Analysis of urban blue spaces accessibility based on GIS – a case study from Wuhan, China

Xinliu Yang - 964380

Supervisor: Prof. Mattia Previtali | Prof. Fabio Manfredini

Academic Year 2021/2022

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Abstract

L'acqua è un importante elemento paesaggistico che contribuisce alla salute umana e al benessere nelle aree urbane. Tuttavia, a Wuhan, in Cina, come in molte altre città del mondo in via di sviluppo, mancano informazioni dettagliate sull'accessibilità blu a diverse scale. Questo studio ha studiato l'accessibilità del blu urbano a Wuhan attraverso un questionario semi-risultato e una combinazione di dati sulla popolazione della comunità a Wuhan, in Cina, dati spaziali blu di diverse scale, rete stradale e altri dati GIS.

L'accessibilità del blu a Wuhan è misurata dalla distanza di rete (in metri) tra il punto comunitario e lo spazio blu più vicino. I risultati dell'analisi della distanza hanno mostrato che rispetto a fontane e stagni, i punti comunitari di Wuhan erano generalmente più vicini a fiumi e laghi e le aree situate nel centro della città godevano sempre di una migliore accessibilità blu (per i quattro tipi). tipi blu).

Inoltre, i risultati di questo studio mostrano anche che l'accessibilità dei punti della comunità di Wuhan a fontane e stagni è negativamente correlata al reddito disponibile pro capite regionale, il che significa che maggiore è il reddito disponibile pro capite regionale, più vicina è la distanza dalle fontane e stagni. Più è breve (migliore è la raggiungibilità). L'accessibilità di fiumi e laghi è non linearmente correlata al reddito disponibile pro capite regionale. Si ipotizza che la posizione di grandi laghi e fiumi non sia determinata dallo sviluppo economico, ma le condizioni geografiche siano fattori molto importanti.

I risultati forniscono informazioni utili per la politica e la pianificazione per garantire uno spazio blu adeguato ed eliminare le disuguaglianze ambientali.

Water is an important landscape element that contributes to human health and well-being in urban areas. However, in Wuhan, China - like many other cities in the developing world - detailed information on blue accessibility at different scales is lacking. This study investigated the accessibility of urban blue in Wuhan through a semi-resultant questionnaire survey and a combination of community population data in Wuhan, China, blue spatial data of different scales, and road network and other GIS data.

The accessibility of blue in Wuhan is measured by the network distance (in meters) between the community point and the nearest blue space. The results of the distance analysis showed that compared with fountains and ponds, Wuhan's community points were generally closer to rivers and lakes, and the areas located in the city center always enjoyed better blue accessibility (for the four types). blue types).

In addition, the results of this study also show that the accessibility of Wuhan community points to fountains and ponds is negatively correlated with the regional per capita disposable income, which means that the higher the regional per capita disposable income, the closer the distance to fountains and ponds. The shorter (the better the reachability). The accessibility of rivers and lakes is non-linearly related to the regional per capita disposable income. It is speculated that the location of large lakes and rivers is not determined by economic development, but geographical conditions are very important factors.

The findings provide useful information for policy and planning to ensure adequate blue space and eliminate environmental inequalities.

Index

chapter 1

Introduction

"Concerning psychological effects of the three environements [water, nature, urban] […], exposures to the two nature categories – especially water – had more beneficial influences"

(Ulrich, 1981, p. 548)

1.1

Research Background

Many predict that in the decades ahead, we will move beyond having just ca. 50% of the global population living in cities, to a much higher proportion - Perhaps as much as 70% by 2050, according to the United Nations (Bell et al., 2021). Urbanisation can have a range of negative impacts on human health, such as increased car ownership, leading to congestion and increased noise and air pollution; pressure on sewage systems; pressure on already stretched urban infrastructure (e.g. housing, transport and healthcare), and increased socio-economic disparities and problems such as poverty and crime (Hou et al., 2019). And densely populated urban areas can be cognitively and emotionally stressful, undermining mental health and well-being (Gong et al., 2012). Therefore, it is crucial for urban planners to create sustainable and healthy urban environments that promote human physical and mental health.

There is now a large body of experimental research showing that more natural environments reduce stress or promote recovery from attention fatigue and improve mood more than built environments (Hartig et al., 2014). As one of the effective measures, blue spaces are attracting considerable attention from policy makers and academic researchers. Quantitative and qualitative studies have shown that the use of blue spaces has a positive impact on the physical and mental health of people living in urban areas. And (Vries et al., 2016) found that blue space accessibility was more strongly associated with health variables than green space accessibility. Living near the coast has been shown to be associated with greater physical and mental health (Hooyberg et al., 2020; Pasanen et al., 2019; Wheeler et al., 2012). In addition to seawater, freshwater in cities also plays an important role, for example exposure to freshwater can reduce stress and provide cognitive recovery, as aquatic environments are highly restorative (Maund et al., 2019; Wang et al., 2016; Wilkie and Stavridou, 2013) and relaxing (Grassini et al., 2019). al., 2019). The presence of freshwater alone can induce health benefits by improving many environmental attributes, for example water features such as fountains can improve the soundscape by buffering anthropogenic noise (Axelsson et al., 2014; Jeon et al., 2012). The presence of freshwater can also improve thermal comfort by reducing the urban heat island effect (Gunawardena et al., 2017) and provide a variety of ecosystem services, including carbon sequestration (Apostolaki et al., 2019). In addition, water is an important and highly valued aesthetic component in terms of landscape preferences (Faggi et al., 2013; Velarde et al., 2007).

Considering that half of the world's population currently lives within 3 km of a freshwater body (Kummu et al., 2011), the role of blue space in influencing human health and well-being cannot be overlooked. As a sustainable urban environmental asset that can promote human health, access to urban blue space is an essential component of maintaining public health, and disparities in access to it can mean inequitable access to important health promotion resources, leading to unequal health outcomes. This is why we must gain a deeper understanding of the relationship between accessibility and equity of blue space, which is crucial for the physical and mental health of humans in dense cities.

Although UBS has been studied in the existing literature, there are still research gaps in (1) previous research on the accessibility of blue spaces has mainly focused on developed Western countries (Völker et al., 2018; Wüstemann et al., 2017), while little is known about the accessibility of UBS in developing countries. Given that non-Western countries are very different from Western countries in terms of urban environment, society, economy and culture. Therefore, research on UBS accessibility at different scales in non-Western countries can expand the scope of knowledge on UBS accessibility and equity. (2) Among studies that distinguish between types of blue spaces, studies of coastal blue spaces predominate (Amoly et al., 2014; Dempsey et al., 2018; Wheeler et al., 2012; White et al., 2017a; Witten et al., 2008a; Wood et al, 2016a). Relatively much less attention has been paid to freshwater blue spaces (McDougall et al., 2020). This is despite the fact that the volume and spatial coverage of freshwater is considerably smaller than that of the marine environment. However, it is imperative to investigate the health promotion potential of freshwater blue spaces, as more than 50% of the global population lives within 3 km of a freshwater body, with limited coastal access for those living inland (Kummu et al., 2011). Therefore, a better understanding of the relationship between access and exposure to freshwater blue spaces is essential to support a more comprehensive assessment of blue spaces as a public health resource. (3) Current research remains limited in terms of the scale at which blue spaces can be studied, with none of the articles included in (Smith et al., 2021) discussing the potential beneficial health benefits of microscopic, man-made blue spaces such as urban wading fountains. Given their health benefits in terms of relaxation and recreation, and their often reasonable scale in the urban landscape, research on these 'micro' urban blue spaces should be a focus of future research.

To overcome the limitations of existing studies, this thesis aims to use Wuhan, China, as a case study in an attempt to reveal accessibility differences between different regional groups by comparing the spatial accessibility of different scales of UBS in their city. To achieve this goal, this study aims to address two questions: (1) Is urban blue accessibility determined by the socio-economic background (2) Are there significant differences between different types of blue spaces in terms of accessibility? Examples include lakes, rivers and man-made fountains at different scales.

1.2

Dissertation Outline

The rest of the dissertation is organised as follows:

After a review of the global context and the smaller context of blue space to introduce the need for research on the accessibility of blue space, the second section of this study systematically reviews existing definitions of blue space and the relationship between human well-being in order to provide a deeper understanding. Specifically, it is divided into four sections: (1) an introduction to the comprehensive typology of blue space, which provides a better understanding of the existing definitions of blue space; (2) an introduction to the definition of the four existing exposure types of blue space; (3) the impact of each of the four exposure types of blue space on human physical and mental health; and (4) an explanation of how the presence of blue space, as an essential element of the natural environment, can bring benefits to the human habitat. (4) explain how the presence of blue space, as an essential element of the natural environment, can bring benefits to the human habitat.

