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SUSTAINABLE WATER MANAGEMENT STRATEGIES FROM A HISTORICAL LANDSCAPE — CASE STUDY OF GANZHOU, CHINA

ZRÓWNOWAŻONE STRATEGIE ZARZĄDZANIA WODAMI W KRAJOBRAZIE HISTORYCZNYM — STUDIUM PRZYPADKU GANZHOU W CHINACH

ABSTRACT

Starting from the consideration that sustainability of landscape heritage is logically coupled with today's sustainable development needs, the research explores the general ideas, methods and strategies of ancient Chinese urban water management. Based on the traditional Chinese water management experience from the ancient city of Ganzhou, the paper — analyses the current water landscape heritage in Jiangxi Province, China.

Based on the historic experience and knowledge introduced and analyzed in the case study of Ganzhou, it is possible to define rainwater management principles and sustainable development strategies for modern urban landscape that could be the basis of a new research perspective in facing today's climate anomalies.

Keywords: Landscape Heritage, Urban Ecology, Waterscape, Sponge City, Ganzhou Stormwater Management

STRESZCZENIE

Zaczynając od konstatacji, że zrównoważony rozwój dziedzictwa krajobrazowego jest logicznie połączony z dzisiejszymi potrzebami zrównoważonego rozwoju, badania wskazują ogólne pomysły, metody i strategie starożytnej chińskiej miejskiej gospodarki wodnej. Bazując na tradycyjnych chińskich doświadczeniach w zakresie gospodarki wodnej ze starożytnego miasta Ganzhou, artykuł analizuje obecne dziedzictwo krajobrazu wodnego w prowincji Jiangxi w Chinach.

W oparciu o historyczne doświadczenie i wiedzę wprowadzoną oraz przeanalizowaną w studium przypadku Ganzhou, możliwe jest zdefiniowanie zasad zarządzania wodą deszczową i strategii zrównoważonego rozwoju dla nowoczesnego krajobrazu miejskiego, które mogłyby być podstawą nowej perspektywy badawczej w obliczu dzisiejszych anomalii klimatycznych.

Słowa kluczowe: dziedzictwo krajobrazowe, ekologia miejska, zarządzane wodą burzową w Ganzhou, *Sponge City* (miasto gąbka)

1. INTRODUCTION

With the continuous progress of urbanization and under the effect of climate change, China's urban problems are gradually emerging. In recent years, the urban waterlogging problem became more and more serious. (Kundzewicz et al., 2020) such as intense precipitation, high river discharge, flood magnitude, and flood loss in China. Part of this variability can be random or chaotic, but it may well be that climate variability track plays an important role in the interpretation of the variability of water abundance. The principal aim of this review paper is to create a summary of literature-based information on links of various climate-variability drivers, i.e. natural oscillations in the ocean-atmosphere system, and the variability of characteristics of destructive water abundance in China, at a range of spatial scales (national, provincial, basin-based, municipal). While modern cities are heavily affected by rain and flood, several settlements with traditional structure in China — for instance the Forbidden City — had no waterlogging problems during their 600-year history because of their complete drainage systems (Shao, 2019).

As one of the most representative world cultural heritage sites in China, the Forbidden City collectively represents the highest technical and artistic level of traditional Chinese landscape and urban architecture (Sun et al., 2020). In terms of preventing urban waterlogging, the designers of the Forbidden City made full use of the terrain to build palaces and estates on the plateaus. The rainwater harvesting and discharge system of Jiulong Drainage was designed internally, and drainage systems — including moats and culverts — were set up outside the city wall (Liu et al., 2019). In addition to the world-famous Forbidden City, Shen Yang Palace, Xi An City, Shang Qiu City, Jingzhou City, the ancient city of Ganzhou and several other cities do have drainage systems with similar principles, which have been in operation until now. However, compared to the other locations, Ganzhou has a longer history, but a lower financial and technological background in waterlogging management. Since the city was built at the confluence of the Zhangjiang River and the Gongjiang River, the conflicts between urban development and water related hazard is higher than in case of many other ancient cities of China. Through the historical review and case analysis, it can be more clearly demonstrated that the traditional Chinese water management strategy has been continuously improved over time, in spite of the insufficient funds available and

the uninhabitable environments. The results represent a useful theoretical input for today's sustainable landscape development (Tillie & van der Heijden, 2016)

