Research article

The Legacy of the Waternetwork from the Past: Characteristics and Types of the Covered Waterways in Tokyo

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Abstract Edo was once a city of water and everyday life was intertwined with its rich water network. Unfortunately, the connection with water was lost due to the rapid urban growth of the city and now most of the local scale water streams in Tokyo are culverted. They have turned into green streets and their tributaries into narrow pathways. The objective of this study is to trace the covered waterways in the broader network of the blue and green infrastructure of the city and to catalogue them in accordance with their different features like design and usage. In the first part, analysis is done on the legacy of the urban streams from Edo to Tokyo. Furthermore, the methodology and the results of the research are presented, showing a map of the covered waterways and their classification. For this reason, two different scales of the linear elements are assessed. The findings show that, based on a short section, considering the width and landscape design, there are four groups of types of which three are covered kind of types. Based on assessing a few hundred meters long segment, there and five groups of types based on their primary usage each having two sub-types except for the last that has only one. According to the results a conclusion is drawn that today most of the covered streams in the city have some commonalities in their design and how people use the space. Typically, the route of most of those ancient streams is accompanied by endless kilometers of pedestrian and cycling paths regarded as "green ways". Together they form a rich network spreading throughout the city. They represent inclusive public spaces that plays a vital part in strengthening communities and need further research.

Keywords Tokyo, covered waterways, legacy, scales, typology

INTRODUCTION

Since its formation up until the end of Edo (old name of Tokyo) the city has been compared to Venice and Amsterdam in Europe. Unfortunately, the connection with water was lost due to the rapid urban growth of the city, especially after the Olympics in 1964 when many of the rivers and streams were covered by roads and now remain as hidden waterways. In his book Tokyo: A Spatial Anthropology, the renowned architectural historian Hidenobu Jinnai, 1995 states that water was the element that brought people together and the first public spaces in the city of Tokyo emerged on the riverbanks and around bridges. He argues that the waterways today, even though overlooked in the planning practices, are an asset so valuable as to make Tokyo stand up as a unique nature-based metropolis of the future. But even though “Edo- a beautiful city integrated into the great natural

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world'' today "the city itself faces a crisis because we, the citizens of present-day Tokyo are discarding this legacy in the name of functionality and efficiency (Jinnai, 1995)".

In the past decade a growing number of literatures appeared with the aims to evoke the water network of Tokyo. Moreover, in the midst of scrap and build culture, the attention is growing stronger for permanent elements in the city such as topography and terrain (Jinnai, 2017). While the existing works are focused in exploring the appearance and geographical features of the open and hidden waterways, a more comprehensive study is lacking in the field of their identification and cataloguing based on different features.

Therefore, this study is trying to fill the knowledge gap by adding more valuable information for studying the urban open and covered water network. Emphasis is given in exploring the smaller scale streams which have a local character and are mostly culverted and transformed into greenways. Both primary and secondary data are used to meet the objective of this study. Quantitative data comes in form of a map showing the covered streams and empirical data is presented by their classification by two different factors.

URBAN WATERWAYS TROUGH HISTORY

The city's connection to water through history is giving a background to the phenomena of the hidden waterways today. Using literature review and historical maps, three points in history are recognized as major water related transformations. Fig. 1 shows the timeline and the consequences of urban transformation to water in each period.