Chapter 3 of this study summarizes the indicators related to blue space planning and design. In detail, it first describes the significance and importance of the Co-design mode in the planning and design of blue space. Secondly, through the summary of case studies, it expounds the strategies for improving the accessibility of rivers, because rivers are an important part of the blue space in Wuhan, and also analyzes the cases of small-scale interventions to improve the accessibility of blue spaces. Finally, this chapter is summarized and the prospect of future blue space planning and design is made.

Chapter 4 of this study systematically reviews the current literature related to the study of blue space accessibility. In detail, the definition of accessibility is reviewed, followed by a comparison of human-based and place-based accessibility analysis methods, and finally a list of existing blue space accessibility analysis methods, comparing them to their green space accessibility counterparts and drawing conclusions as to why the final analysis method was chosen.

Chapter 5 of this study is the most important section and focuses on the methodology of this study. In detail, (1) the study area - Wuhan, China - is first introduced; (2) the data collected for the study of blue spatial accessibility is presented, divided into two parts: questionnaire and GIS data. (3) The data collected are analysed using different methods and conclusions are drawn. In detail, the key indicators affecting the accessibility of blue spaces were first analysed through methods such as cross-tabulation analysis of local Wuhan respondents' questionnaire results, and then the OD matrix method in Arcgis was applied to study the differences in the accessibility of different scale types of blue spaces in Wuhan and to draw relevant findings.

The last chapter of this study includes a discussion and conclusion based on the results. In detail, first of all, based on the results of the previous accessibility analysis, economic factors of per capita disposable income are added, and SPSS data analysis software is used to analyze whether the accessibility differences of different types of blue spaces in Wuhan are related to per capita disposable income. income related. The results show that areas with higher per capita disposable income have better accessibility to ponds and fountains. The accessibility of lakes and rivers showed lower correlations, suggesting that geographic location is an important factor in determining the location of large-scale blue spaces, rather than economic development. Then it analyzes the strengths and limitations of this study, and finally summarizes the accessibility differences of different types of blue spaces in Wuhan.

chapter 2

water, blue space and health and well-being

2.1

Definitions and types of blue space and blue space exposure

The term "blue space" encapsulates all visible surface water in space and is similar to green space (Völker and Kistemann, 2011). In the review by (Smith et al., 2021), urban blue space is defined as all natural and man-made surface water in the urban environment. Examples include shores, rivers, lakes, canals, ponds and fountains located within cities. A more comprehensive and detailed explanation of blue spaces is given in (Bell et al., 2021), (Table. 01) which summarises the comprehensive typology of blue spaces it uses.

Table. 01

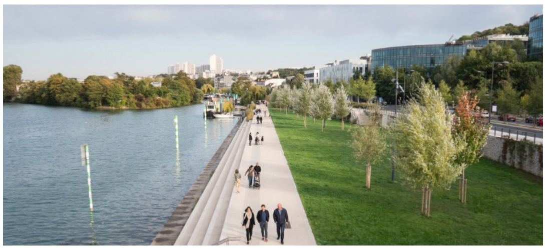
Summary of the blue space typology

Main categories	Types within the category
Constructed coastal spaces	Promenade, pier
Natural coastal spaces	Sandy beach, stony beach, sand dunes, sea cliffs, salt marsh, estuary
Lakes and other still water bodies	Natural lake, artificial lake, reservoir, pond, wetland, fen, marsh, bog
Rivers, streams and canals	Large river with artificial banks, large river with natural banks, medium-sized river with artificial banks, medium-sized river with natural banks, stream with a mix of artificial or natural banks, urban canal, rural canal, waterfall or rapids
Docks, ports and marinas	Dock, harbour, marina
Other blue infrastructure	Ornamental water feature or fountain, mineral spring, thermal spring, outdoor skating, curling or ice hockey rink, lido/ open-air swimming pool

Fig. 01-02: Constructed coastal spaces

01

Promenade



02

Pier

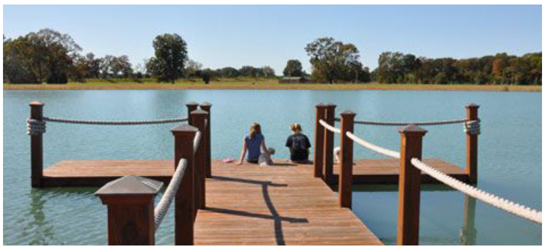


Fig. 03-05: Natural coastal spaces

03

Sandy beach

04

Stony beach

05

Sea cliffs

Fig. 06-08: Lakes and other still water bodies

06

Natural lake

07

Pond

08

Wetland

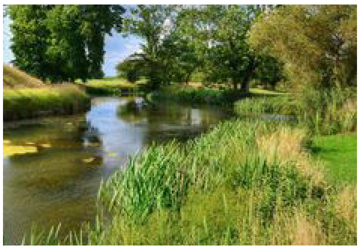
Fig. 09-11: Rivers, streams and canals

09

River with artificial banks

10

River with natural banks



11

Waterfall

Fig. 12-14: Docks, ports and marinas

12

Dock

13

Port

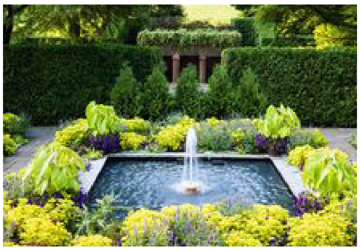
14

Marina

Fig. 15-17: Other blue infrastructure

15

Fountain



16

Outdoor skating

17

Open-air swimming pool

For many years, research on blue space has focused on its negative effects, such as drowning (Tyler et al., 2017), contaminated drinking water (Villanueva et al., 2014), increased risk of flooding and increased levels of disease transmission often associated with blue space (Völker and Kistemann, 2011). However, in recent years there has been increasing interest in understanding the potential beneficial health effects of blue space exposure (Grellier et al., 2017). In detail, there are four types of blue space exposure (Bell et al., 2021) （table. 02) :

Table. 02

4 types of blue exporsure

Types	**Explanations**
Home/work proximity	Live or work in the vicinity of the Blue Space
Indirect exposure	e.g. window views or TV programmes
Incidental exposure	i.e. exposure that occurs even though the main activity was for a different purpose, e.g. commuting
Intentional exposure	deliberately spending time in aquatic settings, e.g. for work or recreation

2.2

Potential benefits of blue space exposure for human health and well-being

Studies have now been conducted to show the relationship between various types of blue space exposure and health and well-being.

In terms of proximity to blue space, the relationship between living near blue space and people's health and wellbeing was first examined by Brereton et al. (2008), who found that people living within 2 km (but not 2-5 km) of the Irish coast were significantly more satisfied with their lives than those living beyond 5 km. Subsequent studies have found that living near coastal or inland bodies of water is associated with better mental health, for example in Canada (Pearson et al., 2019), China (Helbich et al., 2019), the UK (Alcock et al., 2015; Garrett et al., 2019b) and the Netherlands (de Vries et al., 2016). A longitudinal study in the UK found that, over time, the same people had better mental and general health in years closer to the coast (<5 km) than inland (White et al., 2013a).

In many developed countries, homes close to inland and coastal waters, particularly those with blue space views, tend to be more expensive (Gibbons et al., 2014). Economists argue that people are willing to spend more money close to blue spaces because of the additional benefits or 'utility' buyers receive. If this is true, then this 'hedonic pricing' approach would also suggest that happiness is derived from living or living near water. Some recent studies have also shown that the effects of living near blue space on health and well-being tend to be greater for people living in deprived areas (Wheeler et al. 2012) or in low-income households (Garrett et al. 2019b). Therefore, if more studies are conducted in the future to reveal differences in blue space access across income level groups, this may also help to mitigate long-term socioeconomic-related health inequalities.

Several recent studies on the relationship between indirect and incidental exposure to blue space and health and well-being have found evidence of the physical and mental health benefits of having a water feature visible from above. In New Zealand, for example, Nutsford et al. (2016) found that people with a view of the sea from home, controlling for distance (and other factors), had lower rates of poor mental health. In Hong Kong, Garrett et al. (2019b) found that overall health was significantly higher for those near a sea view, but was not associated with mental health. Finally, in Ireland, Dempsey et al. (2018) found that people with more sea views had a lower risk of depression. The latter two studies were both conducted on samples of older people. It has also been suggested that viewing blue space at home may be particularly important for older people with poor mobility (Coleman & Kearns, 2015). blue landscapes, they were less likely to show signs of depression. Crucially, the proportion of blue and green space in the satellite view had no significant effect on mental health, suggesting that the pedestrian view may be more important than the basic amount of land cover.

