office, Water Resources Agency Ministry of Economic Affairs. (in Chinese)

Minamino T. (2006): Tanks of Hyogo. Hyogo Geography, 51, 11–19. (in Japanese)

Minamino T. (2011): Continued Existence of Tanks and Maintenance Measures: The Case of the Higashi-Harima Region, Hyogo Prefecture. Annals of the Association of Economic Geographers, 57(1), 75–89. (in Japanese)

Minamino T. (2014): Tanks in India and Their Conditions. Proceedings of the General Meeting of the Association of Japanese Geographers, 85, 157. (in Japanese)

Morino Y., Kadono H., Tadakuma K., Kojima A., Namie A., and Kobayashi S. (2012): Development of Irrigation in the Taoyuan Tableland, Taiwan and Development of Rice Paddies. GAIHOZU Research Newsletter, 9, 40–47. (in Japanese)

Osaka Sayama Tameike(=Tank) Museum (2010): "Osaka Sayama Pond Museum: A Guide to the Permanent Exhibitions." Osaka Sayama Pond Museum. (in Japanese)

Pan Cyao-Yang, ed. (2010): "New Taoyuan Prefecture Geography." Taoyuan Prefectural Government. (in Chinese)

Pearce, Fred (1995): The Dammed: River Dams and the Coming World Water Crisis. Kyodo News. (in Japanese)

Taiwan Literature Committee (2000): "Taiwan District Water Resources History Part III." Taiwan Literature Committee. (in Chinese)

Taiwan Literature Committee (2001): "Taiwan District Water Resources History Part V." Taiwan Literature Committee. (in Chinese)

Takeuchi T. (1971): Development of Water Use in the Taoyuan Tableland, Taiwan and Land Use. Geographical Review of Japan, 44, 665–684. (in Japanese)

Taoyuan Irrigation Association of Taiwan (2004): "The Taoyuan Main Canal 80th Anniversary Special Issue." Taoyuan Irrigation Association of Taiwan. (in Chinese)

Vaidynathan, A. and Sivasubramaniyan, K. (2001): Tank Irrigation in South India: An overview. Vaidyanathan, A., ed. Tanks of South India, Center for Science and Environment, 5–30.(in English)

Watanabe H. (1939): Taiwan Zhongli District Tableland: An Economic Geographical Inquiry. Journal of Chinese Historical Geography, 8, 789–790.(in Japanese)

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