2. GEOGRAPHICAL BACKGROUND

The city of Ganzhou — with its 9,830,700 inhabitants — is located in the lower reaches of the Yangtze River in the south part of Jiangxi Province. (Ganzhou Gov., 2019) (Ill. 1). The region belongs to the subtropical monsoon climate zone, with an average annual precipitation of 1461.2 mm, and an average annual temperature of 16.18°C (He et al., 2020; NMA, 2021). High in the middle and lower around — just like a tortoise floating on the water — the old city of Ganzhou is surrounded by water on three sides. This is the reason why the ancestors also called it 'The Turtle City' or 'The Floating City' (Li et al., 2020).

3. HISTORICAL OVERVIEW

Ganzhou City is one of the oldest cities in China. The city is located in an important position of China's waterway transportation, with a long history of urban development and a profound urban cultural heritage (Xu et al., 2018). After the first emperor of the Qin Dynasty (206 BC) established the State of Qin, he sent troops to guard Jiujiang County. The administrative system of Gannan began here. In 349 AD, Gao Yan founded Ganzhou City, the city area is 1.23 km², and the average height of the settlement is over 100 m above sea level. In order to strengthen its power, an expansion was completed in 910. Accordingly, the city area increased to 3.05 km² and the height of the city was 90 m above the sea level (Ill. 2.). In 1013, Kong Zonghan replaced rammed earth buildings with a brick city. During the Qiandao period of the Southern Song Dynasty (1165–1173), Hongmai built bridges to further expand the city. In 1668–1677 Yi arrived at Ganzhou and designed two underground ditches based on the local hydrology and geomorphology to alleviate urban waterlogging.

In 1867, Wen Yi took office in Ganzhou and asked the central government to repair the Fushou ditch, which was neglected and silted up during the war. At that time, it was difficult to allocate funds due to the central financial difficulties. Therefore, he established a model of management sustained mainly by local residents. This model has continued to exist, and the city has also been in the process of continuous expansion (Ganzhou Gov., 2020).

4. DISCUSSION

4.1. The evolution of water management in Ganzhou

Ganzhou, as a waterfront city, has experienced a large number of flood disasters during its history, and with the expansion and development of the city, the management of water resources in Ganzhou has been continuously improved. There are five stages of this process, presented in illustration 3.

Stage 1. With the establishment and gradual expansion of the city, as the urban areas approached the water bodies, and more and more waterfront areas appeared, floods became more frequent.

Stage 2. Analyzing the topography of Ganzhou, Yang Junsong, a geographer proficient in site selection and construction, conducted a replanning of Ganzhou based on the original (turtle) shape of the city. This new plan was focused on the prevention and control of floods, and introduced radial drainage channels based on the slopes of the tortoise's back. These were build so that to prevent floods from flowing back and also to discharge sewage. Simultaneously, a moat was excavated on the south side of the city so that Ganzhou became surrounded by water, and its central height was 1km away from the water body. Also, the water on the south slopes was possible to drain more easily. After replanning the water canals inside and outside the city, functional zoning of the urban areas was also proposed. The southwest section of the city was the training ground and the garrison camp. At the southeast of the city was the area of religious temples. The economic centre of the city had a gradual transition from the riverside area at the west. The east side became the main residential and commercial area.