In terms of intentional exposure to blue space, (Garrett et al., 2019a) found in their Hong Kong study that visiting blue space for recreation at least once a week was associated with better psychological well-being. Another repeated conscious access to blue spaces that has received more research attention is outdoor (or wilderness) swimming. Outdoor swimming can reduce fatigue (Huttunen et al., 2004), promote mental health (Denton and Aranda, 2020) and may also be able to be used to treat major depression (Tulleken et al., 2018). There is also evidence that it can promote immune function (Tipton et al., 2017) and the treatment of inflammation-related diseases (Tiptton et al., 2017) and support higher insulin sensitivity (Gibas Dorna et al., 2016). Regular outdoor swimmers also report an increasing connection to their local and natural environment (Foley, 20152017), which in turn may lead to behaviours aimed at protecting these blue spaces in terms of health promotion.

2.3

Blue space as an essential factor in environment and health

In addition to the benefits of contact with blue space, as an important part of the natural environment, blue space also has a significant impact on human health by regulating the surrounding environment, particularly in terms of temperature, noise and UV light.

For example, as global average temperatures rise, urban environments are particularly vulnerable as they are better able to generate and retain heat than natural environments. Blue spaces, particularly in urban environments, provide an important thermoregulatory role, absorbing heat during the day when temperatures exceed water temperatures and releasing heat at night when water temperatures exceed air temperatures. In a review of 27 urban blue space versus non-blue comparison sites (mainly in China, Japan and Korea), Völker et al. (2013) found an average cooling effect of 2.5 Kelvin between May and October. in aquatic environments including rivers, lakes, wetlands, ponds and oceans, and in a range of climate zones including marine, subtropical and tropical lower temperatures were observed in a range of climate zones including marine, subtropical and tropical. The ability of urban blue spaces to mitigate urban heat islands has also been shown to be associated with positive human health impacts, such as reduced heat-related mortality in vulnerable populations within 4 km of water in Portugal (Burkart et al., 2015).

Also in terms of noise, water itself can significantly increase sound levels in the environment, so in this sense it may have the opposite effect to green space, which may absorb sound (Rådsten Ekman et al., 2013). However, the question is whether these aquatic sounds are considered 'noise' (i.e. unwanted sounds). In many experimental studies, water sounds, either in isolation (Thoma et al., 2018) or in combination with other natural sounds (e.g. birdsong) (Annerstedt et al., 2013), are more likely to reduce experimentally induced stress than city sounds, silence or conditions specifically designed to reduce stress (e.g. calm music). Adding pleasant water sounds (e.g. streams, waterfalls, the sea) to unpleasant traffic sounds can also improve positivity ratings (Rådsten-Ekman et al., 2013). Thus, while green space has the advantage of mitigating noise, blue space can actually add sound, but if these water sounds effectively 'drown out' more unpleasant sounds such as traffic, a more positive state of well-being can result.

Finally, blue space is also associated with higher levels of solar irradiance, resulting in higher UV exposure for those exposed to the sun. On the one hand, this increases the risk of skin cancer (Stenbeck et al., 1990), but it also leads to increased vitamin D synthesis, which is associated with a reduced risk of certain autoimmune and cardiovascular diseases, certain cancers and poor mental health (Cherrie et al., 2015). Clearly, personal behaviour is key in terms of time of day, duration of exposure, and self-protective measures.

chapter 3

Indicators of blue space planning and design

3.1

Co-design with local stakeholders

Co-design is a hybrid concept used in many disciplines and fields, such as service and product development, knowledge co-production in sustainable development transitions or collaborative planning and design of urban policies and plans (Evans and Terrey, 2016; Moser, 2016). There is now a growing recognition that those affected by design projects need to have a say in the whole process. In the context of planning and managing urban blue spaces, those affected by design projects often include citizens as individuals, but also stakeholders representing groups or organisations, such as different user groups of blue spaces, local residents, landowners, local government and council representatives, investors and local entrepreneurs (Stelzle et al., 2017; Webb et al., 2018).

An important part of co-design is learning, which takes place in a group setting through the exchange and sharing of knowledge between designers and the public/stakeholders (Cumbula et al., 2013). Ideally, during the co-design process, all stakeholders increase their knowledge and understanding. In effective co-design, it is assumed that citizens do not always speak the same language as experts. Therefore, one of the most important tasks of co-design is to create inclusive activities that facilitate the participation of all citizens involved. Because users are not necessarily professionals in the field under discussion who are free to ignore the feasibility of various aspects of the design (e.g. in relation to engineering, economic, technical, etc. constraints), the manager of the co-design process must 1) inform all participants of the possibilities and limitations of any proposed design solution and 2) envisage different possibilities that can meet the needs of the users. Users can benefit from potential options that they may have overlooked and designers can gain experiential knowledge about users. This should ultimately also support the creation of a richer knowledge base for better planning and design outcomes (Stelzle et al., 2017). Understanding the concept of Co-design is therefore crucial to the research objectives of this study, namely the subsequent design and planning of blue spaces.

3.1.1

Benefits and challenges of co-design

Co-design processes are intended to achieve three main goals: enhanced legitimacy of expertise (via collaborative knowledge exchange), increased relevance of design outcomes (via a fit better to the needs of citizens, users and other stakeholders) and a wider knowledge basis in support of design solutions (via the integration of multiple knowledge sources) (Moser, 2016). Examples of specific benefits of co-design include (adapted from The Co-Create Handbook, 2019):

- greater opportunities for discussion and reflection with different stakeholders;
- being able to form links and networks more easily, which will enable sharing information better than before;
- some groups and individuals who do not normally have a 'voice' may become included in negotiations and dia-logue;
- different stakeholders can gain greater responsibility for various stages of a project development process, which increases the motivation and commitment of everyone who participates.

Most challenges in co-design relate to working with inter- and transdisciplinary groups (e.g. creating a common lan-guage) but also to creating and managing meaningful collaborative platforms (e.g. facilitating the group dynamics) (Lee, 2008; Moser, 2016). Examples of difficulties encountered during co-design (adapted from: The Co-Create Hand-book, 2019) include:

- group size complexity: due to the involvement of a large number of stakeholders and design actors;
- social complexity: the personal characteristics of stakeholders and their relationships, as well as social style and differences of culture and knowledge, can limit effective collaboration; and
- resource-intensive management: it may be necessary to expend a lot of effort and time on specific communica-tion with individual actors.

3.1.2

Typical phases of a co-design process

Typically, the co-design process consists of three or four stages (Evans and Terrey, 2016; Lee, 2008; Stelzle et al., 2017) (Fig. 18).

Fig. 18

Typical phases of the co-design process, which ideally becomes an iterative cycle

Source: Mart Külvik and Anna Wilczyn'ska

1 Initiation:

This phase is the first step in realising the co-design process. This phase may involve several sub-steps：

- Understanding the context and setting goals, gathering information about the problem, identifying the most relevant stakeholders, and disseminating this information among these potential stakeholders.
- Clarifying the prerequisites for the collaborative process (e.g. laws and regulations, deadlines).
- Defining key structural aspects (e.g. funding, division of responsibilities).

2 Preparation：

Before the actual process of co-design begins, decisions about content and organisation are taken. This phase may include the following:

- Define aims and assignments;
- Inform all potential stakeholders;
- Clarify and record timescale and financial framework.

3 Realisation of the process:

Co-create and develop (practice-oriented) solutions, democratically agreeing on the sequence of events and the rights and obligations of the participants. The flow of information between the participants is organised and communicated to the public during the implementation process. Finally, the presentation and implementation of the jointly achieved results are clearly defined.

4 Reflection on the process and distilling of lessons for the future：

This summary phase focuses on emphasising that stakeholder identification and engagement should be iterative; for example, if important new participants become apparent and as the co-designed project evolves, they may be added to the stakeholder list during the process. In addition, the co-design process should encourage iterative learning (Reed, 2008): participants should be able to monitor progress and outcomes, and adapt future co-design projects based on lessons learned during the reflection phase.