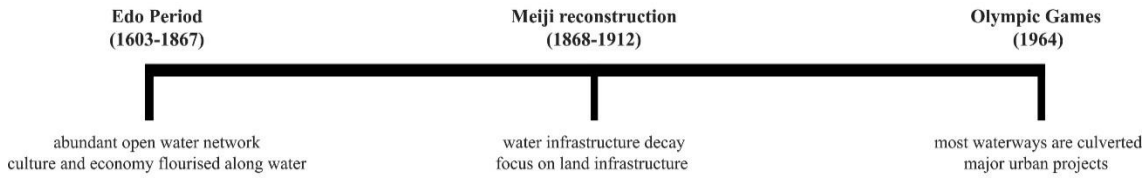

Fig. 1 Waterway transformation timeline for Tokyo

Edo Period (1603-1867): *Tokyo Aquatic*

Tokyo is a legacy of the original urban planning of Edo, the old name of the city. By definition the word 'Edo' equals an 'estuary'. This period was the most fruitful for the city expansion and the establishment of its wider structure that grew along with the spiraling moat system. The rich water network enabled a close connection to water for the people in the marsh lands. All sorts of commercial, cultural and even spiritual activities happened along the riverbanks in the low land Edo. Water is depicted in more than 80% of the paintings in "One Hundred Famous View of Edo", showing how entrenched it was in the livelihood of the people. Many of the shrines and temples were faced towards the water edge. In the peripheral areas of the city, numerous townships produced food and transported it by boats to central Edo making use of the rivers and aqueducts. According to the land use of Edo, over 40% of the land was used for farming (Fujii et al., 2002), Edo was a garden city making use of the abundance of water. As the city was growing over time, it took an organic shape respectful of the natural topography and conditions. "The city has been built with knowledge of its vulnerability to natural forces (Shelton, 2012) ". In this period not only did the city blueprint was established but also the cultural and social life reached its peak. Water brought value to people's life and there was a very sophisticated and sustainable water treatment unbeknownst to any western civilization at the time.

Meiji Restoration (1868-1912) and Taisho Period (1912-1926): *Channelizing Urban Waterways*

Meiji Era came as the time of industrialization and implementation of Western ideologies. To keep up with the trend of technological advancements, the process of industrialization took on a high

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speed in Japan. Neoclassical approach in the urban planning and architecture practices of the time was applied on top of the old layers of the city (Hein, 2008). Major transportation networks for cars and trains were planned but were not fully constructed due to the scarcity in resources after World War 1. As land transportation took over, local streams were left neglected, and the lively riverbanks slowly lost their cultural value and were left to serve as mere industrial complexes. Moreover, the city's water-based structure experienced a second huge disruption when the devastating Great Kanto earthquake of 1923 caused a myriad of uncontrolled fires that left devastating consequences on people's lives and their environments. This natural disaster has led to revaluation of the waterside spaces and their safety. The event marked the beginning of channelizing the city's waterways. The disaster response was a clear sense that "Japan had been granted an unprecedented chance to upgrade the city. (Charles, 2008) ".

Showa Era (1926-1989) to Modern Tokyo: *Local Culverts*

Showa period is represented by two contrasting periods, before and after World War 2. After the devastating raid that took over the city during the war, it took 6 years to completely recover. This period is when most of the waterways were covered due to safety, aesthetic and land reclamation reasons. In the upheaval period after the 50s big urban plans for the city were executed and local urban planners adopted the ideas that could easily implement the concept of *machi*-small town "comprised of many small towns with different purposes (Hein, 2008)". In line with those ideologies, planning principles from the 20s and 30s were adopted that emphasized polycentricity and green areas in between neighborhoods. In Tokyo Olympic Games land-based infrastructure grew immensely in order to give the city a new international look. There was a boom in the construction of expressways and many of the rivers and canals were left covered by the elevated road structures. This period of intense construction led to huge environmental crisis. The smaller scale waterways were contaminated, and people complained from the bad smell. Taking in consideration the natural disaster prevention management and the decay of the local streams, decisions were made to culvert most of them. In the 80s Tokyo was re-discovered as a city on water. Old societal ideologies that celebrated the connection to the natural environment and culture were reconsidered and gained popularity. Appreciation for the local qualities emerged again. Urban policies for the protection of water and greenery, and conservation of historical sites were established. Many waterside regeneration projects took part like converting the river coast into public leisure areas (Jinnai, 2017). Smaller and more local initiatives took interest in revival of the covered waterways that continued through the 90s.

Present Day Tokyo: *Reconsidering the Role of the Local Culverts*

Today Tokyo represents the largest city in the world, an agglomeration of many *machi,* a polycentric city (Shelton, 2012). The township culture is still kept until the present day, providing a sense of authenticity and belonging, a vital factor for strengthening communities (Kuma et al., 2021). Even though due to strong globalization forces the city has drastically lost its rural landscape and connection to water, the legacy of the abundant water network is kept in the form of myriad of greenways curving their way in the city landscape. They are very much used and treasured by the citizens.

Future brings challenges, and for Japan the main one is the demographic change, natural disasters and public debt (Ohno, 2018). When the challenges mentioned above translates onto the city landscape, it is expectable to see some urban patterns completely change. One of the repercussions will be the decaying infrastructure in suburban areas caused by the drop in residential density. According to Hidetoshi Ohno, in this scenario the city will be reduced to smaller centers with inclination towards urban greenery, supported with the creation of new open spaces. Reconsidering the role of the linear public spaces created on top of the culverted waterways is crucial for addressing the forthcoming challenges. It is important to examine what kind of asset those elements represent for the quality of life of the city dwellers.