Stage 3. Due to erosion through the years, the water-proof embankment wall and other facilities built from rammed earth have lost their usefulness and needed to be refurbished and rebuilt. After surveying the flood control facilities in Zhangzhou, Kong Zonghan — the new governor — decided to rebuild the key waterproofing feature. That is, to pull down the earth wall, and build a new brick wall. Upon the order of Kong Zonghan, melted iron was poured into the cracks in the city walls, and when the iron cooled down, the entire wall became impervious, according to the Luzhou Provincial Journal. At the same time, the wall was raised to 10 meters to effectively prevent flooding. The design of the city gates also fully considers the needs of flood control. In addition to the general defense function, Ganzhou's five city gates are designed as barriers against the flood, and combined with a strong wall they can effectively prevent flooding. After constructing the wall gate with

flood control as its primary function, a new landscape plan was also proposed on this basis. Urban flood control and landscape aspects were cleverly combined in the design of the wall and of a building, climbing on which the eight scenery of Ganzhou was possible to see as in a mirror, so the building was named: The Eight Mirrors (Ill. 4).

The Eight Mirror became China's first scenic landscape integration, and since then, various places had started to deliberately design the urban landscape (Cun et al., 2019).

Stage 4. Since the location of the city surrounded by water hindered the further development of Ganzhou, Zhijun Hongmai began to build a floating bridge on the Gongjiang River, which allowed the further expansion of Ganzhou City to the other side of the river. Due to the broad surface of the Gongjiang River and the rapid flow of water as well as the limitation of capital and technology available, it was difficult to build wooden or stone bridges. Zhijun designed a floating bridge consisting of 100 wooden boats, a unique landscape heritage of Ganzhou ancient city. Thus Ganzhou had developed from a city at the river to a city across the river. However, due to the increasing density of the city, the problem of waterlogging began to appear again (Ill. 2).

Stage 5. After Yi arrived in Ganzhou, he redesigned two elements of underground drainage under the original ditch system according to the local hydrology and landform in order to connect the water systems inside and outside the city. The drainage lines resembled the two characters 'Fu Shou' in calligraphy, so it was called the Fu Shou Ditch. The construction was completed in 1677, and since then, the waterlogging of Ganzhou City has been resolved (Ganzhou Gov.) (Ill. 3).

4.2. Research on the sustainable water management model

Two thousand years ago, Chinese ancestors developed the theory of site selection and construction of cities. In ancient times, cities were called 'Chengchi'. Literally, this means 'cities' and 'ponds'. 'Cheng' refers to the living area inside the city wall, while 'Chi' refers to the moat outside the city. According to historical sources (Guanzi, 2021), site selection and urban development should take place near the water, adapted to the terrain: the city has a higher location, and the water a lower one, convenient for residents to use the water, and at the same time, prevent floods.

Furthermore, these ideas of site selection and urban development are all from real-life experience, from tradition that is a historical knowledge derived

from practice. It can be concluded that traditional water management in China results from systematic engineering and active participation of local residents.

4.2.1. Systematic engineering: the combination of landscape and sustainable water management

Ganzhou's water management system comprises five main parts: Reservoir (1) — Fushou Ditch (2) — Sluice (3) — City wall (4) — Moat (5). Each element has a different water management function or urban landscape function. The city wall has the function of defense and flood control, and at the same time, it also has the function of viewing: the Eight Mirror Terrace and Yugutai built on the wall has been an urban viewing platform that has continued to exist to this day.

The reservoirs in the city have multiple functions such as water storage (household use, etc.), maintenance of ecological diversity, and regulation of urban climate. The reservoirs are linked by the Fushou Ditch. When the water level inside and outside the city rises due to heavy rains, the sluice gates are closed, no drainage is possible, and the water level inside the city rises, it is the reservoirs that can store the accumulated water in the city. According to the records (Ganzhou Chengxiang Ancient Street), 84 reservoirs are located near and connected to the Fushou Ditch (Ill. 5).

The structure of the Fushou Ditch in Ganzhou is divided into two parts: open ditch and culvert. The open ditch collects and discharges rainwater, and the culvert collects and discharges gray water. The culvert is an arched structure that is firm and stable. Increase the flow velocity to discharge the silt at the location.