3.2

Case inspiration for designing and enhancing the accessibility of different types of blue spaces

Waterfront development and water accessibility projects are a major component of current landscape architecture and urban design practice (Bell et al., 2021), a trend that has been on the rise since the 1980s with de-industrialisation and the development of new port technologies. Planners and designers are well aware of the need to make these places attractive, iconic, safe, easy to maintain as well as enhancing their accessibility, allowing users to be as close to the water as possible within physical and other constraints.

It is clear from current blue space projects that the vast majority of sites, wherever they are located, are very well used, and that in dense cities where green space is scarce, blue space provides an additional or alternative environment. This is why it is particularly important to understand the different design approaches to enhancing the accessibility of particular types of blue space - after all, designers are always looking to showcase projects with truly inspiring and unique site features, rather than very valuable but fairly generic solutions.

This section draws on a selection of case studies related to the type of blue spaces covered in this study, mainly in inland cities like Wuhan rather than coastal cities, to explore different design approaches and principles for enhancing the accessibility of different types of urban blue spaces.

3.2.1

Urban river revitalization

Rivers are a major component of the landscape and one of the key blue spaces in Wuhan, the study area for this study. The character of each river depends on several factors within the catchment that shape the surrounding landscape in different ways, while the surrounding environment influences the shape of the river through the interaction of topography, geology, climatic conditions and the erosion and cumulative activity of water flow (Prominski et al. 2012). And all along, most rivers have had a significant impact on the natural balance, cultural history, transport development and necessary freshwater supply of the areas they flow through.

This chapter highlights the importance of enhancing the accessibility of riverbanks and connected linear public spaces as places that benefit health and well-being, through a review of projects (collected from Blue Space related books and landscape design websites). These projects demonstrate a wide range of design approaches while retaining context-specific design, enhancing the accessibility of linear spaces along the riverbanks by bringing people physically closer to the water, enabling direct contact with the water or safe access within the project area, thereby enriching people's activities along the riverbanks and activating the corresponding landscape spaces.

Fig. 19

A view along the stream and the boardwalk at Norges-la-Ville

Source： Agence Territoires. Photographer: Nicolas Waltefaugle

3.2.1.1

Rivers and local identity

Case: Wet Meadow and Source of the River Norges, Norges-la-Ville, France

Source: https://landezine.com/wet-meadow-and-source-of-the-river-norges-by-territoires/

why this case:

In landscape design, respecting and presenting the identity and character of the region is a necessary foundation. And rivers are closely related to the identity of a community and its associated area. The project enhances the accessibility of the site while emphasizing the characteristics of the site itself, creating an important place for the local area.

Improve accessibility:

This project in Norges la Ville, France, is a wooden boardwalk system(Fig. 19). To enhance the site's accessibility, a series of stilt boardwalks bring walkers into this fantastic land without touching the ground, creating a feeling of suspension. This choice is a respect for the ecosystem, the protection of wildlife, and a technique that still maintains the path as the river floods and the water level rises. Meanwhile, some piers(Fig. 20) and wooden bridges(Fig. 21) are set over the tributaries of the site, bringing new perspectives to this poetic journey. Geometric contrasts also play an important role, juxtaposing the natural meandering curves of the river with the aggressive lines of the boardwalk.

Fig. 20

Wooden pier at Norges-la-Ville

Source： Agence Territoires. Photographer: Nicolas Waltefaugle

Fig. 21

Wooden bridge at Norges-la-Ville

Source： Agence Territoires. Photographer: Nicolas Waltefaugle

Fig. 22

A view along the Rhone riverbank

Source： IN SITU. Photographer Karolina Samborska

3.2.1.2

Rivers and urban life

Case: Rhone riverbank, Lyon, France

Source: https://www.in-situ.fr/#/en/projects/berges-rives/berges-du-rhone

why this case:

The project does not reverse the historical development of the banks of the Rhône, but adds a new component of blue-green public space to the urban environment. It replaces single-purpose spatial features and impervious materials, allowing people to reconnect with water in a premium riverside environment by creatively connecting the riverbank to existing infrastructure. While improving the accessibility of the site, it provides a convenient and lively place for people, forming a new model for the urban public to experience water.

Improve accessibility:

The project transforms the riverside parking lot into a multi-purpose public space, greatly improving the accessibility of the site and reconnecting the city and its inhabitants with the riverbank(Fig. 22). In detail, the 5-kilometer-long river bank facilitates relaxation and socialization, and encourages local residents and tourists to use public transport or light transport, and it also provides pedestrians and cyclists with a continuous route along the river. The upgrades to the sections ensure a safe and picturesque experience for cyclists(Fig. 23). It is worth mentioning that the project is also part of a trans-European cycling route from Lake Geneva to the Mediterranean coast. The appearance and thematic content of the linear route also changed during its course. The width is between 5m and 75m, which creates a different atmosphere, described as more natural in the upstream and downstream areas, and more urban in the central area. A large linear grass area, coupled with an easily accessible linear basin and a terraced open space(Fig. 24), provides a stage for viewing the river and defines the central section.

Fig. 23

Bike route

Source： IN SITU. Photographer Karolina Samborska

Fig. 24

Terraced open space

Source： IN SITU. Photographer Karolina Samborska

Fig. 25

Red ribbon as seat

Source： Turenscape

3.2.1.3

Being away at the river

Case: Red Ribbon Tanghe River Park, Qinhuangdao City, China

Source: https://www.archdaily.cn/cn/929121/qin-huang-dao-hong-si-dai-gong-yuan-turenscape?ad_name=article_cn_redirect=popup

why this case:

The last project may give the user a sense of distance from everyday life when approaching the river and entering it directly. The built solution may present challenges for each potential user at some point, but also offers the possibility to appreciate the natural and close-to-nature atmosphere by the water. While preserving the natural habitat along the river, the project enhances the site's accessibility with minimal intervention that creates space for people to rediscover the nearby urban wilderness.

Improve accessibility:

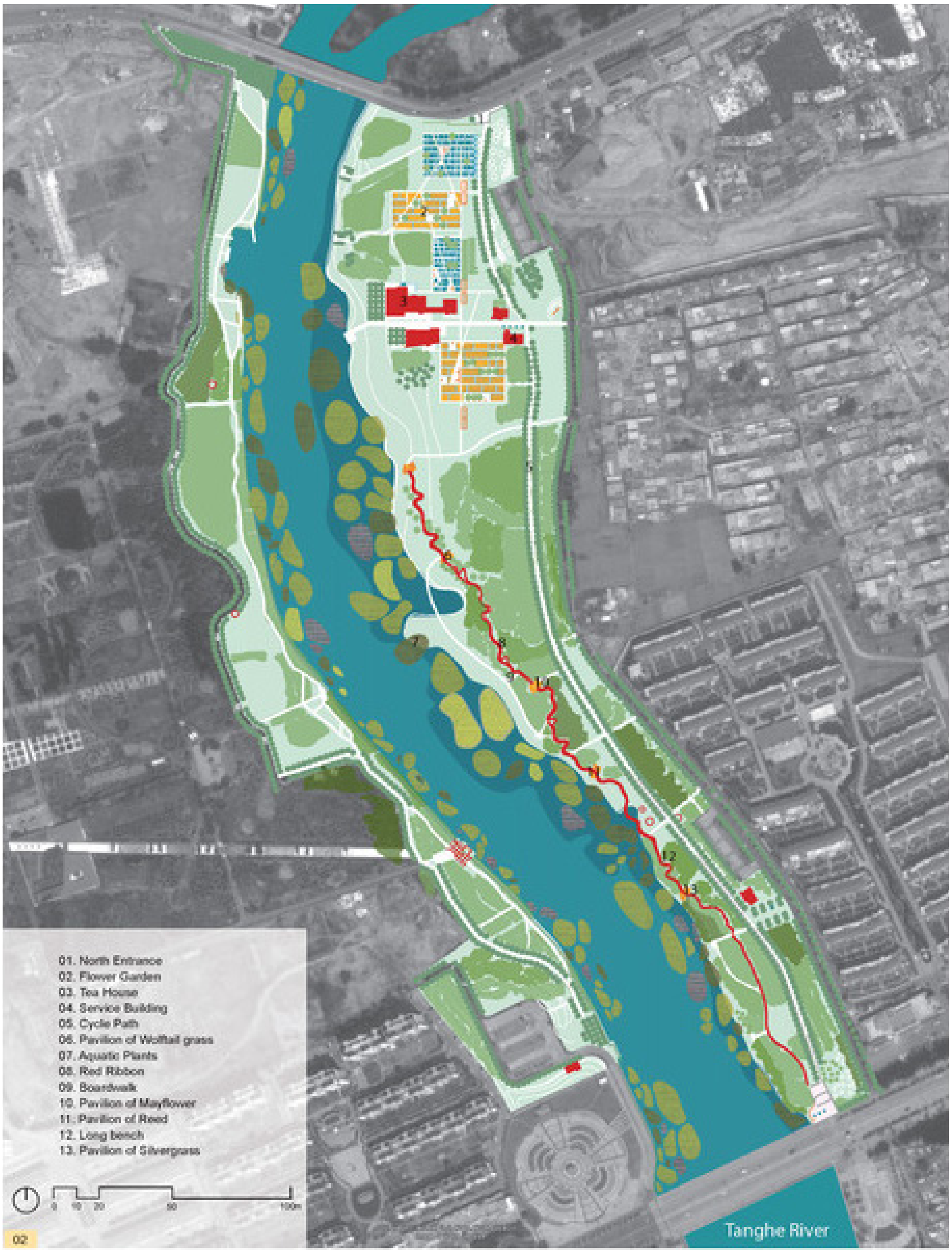
The Red Ribbon Tanghe Park project in Qinhuangdao, China, is located on the Tang River on the edge of Qinhuangdao's growing city(Fig. 26), a garbage dump with abandoned sheds, sheds and irrigation facilities covered in lush native vegetation. Although the venue has provided some recreational uses in the past, such as fishing or jogging, it is virtually inaccessible to most visitors.