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OBJECTIVE

Public spaces can solve a number of the above-mentioned challenges at once. They contribute for the increasement of biodiversity, humans' health and pollution. In the Japanese setting public spaces such as plazas do not exist but instead, multiple sites for social interchanges have been constructed to the scale and form that are appropriate to the Japanese physical and cultural context. Many of the small-scale common spaces are overlooked in the urban research practices but are frequently used and often exclusively known by locals. The linear public space, the path on top of the culverted rivers is such a place. Thus, this research is trying to address the importance of this urban phenomena in the context of Tokyo.

The objective of this study is to, initially, identify the location of the covered waterways in the broader network of the blue and green infrastructure in the city and, subsequently, to identify and group them in accordance with their design features and the way people use them. The study location is within Tokyo 23 Special wards. According to the classification given by Bureau of Construction (2015) there are Class A, Class B and Secondary rivers or streams. This research is focusing on the secondary rivers that can be either covered or open and are administrated by the wards.

METHODOLOGY

A research design was developed in an integrated manner to guide each phase of the research. Table 1 (Yin, 2014) defines a research design as a coherent and logical plan to collect data, measure and analyze the data collected, connecting empirical information to the research question and its conclusion. The research design created for this study is comprised of five consecutive parts: *Research question; Source of data; Methods of data analysis; Data processing & tools and Result.* In the first phase of the research, three questions were modelled in relation to the objective of the study. Secondary, the source of data needed to answer each of the question is identified. Primary data is being collected through extended systemized fieldwork of one year, from April 2020 to April 2021, using the map of covered waterways developed in the first phase of the study. Secondary data is collected from official digital maps, namely the online database from National Land Numerical Information in conjunction with Google Satellite View and the authors own fieldwork mapping based on observation. Methods of data analysis show how the data was studied. 20 samples were used to classify the waterways in question 2 and 3. To process the data, tools such as QGIS software, LiDAR 3D camera and Google Street View were used to process the data. The expected results from each research question are presented at the end of the research design.

Table 1 Research design

Research question	Source of data	Methods of data analysis	Data processing & tools	Result
1. What part of Tokyo's waterway network is covered?	Secondary data (National Land Numerical Information &Google Satellite View) +Primary data (field research)	Spatial distribution analysis	Overlaying both sources of data in GIS (Geographic Information System) software	Map of Tokyo metropolitan area showing open and covered waterways
2. What kind of waterways are there according to design?	Primary data (field research) + Secondary data (Open street Map)	Comparative analysis of 20 samples of waterways short sections.	LiDAR camera and Open Street Map measurement tool to measure the width of short sections	Classification based on types of design
3. What kind of waterways are there according to primary usage?	Primary data (field observation) + Secondary data (Google Street View)	Comparative analysis of 20 samples of waterways line segments.	Field observed data and Google Street View recordings of line- segments	Classification based on types of use (including design)

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RESULTS AND DISCUSSION

A digital map of Tokyo metropolitan area is showing what part of the water network of the city is covered and is serving as green corridor and what part of it are open rivers and streams is shown in Fig. 2. For data on the overall water network in the city the GIS Data on waterways from National Land Numerical Information (in blue) is used. To make a clear distinction between covered and open streams, data from Google Satellite view, municipality maps of greenways and field observation maps were combined to trace the covered streams (in red). Findings show that while there are a total of 712 kilometers of urban waterways, 490 kilometers or 68% are covered. In terms of distribution by districts, Edogawa ward has the largest number of waterways in total while Setagaya ward has the largest number of covered waterways landscaped like greenways.