4.2.2. Participatory management

In addition to fully considering the water management function in the design, the quality is also ensured during the construction process, and the continuous operation through the later maintenance, which make the sustainable water management of Ganzhou ancient city realized. The bricks and stones used in the walls of Ganzhou ancient city and the Fushou Ditch are donated by the local residents. The detailed information of the donors and builders is recorded on the corresponding bricks and stones, which helps to ensure the construction quality and unites the local community. Seal cutting marks from the Northern Song Dynasty to the People's Republic can still be found today, as a cultural layer in archaeology, recording the ancestors' construction and renewal process in water management. Local residents also participate voluntarily in the maintenance. Especially where part of the Fushou Ditch passes through

residents' buildings, the nearby residents concerned carry out daily maintenance and regularly clean up the sediments to ensure smooth drainage.

5. CONCLUSIONS

Ganzhou has gone through a thousand years of history. In the process of water management, it has been continuously adjusted and adapted to the local environment. Through the five-stage design and construction of the city, and a continuous maintenance and repair, sustainable water management has been finally realized.

The sustainable water management strategy for the ancient city of Ganzhou can be summarized in the following three points:

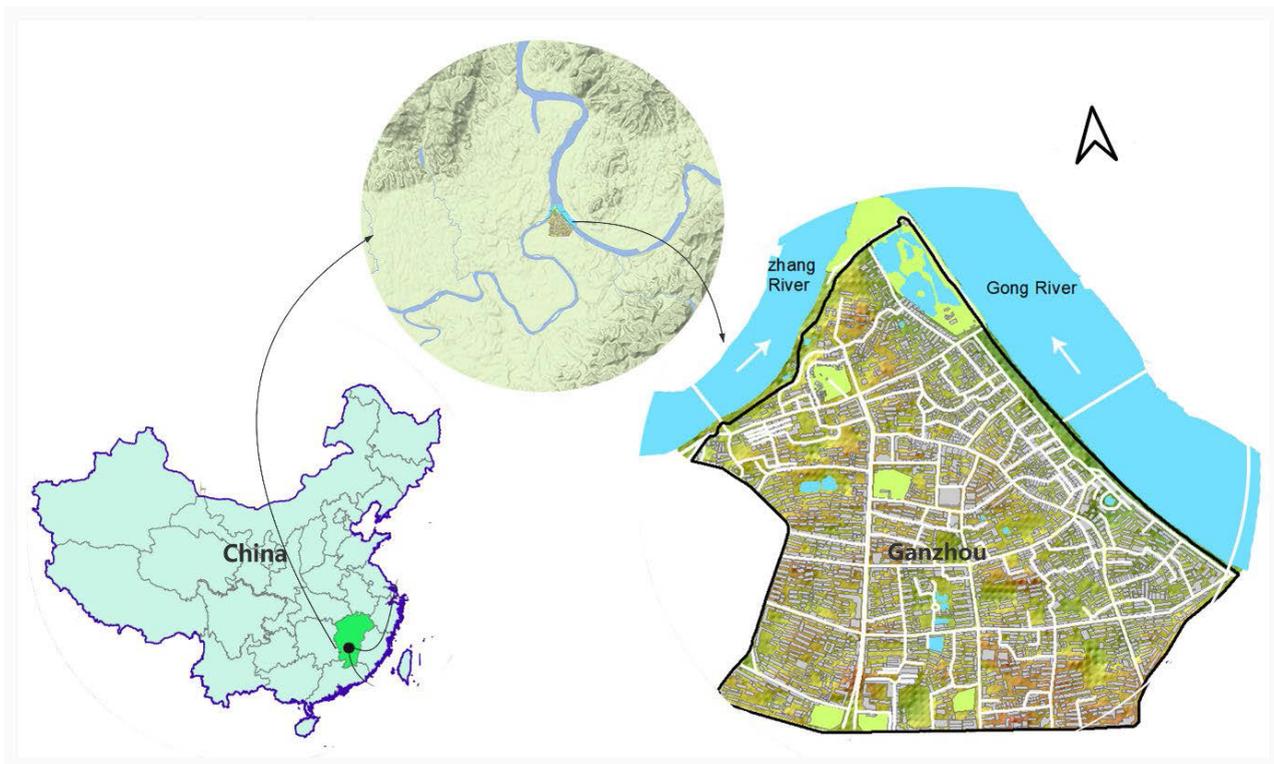
- 1) Realization of a systematic and adaptive design in blueprint;
- 2) Pursue of high standards and quality in the construction process;
- 3) Maintenance and implementation of an innovative management model and making full use of the strength of the local community.