The project incorporates obvious artistic elements into an almost forgotten natural terrain overgrown with vegetation. The red ribbon(Fig. 25) extends along a 500-meter-long rectilinear corridor, covering an area of about 20 hectares, integrating lighting, seating and directional signs. It shows how minimal but unique design solutions can enhance the surrounding river landscape. The red ribbon connects the natural vegetation to the new flower garden, providing a structural tool to reorganize the previously cluttered and inaccessible site. This minimal intervention transforms the previously inaccessible riverside into a recreational area, greatly improving the accessibility of the site.section.

Fig. 26

Project plan

Source: ArchDaily



3.2.2

Small-scale projects

This section contrasts with the previous section of this chapter, presenting small-scale projects that use different design approaches to improve site accessibility. Highlight the positive benefits of less but more, small but impactful. Since they do not require a large investment, they provide an opportunity for an experimental and playful approach, in detail, they can be used to experiment, analyze their impact, learn and translate the experience gained into larger-scale planning and design in principle. They demonstrate the scope of creativity and the potential for true experimentation with few of the risks associated with large capital-intensive projects.

And this section is detailed in three parts:
- Temporary interventions;
- Seasonal interventions;
- Permanent interventions.

Fig. 27

The seating on the steps near Piaskowy bridge viewed from the river

Source： Studio NO

3.2.2.1

Temporary interventions

Temporary interventions mean designed measures are built and then taken away, and photos and reviews help to recreate the impact of these projects.

Case: Micro-installations on stairs near Piaskowy bridge in Wrocław

Source: https://www.studiono.pl/?portfolio_page=mikroinstalacje-2

why this case:

With minimal investment and minimal design, the project brings into practical use a previously neglected and underutilized space near the river, greatly improving the accessibility of the site.

Improve accessibility:

This temporary facility was designed and constructed to provide recreational functions in an abandoned space near the river. Although the stairs to the water, built decades ago, provided an opportunity to see and get close to the water, there was no infrastructure needed for a long stay: no seating or benches. Wrocław-based studio No designed and built the intervention in 2016, with minimal investment and minimal design (almost none, according to the authors), near the river that was previously neglected And the underutilized space becomes practical and the accessibility of the site is greatly improved.

The installation is site-specific, revealing the potential potential of a place, and the design offers the possibility to stay, relax and socialize by the water while enjoying views of the river. And the units are constructed from simple plywood, which is easy to construct on site. Viewed from the other side of the river, colorful benches(Fig. 27) draw attention and invite users to explore the stairs near the river.

Fig. 28

A view of Olive Beach from the Pushkin Bridge showing the wooden decking structure.

Source： Wowhaus

Fig. 29

Shower jetty by the river

Source： Wowhaus

3.2.2.2

Seasonal interventions

Seasonal projects are primarily those built for a specific season, they are dismantled at the end of the season and rebuilt the following year. They can play an important role - activating spaces and providing different insights depending on the season - and this approach deserves wider consideration in design projects for the land-water interface.

Case: Olive Beach, Moscow, Russia

Source: https://www.archdaily.com/422423/olive-beach-wowhaus-architecture-bureau

why this case:

The project offers a more welcoming entrance, a comfortable summer retreat and a series of shower docks. After the summer, the entire structure was dismantled, removed, stored, and then reassembled the following summer. This intervention provides comfort and fun entertainment while enhancing riverside accessibility, where this type of use was previously unimaginable.

Improve accessibility:

In addition to providing a recreational area close to the water, the project aims to create a side entrance to the park that looks more "comfortable" than the plain granite and marble of the official entrance(Fig. 28), with a wood-paved area providing a warm, playful entry , making people want to enter more and improving the accessibility of the venue. At the same time, the project offers a variety of space-saving and comfortable options for lounging in the sun and has proven to be a popular spot in summer, turning a dull space squeezed between the wide river and the road through Gorky Park into a leisure area. Swimming in the river is not an option due to poor water quality, so visitors can cool off throughout the summer with a shower located on a pier that protrudes from the river(Fig. 29), a design that also brings people closer to the water.

Fig. 30

The Ljubljanica platform showing its relationship to the retained riverside wall and the steps leading down to the deck

Source: Breda Bizjak, BB arhitekti; photographer Jani Peternelj

Fig. 31

Project plan

Source: BB ARHITKTI

3.2.2.3

Permanent installations

Finally, the introduction of permanent installations. This project tells us that just because the project is small in scale and the cost is lower than that of general landscape design or construction projects, it does not mean that it cannot meet high standards. It can also take into account details and structure at the same time. Improve site accessibility.

Case: River Ljubljanica platform, Slovenia

Source: http://www.bba.si/ponudba/pier-at-the-grain-bridge-c-poljanski-nasip-ljubljana-slovenia.html

why this case:

The project is a successful case of reintegrating the river into the urban landscape through a series of small interventions, greatly increasing the accessibility of the riverside area and bringing a different perspective to urban life. These interventions bring the river closer to the community and are more visible in the day-to-day functioning of the city.

Improve accessibility:

The Zitni Bridge intervention consists of several elements. A precast concrete staircase and lounge area leads to a platform built over the water(Fig. 30). The pier itself is built on a steel pontoon and paved with timber. The pontoon moves up and down as the river water level changes. The piers are connected to the concrete platform by adjustable wooden and steel stairs.

The intervention provides a connection from the city to the water(Fig. 31), enhances waterside accessibility, allows visitors to perceive the urban landscape from an unusual angle, and also provides a space to view the river or a fishing platform. At the same time, the concrete seating area on this embankment allows for sitting and contemplative life, including the view of the frequent boats.

3.3

Conclusion and future perspectives

Improved access to blue spaces is a key objective of all projects, although realised in different ways. As far as this chapter is concerned, this research mainly selects the blue type-related cases with strong blue space correlation in Wuhan, that is, it mainly studies the type of river that runs through the entire city. Increased accessibility to this blue space will have an immeasurable effect on surrounding residents, with positive effects on health and well-being.

The series of cases selected in this chapter are intended to emphasize the following aspects:

- Emphasizes the importance of a linear public space connected to the riverbank and as a place of health and well-being. Depending on the project, depending on a variety of factors such as the local environment, topography, and respective historical or climatic conditions, the design team should come up with solutions tailored to local conditions, improving site accessibility and providing better opportunities to interact with water. In detail, the projects demonstrate a wide range of design approaches to strengthen people's connection to water by enhancing their direct or indirect contact or contact. In addition, by providing meeting and event venues, places to see and be seen, a wide range of activities can be performed at the water's edge. Beneficial application of riparian vegetation also helps to consolidate riparian banks and create a close-to-nature environment.

- Small-scale interventions can play a very important role in improving blue space accessibility, and in specific contexts, modest, inexpensive and community-led accessibility interventions can provide space for experimentation and testing, creativity and flexibility and time. This helps ensure that the final product is not only functional, but also accepted by the local community and more sustainable.