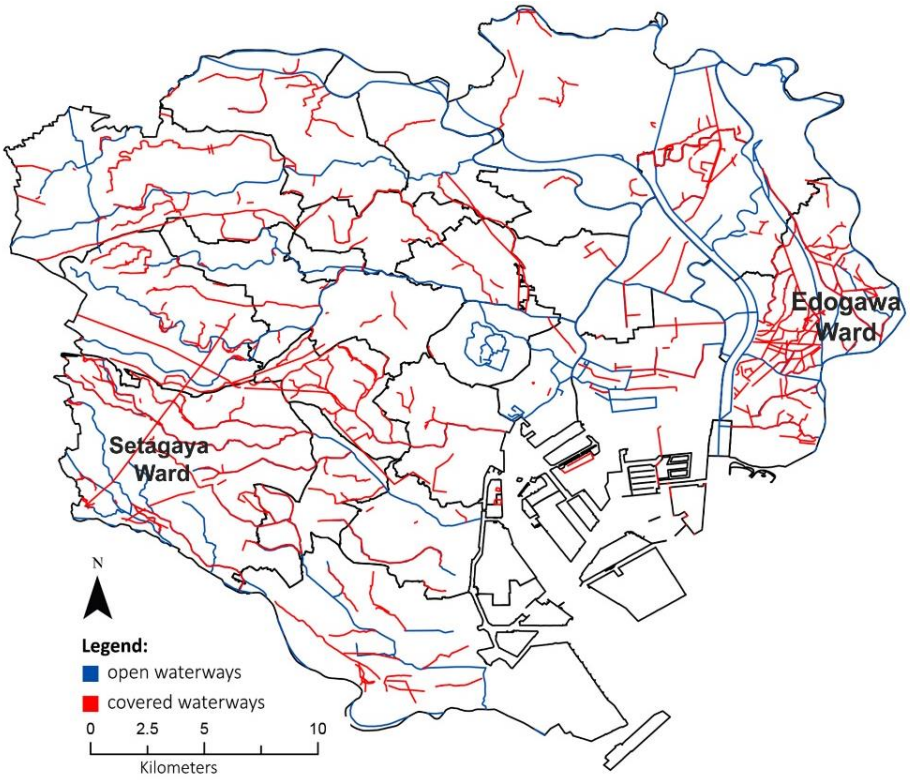

Fig. 2 Map of open and covered waterways in Tokyo

Given the linear shape of the waterway, varieties in use and design can be different in different segments. The same waterway can have a portion with an open stream and a portion of it that is culverted. However, in most cases the treatment is the same for the whole waterway. It is either open or covered. To respond to the second research question, a method was established that focused on the design on a waterway in a micro scale of a few meters long. The width of the waterway and its landscape design, the use of the adjacent streets like vehicle or pedestrian and the land use of adjacent plots were taken in consideration. After an extensive field observation, 20 samples of short sections of different waterways around the city were chosen to test the method. The types and their categorization into groups are presented in Fig. 3. According to the overall design there are four sub-typologies in the *large size group*, 5-12 meters wide. All of them are open. The other three groups represent the covered streams: *medium size*, 3-6 meters wide, typically landscaped like a greenway that can have surface water; *small size*, 2-4 meters wide, narrower greenways; *extra small size*, 1-3 meters wide, narrow pathways. The medium and the small size have four sub- types of covered streams while the extra small size only two.

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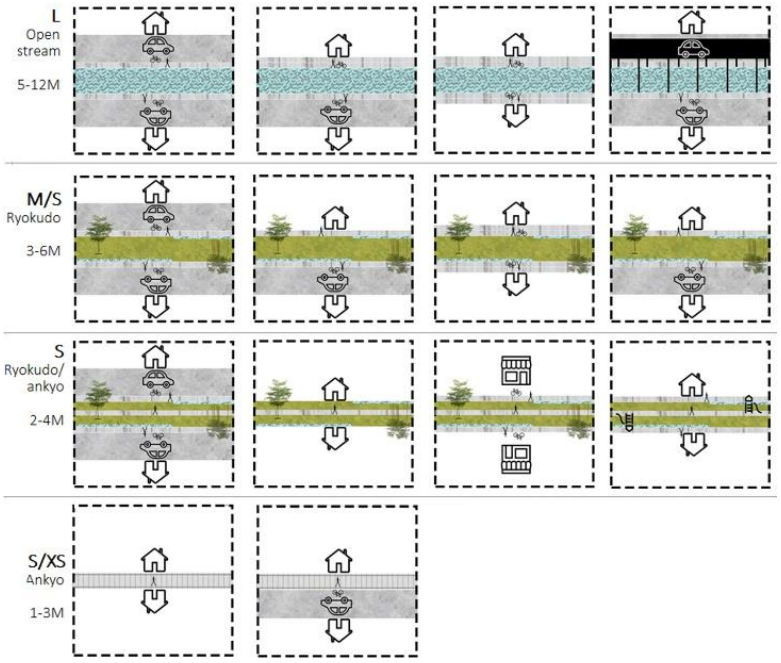

Fig. 3 Types of waterway segments based on landscaping

In terms of the primary usage of the waterway, it depends on the context of where they are located. For example, a stream can run through a commercial area or a residential area which in terms results in different characteristics of use. To respond to the third research question, a method was established that focused on usage of a waterway in a meso scale, of a few hundred meters long. This method tested 20 samples of line segments based on the frequency of users and type of activities they were doing there.