Under the conditions of abnormal climate and more frequent water crises in modern cities, we can learn from the experience of Ganzhou City to achieve sustainability in the process of urban design, construction, and maintenance.

Systematic water resource management has to be the basis for urban, rural and regional planning, in combination with the needs of sustainable development. Systematic water management does not only protect settlements from floods, but more importantly, the connections and relationships between designed water bodies form an organic cycle, contributes to the increase of ecological benefits and contributes to an efficient energy transition. Residents' lives are also closely connected with this water cycle system. In this system, natural processes are used to purify water bodies, enhance the urban environment, maintain biodiversity, regulate climate, and shape urban landscapes. The social aspect also represents an important value, connecting local communities. The construction of the project can also achieve high social standards and high quality owing to the participation of local communities.

The historical continuity of local residents' lives and the local cultural value of urban infrastructure can also be derived from the concept of sustainability.

In the process of maintenance the participation of local residents is fully realized, and the concept of sustainability can be better disseminated from the perspective of social and environmental education. This is also of important value for the education and inheritance of the concept of sustainability.



III. 1. Location of Ganzhou City.

Source: Prepared by the Authors.

II. 1. Lokalizacja miasta Ganzhou.

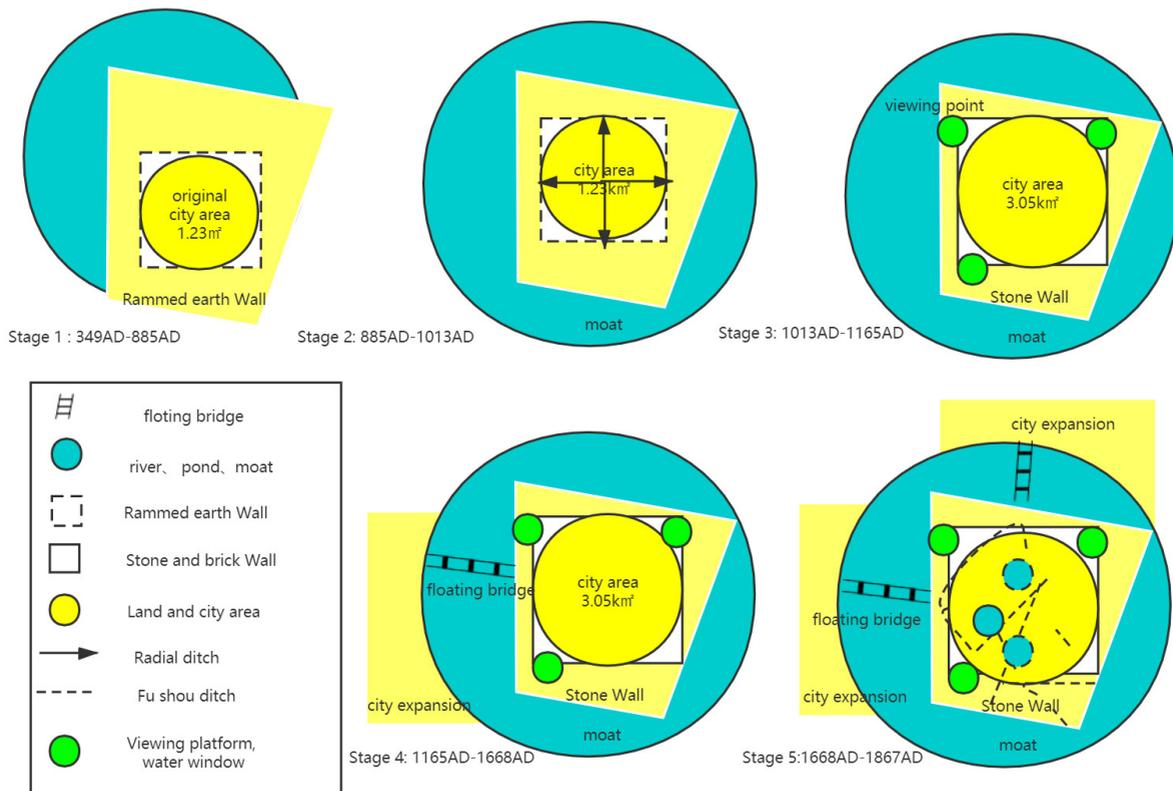
Źródło: Opracowanie własne autorów.