The neighborhood studied in this study is only the tip of the iceberg among the many types of blue space. Future research should tend to be more comprehensive, taking into account the various scales, types of blue space, and different accessibility interventions under different background conditions. In addition to paying attention to the important accessibility of blue space, the planning and design of blue space should also pay attention to the following aspects in the future:

Seating and opportunities for socializing

Seating near blue spaces is often combined with large decks or patios, but there are also linear benches or hybrid seating along the river bank, and in many riversides, informal floor seating is also an option, and users can bring their own blankets.

Use of materials

The use of materials should be determined by the local climatic and hydrological characteristics, the commonly used material is concrete, but planks are also widely used for bridge decks. Rocks and stones are also used to some extent as walls and to guide water, and the use of these materials, such as concrete or raw wood, is also associated with the purpose of reducing maintenance costs.

Use of vegetation and ecological aspects

Vegetation configuration is an important part of protecting blue space ecology and enhancing interaction. In many projects, the planting of new vegetation plays only a secondary role, but in many sites there is a large amount of existing trees and shrubs. This requires the design team to consider whether to choose ornamental plants, newly sown grass, groves, shrubs or aquatic plants and reeds according to local conditions.

Site management and maintenance

Maintenance of a project is an important step after the design is complete, and if construction follows high standards, with appropriate durable materials and good vandalism monitoring, this often reduces the need for extensive maintenance. But where wooden elements and surfaces are used as seating, these elements need to be constantly refurbished, taking into account the local climate and humidity. Keeping them clean at the same time helps keep them as social open spaces.

chapter 4

Literature review on measuring blue space accessibility

4.1

Accessibility definitions

The definition of accessibility has changed and evolved over the years. Accessibility was originally defined as the potential for interaction opportunities (Hansen, 1959). Later accessibility was defined as the ease of reaching a land use activity from a location by a particular mode of transport (Dalvi and Martin, 1976). In recent years, (Alam et al., 2010) accessibility has been defined as the ease of access to spatially distributed opportunities through the choice of travel. (Páez et al., 2012) define accessibility as the potential to realise spatially distributed opportunities (e.g. employment and recreation).

4.2

Place-based and person-based accessibility

Measuring accessibility based on people or locations are two widely used ideas (Ferreira and Batey, 2007; Miller, 2007). Person-based accessibility can be defined as the ease with which a person can reach a location of opportunity. It requires detailed personal activity travel information (e.g., GPS data, activity travel diaries) that is often unavailable or difficult to collect (Delafontaine et al., 2012). For example (Laatikainen et al., 2015a) investigated access to urban blue for different socio-demographic groups based on human accessibility. Their findings suggest that differences in accessibility are related to income level and car ownership. In addition, they conclude that water should be included in environmental justice and equitable supply studies.

Place-based accessibility is considered to be the ease with which a place or location can be reached. It assumes that individuals living in the same area (e.g. census tract, census block or postcode area) have equal access to the same number of opportunities and is known for its ease of implementation and usefulness in the planning environment (Delafontaine et al., 2012). It is simpler to calculate than person-based accessibility.

Many recent studies have used site-based accessibility measures to assess the spatial accessibility of UBS. For example (Wüstemann et al., 2017) analysed unequal differences in accessibility from a 500 m buffer around blue spaces in Germany, but the EUA land cover data used in this analysis only included spatial targets with a minimum area of more than one hectare, ignoring smaller sized targets such as smaller waterways in parks and gardens, and also including potentially basic services for the urban population of small ponds and larger fountains. Therefore, in this study I chose to use place-based accessibility measures to compare the distribution of UBS accessibility in different census areas in Wuhan, China.

4.3

Common blue spaces accessibility measures

It has been suggested that distance from home to blue spaces (e.g. coast, rivers, lakes) may be an important correlate of various health outcomes (Gascon et al., 2017). In previous studies, the most common methods for measuring blue space exposure and accessibility have been based on shortest distances, including linear distances (Halonen et al., 2014; Mavoa et al., 2019; White et al., 2017b; Wood et al., 2016b; Wüstemann et al., 2017) as well as network distances (Witten et al., 2008b).

Linear distance methods calculate the shortest distance from a selected location to the nearest blue space or buffer boundary edge, while network distances calculate the shortest distance from a selected location to the nearest blue space or buffer boundary edge along the street network, thus modelling walkability (McDougall et al., 2020). Network distances may be more appropriate for studies that focus on health outcomes that require access and accessibility, such as physical activity (Labib et al., 2020), or when investigating distances to freshwater blue spaces in urbanised areas with complex street networks. Network distance methods may also be particularly useful when considering freshwater blue spaces with inaccessible parts, as linear methods cannot take this into account. Linear distance methods may be more appropriate for considering health benefits that may occur regardless of access, i.e. observing blue spaces from a distance or environmental improvements such as noise reduction and temperature mitigation (McDougall et al., 2020).

4.4

Compared with other types of accessibility measures

Although in addition to methods based on determining the shortest OD (origin-to-destination) distance, there are other calculations involving determining the attractiveness of the destination and the demand of the origin to measure accessibility, such as common cumulative opportunity measures (Cordera et al., 2016, Handy and Niemeier, 1997) and gravity models (Hansen, 1959) . In contrast, gravity-based measures calculate the accessibility of a place by weighing the attractiveness of travel impedance to opportunities at that location (Hu, 2015; Liu and Kwan, 2020; Tahmasbi and Haghshenas, 2019), which is more realistic as location attractiveness decreases with distance rather than setting a one-size-fits-all cut-off value . A particular form of gravity-based measurement is the two-step floating catchment area (2SFCA) method (Luo and Wang, 2003), which has recently been widely used in studies measuring urban green space accessibility (Shi et al., 2020; Wu et al., 2018; Ye et al., 2018). However, few studies have used this method to measure the accessibility of UBS because the method needs to provide a supply and demand value, and blue space is different from green space or other medical and recreational facilities, and there is currently no standard for how much blue space per capita is required in China.

Therefore, in this study I have chosen to use the most commonly used web-based OD cost matrix approach to compare the differences in UBS accessibility across census areas in Wuhan, China.

chapter 5

Methodology

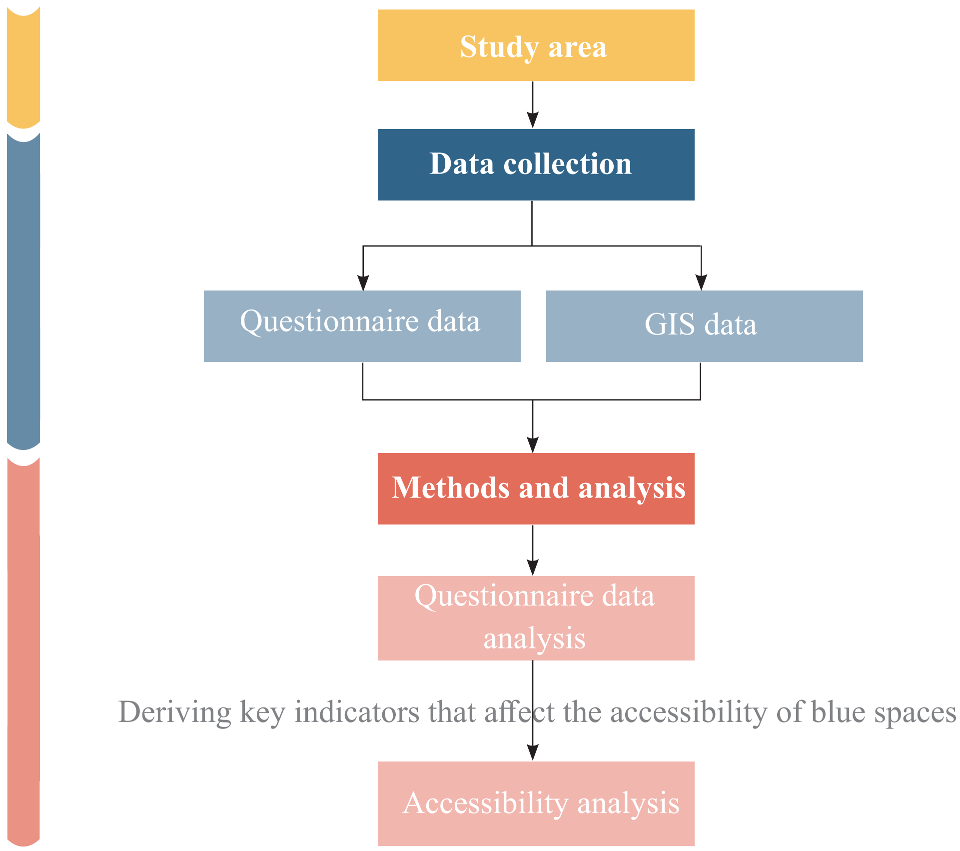
5.1

Research framework

Based on the literature review, this study proposes a research framework (Fig. 32) that will help to better investigate the differences in the accessibility of blue spaces in cities. In detail, firstly, the study area is identified, secondly, data on blue spaces in the area is collected (divided into questionnaire data and GIS data), the questionnaire data is used to derive key indicators affecting the accessibility of blue spaces, and the GIS data is used as the basic element for accessibility analysis. Next, the data were analysed and processed using different methods to produce the analysis results.