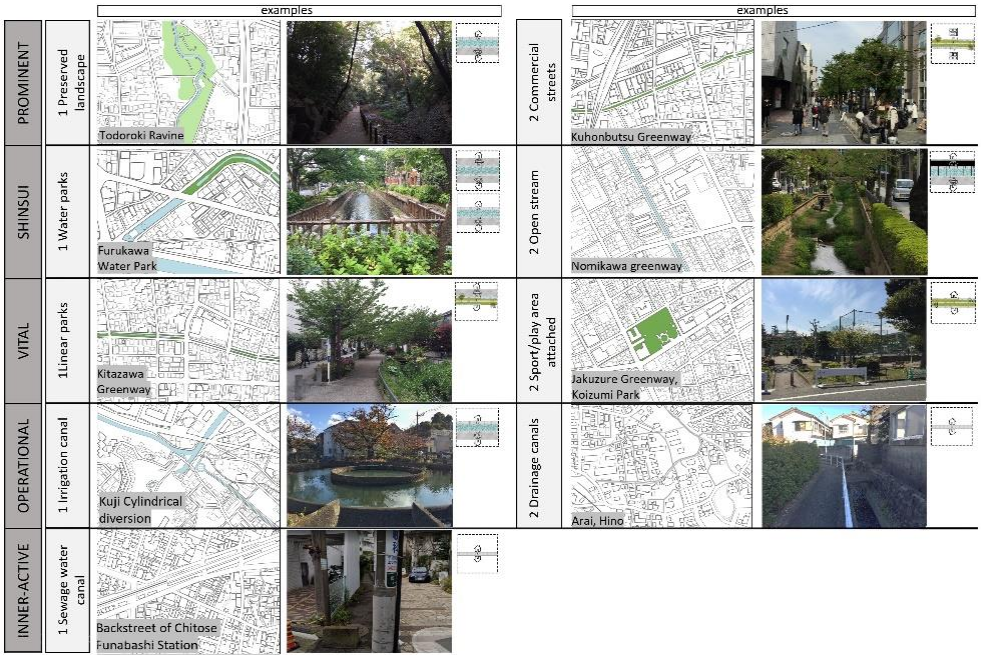

Fig. 4 Types of waterways in line-segments based on their usage

Fig. 4 shows the classification according to the types of use. They are categorized into five main groups: *prominent*-high intensity in use and popularity; *shinsui*-landscaped for water play and

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enjoyment; *vital*-long greenways that connect neighborhoods; *operational*-used for irrigation and drainage on the outskirts of the city; *inner-active*-narrow lanes. Each main type has several sub-types. The Prominent type: *preserved landscape*-protected nature with an open stream and *commercial street*-culverted stream in the middle of a commercial zone. The Shinsui type: *water parks*-landscaped as a water park playground and *open stream*-not landscaped as a water park but used as such. The Vital type: *linear park*-landscaped as a greenway and *sport/play area attached*-playground or a sport field is attached on the greenway. The operational: *irrigation canal*-supplying water for urban farming and drainage canals-small scale open type runoff water. The inner-active: *sewage water canal*- small scale pedestrian street.

CONCLUSION

The study examined two different scales of the urban waterways. Looking in the micro scale, it can be observed that different design principles were used to landscape the covered streams. Most of them are landscaped like linear parks with greenery and some have surface water or even water parks for play. In general, they are inclusively designed for pedestrian activity while most often than not, cycling is prohibited. The adjacent streets mainly have a controlled vehicle activity with speed and use limits. The land use of the area where the covered waterways flow is primarily residential and often times there are schools or sport fields attached to the waterway. In the meso scale different types of activities were observed. People used the space in accordance with its landscaping and the location of the waterway. For example, in the commercial zone people used those elements as pedestrian streets and rarely for recreational activities, while the water park and the greenway type saw a huge amount of people doing leisure activities. In conclusion the covered streams have a specific social, spiritual and environmental dimension. Today a new culture of life related to water, different from that of the past emerged after culverting the streams. A culture specific to the Japanese context of public space use and the challenges of the contemporary way of life. A further exploration of their quality as single linear entities and that of the network quality should be done to understand the broader implications of this urban phenomena in the whole city of Tokyo. For this matter the proposed methodology should be broadened to include an inductive approach for analyzing qualitative data.

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