III. 2. The city–river relationship, Ganzhou.

II. 2 Związek rzeki z miastem, Ganzhou.

Source/Źródło: <https://www.davidrumsey.com/luna/servlet/s/uvp82r>



III. 3. The five stages of improving the water management in Ganzhou.

Source: Prepared by the Authors.

II. 3. Pięć etapów poprawy gospodarki wodnej w Ganzhou.

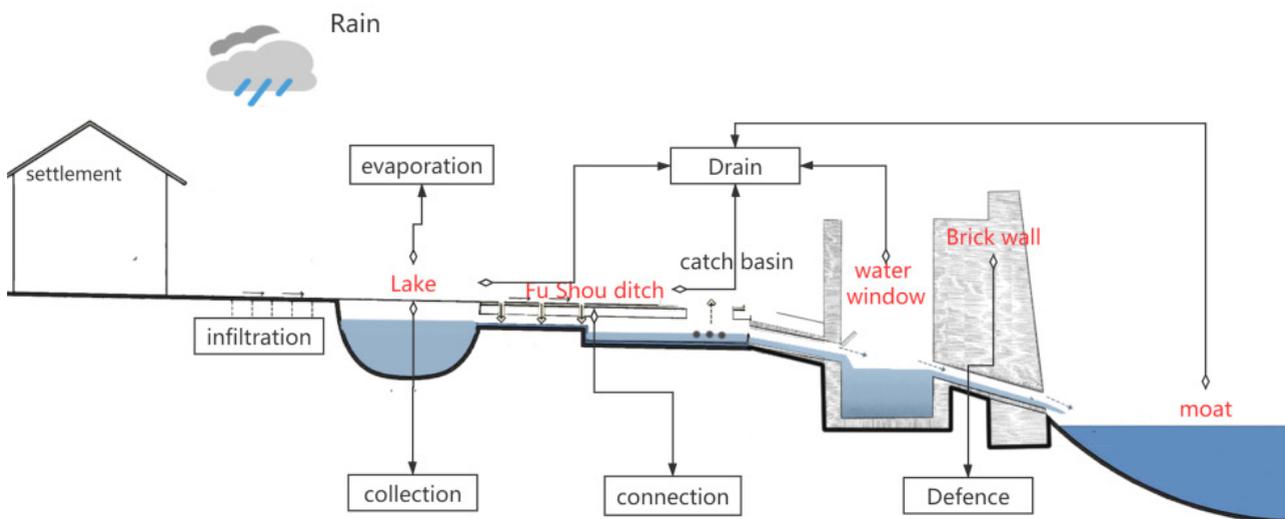