Fig. 32

Research framwork



5.2

Study area

The city of Wuhan, China (Map. 01) was selected as the study area for this study. It is located in central China (113°41′-115°05′ and 29°58′-31°22′) and is the only sub-provincial city in central China, as well as the largest city and economic, cultural and educational centre in central China, with an urban population of >10 million. With a total territorial area of about 8,494.41 km, Wuhan has about a quarter of the city's total water area and the highest water coverage in China (Yang et al., 2015), with a per capita water possession of about 40 times the national average and 10 times the global per capita level.

Famous rivers and lakes in Wuhan include the Yangtze River, Han River, East Lake and South Lake. The above rivers and lakes are scattered throughout the study area, along with other water bodies in Wuhan. The Yangtze River is the third largest river in the world, and its largest tributary, the Han River, runs through the city, dividing it into three parts, hence the name "River City". As at the end of 2017, there were 166 lakes of all sizes in Wuhan, including Liangzi Lake, one of the two most ecologically protected inland lakes in China. At normal water level, the lake has a surface area of 867.07 square kilometres, which is why it is also known as the 'City of Hundred Lakes' and the 'City of Rivers' (Wang et al., 2017).

In summary, Wuhan is a very suitable city for investigating the impact of different types of blue spaces on people in a city rich in natural water bodies, and the differences in accessibility to urban blue spaces for people of different socio-economic levels.

Map. 01

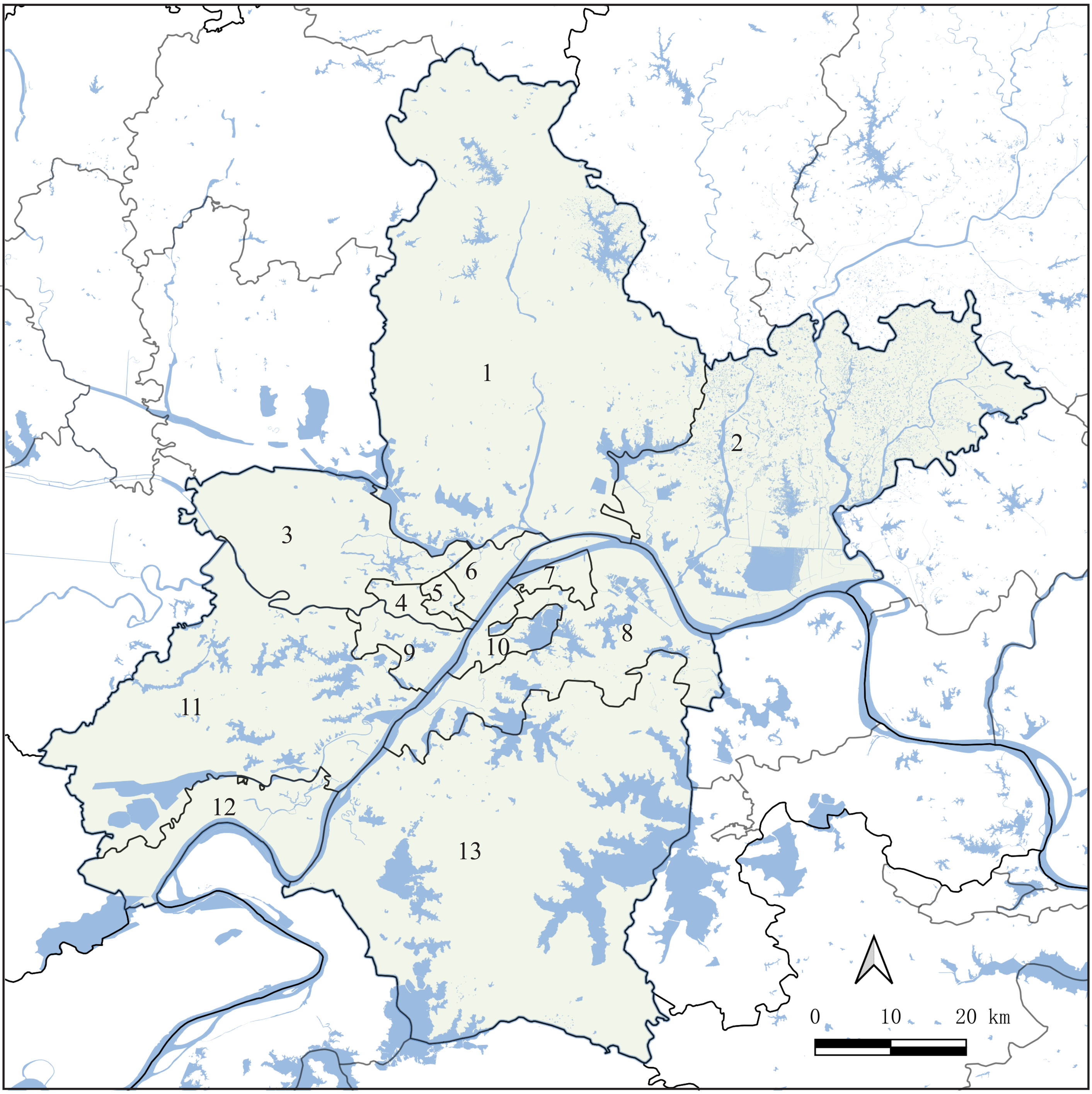
Study area in Wuhan, China

13 administrative districts and blue space distribution

Legend

Wuhan city area
Study area boundary
Blue space

1 Huangpi
2 Xinzhou
3 Dongxihu
4 Qiaokou
5 Jianghan
6 Jiangan
7 Qingshan
8 Hongshan
9 Hanyang
10 Wuchang
11 Caidian
12 Hannan
13 Jiangxia


1
2
3
4
5
6
7
8
9
10
11
12
13
0
10
20 km

5.3

Methods and analysis

The methods in this paper is divided into 2 main steps.

Step 1: Conduct a semi-structured questionnaire survey based on the Questionnaire Star Survey Platform (https://www.wjx.cn/) to obtain and analyze the key indicators affecting the accessibility of UBS. The questionnaire settings mainly include two parts: the characteristics of respondents and the factors affecting the accessibility of the blue space, and will be supplemented in the next section 4.4.

In the second step, the accessibility level of community points to different types of blue spaces was measured by web-based OD cost matrix measurement. The GIS data used includes the blue space type, settlement, road network, etc. of Wuhan. Detailed data sources are explained in the next section, 4.4.

5.3.1

Analysis of questionnaire results

Based on the results of the questionnaire, this study focused on the following analyses:

- For the analysis of the demographic characteristics of the respondents, such as region, gender, age, income, etc., and compare the results of the analysis with the census information from the Wuhan Statistical Yearbook 2021 to verify its reliability.
- Analysis of key indicators affecting the accessibility of the blue spaces, such as type of frequent visits to the blue spaces, mode of travel, walking time, duration and frequency of visits, activities undertaken in the vicinity of the blue spaces and quality assessment.
- The results of the different options were cross-analysed to derive the relevant factors influencing the accessibility of blue spaces.

5.3.1.1

Analysis of respondents characteristics

Title :

Analysis of Wuhan demographic variables

Variables	Options	Frequency	Percentage
district	Jiangan	76	7%
	Jianghan	87	8%
	Qiaokou	67	6%
	Hanyang	85	8%
	Wuchang	77	7%
	Qingshan	82	8%
	Hongshan	95	9%
	Dongxihu	77	7%
	Hannan	87	8%
	Caidian	67	6%
	Jiangxia	91	9%
	Huangpi	72	7%
	Xinzhou	90	9%
gender	male	530	50%
	female	523	50%
age	<20	346	33%
	20-40	404	38%
	40-60	206	20%
	>60	97	9%
income	<5000	563	53%
	5000-10000	296	28%
	>10000	194	18%

Table. 03

Source：
Questionnaire results from the "Questionnaire Star" survey platform

The results of the Wuhan Population Survey show the numerical characteristics of the variables, which reflect the distribution of the respondents, their gender, age and income.