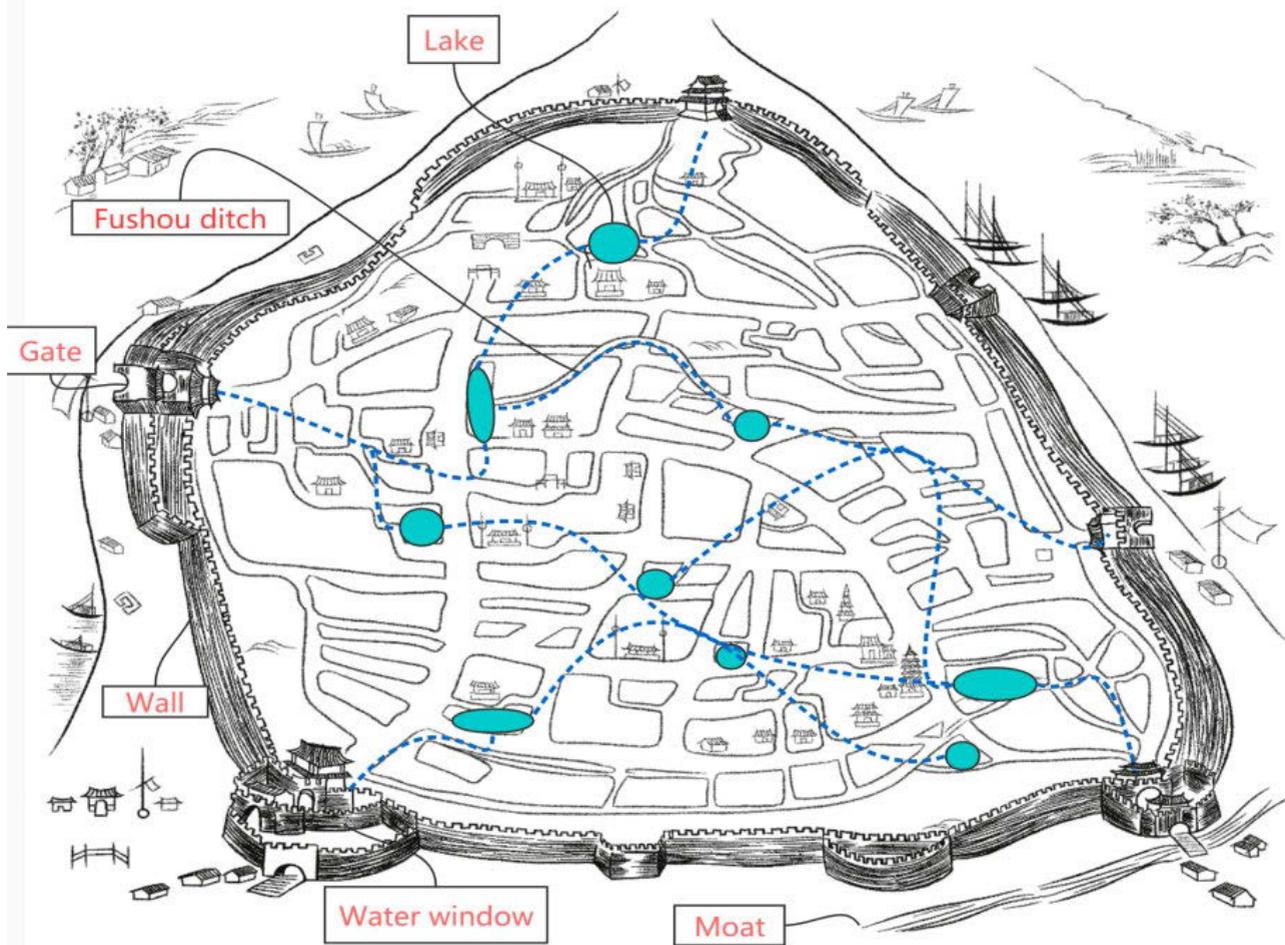
Źródło: Opracowanie własne autorów.



III. 4. The Eight Mirrors.

II. 4. Osiem Luster.

Source/Źródło: Photo by Li (2019).



III. 5. The water management system in Ganzhou City.

Source: Prepared by the Authors.

II. 5. System gospodarki wodnej w mieście Ganzhou.

Źródło: Opracowanie własne autorów.

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