Title :

Population distribution in Wuhan

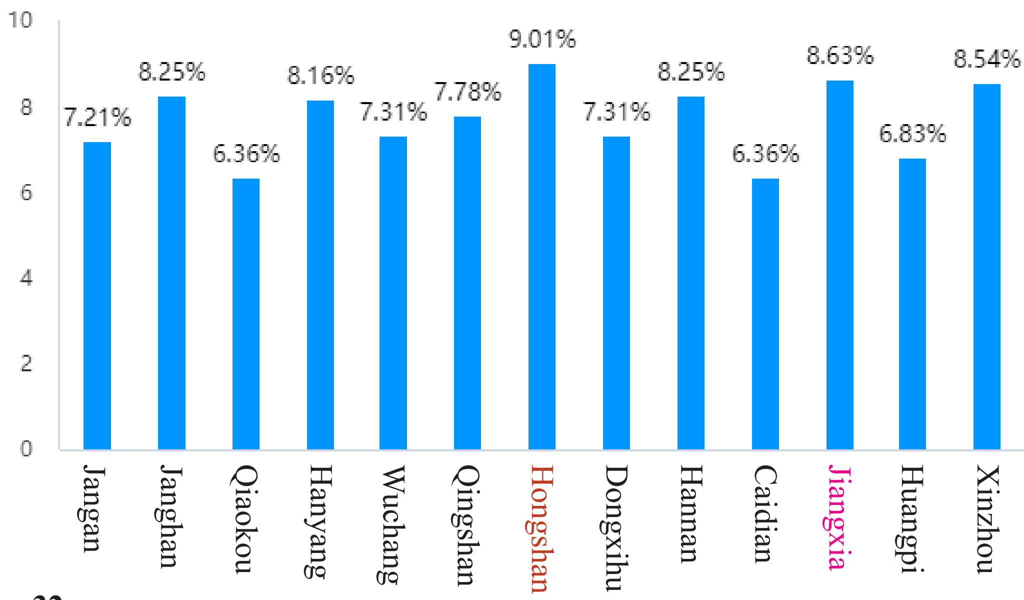


Fig. 32

Sources：
Questionnaire results from the "Questionnaire Star" survey platform

District	Population (million)
Jiangan	96.53
Jianghan	64.79
Qiaokou	66.67
hanyang	83.73
Wuchang	110.22
Qingshan	43.1
Hongshan	255.43
Dongxihu	84.58
Hannan	14.51
Caidian	93.08
Jiangxia	130.85
Huangpi	115.16
Xinzhou	86.04

Table. 04

Sources：
2021 Wuhan Statistical Yearbook

The districts of the respondents are random and not proportional to the population information in the Wuhan Statistical Yearbook, but the most selected districts, Hongshan District and Jiangxia District, also have the largest resident population in Wuhan.

Title :

Wuhan's male and female population structure

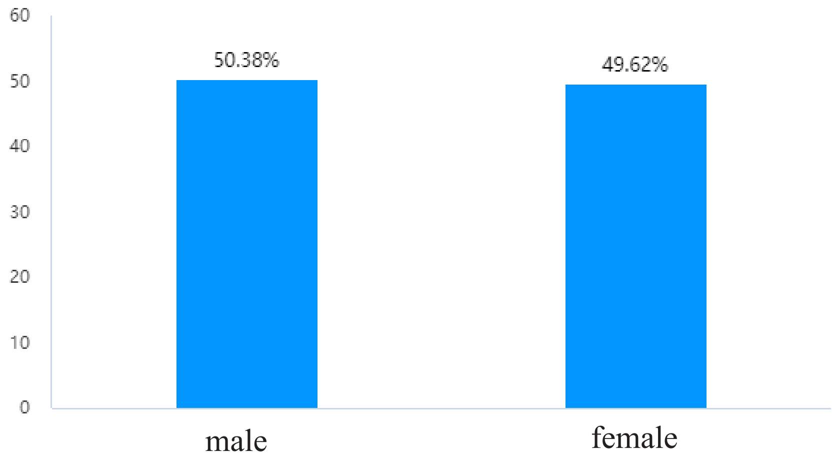


Fig. 33

Sources：
Questionnaire results from the "Questionnaire Star" survey platform

Item	The Whole City	
	Pupulation(10000 person)	Percentage(%) of Total Population
Totle in 2020	916.19	100.0
Male	465.36	50.8
Female	450.83	49,2

Table. 05

Sources：
2021 Wuhan Statistical Yearbook

Comparing the male and female population ratios from the questionnaire with the population data from the Wuhan Statistical Yearbook 2021, the results are similar, with nearly 50% of each gender

Title :

Population grouped by age in Wuhan

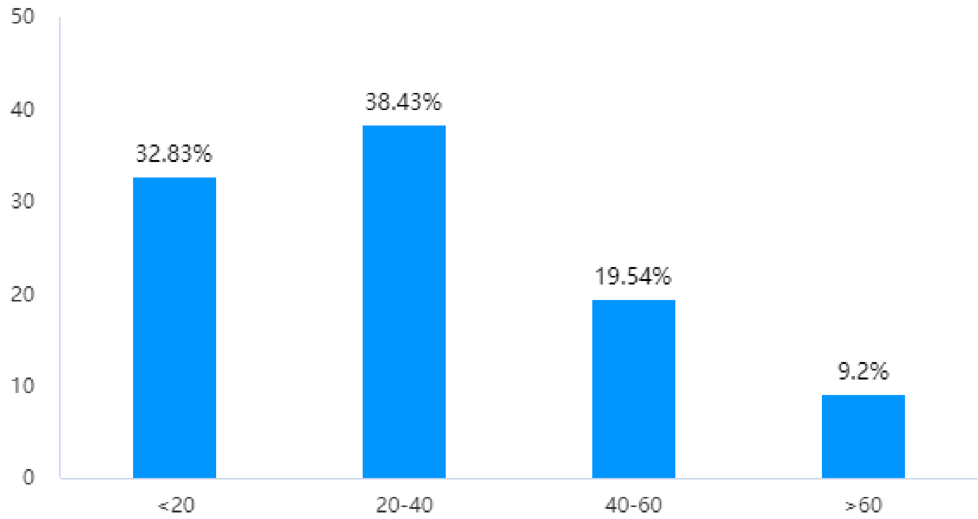


Fig. 34

Sources:
Questionnaire results from the "Questionnaire Star" survey platform

Index Name	Total	Male	Female
Total	9161913	4653615	4508298
0-17(years old)	1544217	824168	720049
18-34(years old)	2210433	1162094	1048339
35-59(years old)	3461922	1739731	1722191
60-79(years old)	1685943	818411	867532
80-99(years old)	258967	109088	149879
>=100(years old)	431	123	308

Table. 06

Sources:
2021 Wuhan Statistical Yearbook

The age of questionnaire completers was concentrated in the <20 and 20-40 age groups, while the largest proportion of Wuhan Statistical Yearbook personnel were in the middle-aged 35-59 age group. The youthfulness of the questionnaire is presumed to be due to the fact that the online method of completing questionnaires is mostly spread among the university student population.

5.3.1.2

Analysis of indicators relating to blue spaces

Table. 07

Sources：
Questionnaire results from the "Questionnaire Star" survey platform

Variables	Options	Frequency	Percentage
Types of blue spaces frequently visited	Lake	200	19%
	River	229	22%
	Pond	213	20%
	Fountain	223	21%
	Reservoir	189	18%
Common ways to go to blue spaces	Walking	277	26%
	Cycling	254	24%
	Public transportation	260	25%
	Driving	263	25%
Walking time to blue space (minutes)	<5	92	9%
	5-10	338	32%
	11-15	319	30%
	16-20	199	19%
	>20	106	10%
When do you usually visit Blue Space	Weekday	100	10%
	Weekend	526	50%
	Holiday	428	40%

The popularity of the different blue spaces determines the type of trade-off for the subsequent accessibility analysis. The mode of travel to the blue spaces determines the methods and thresholds used later to study accessibility, where the number of minutes walked is equally important.

Table. 08

Sources:
Questionnaire results from the "Questionnaire Star" survey platform

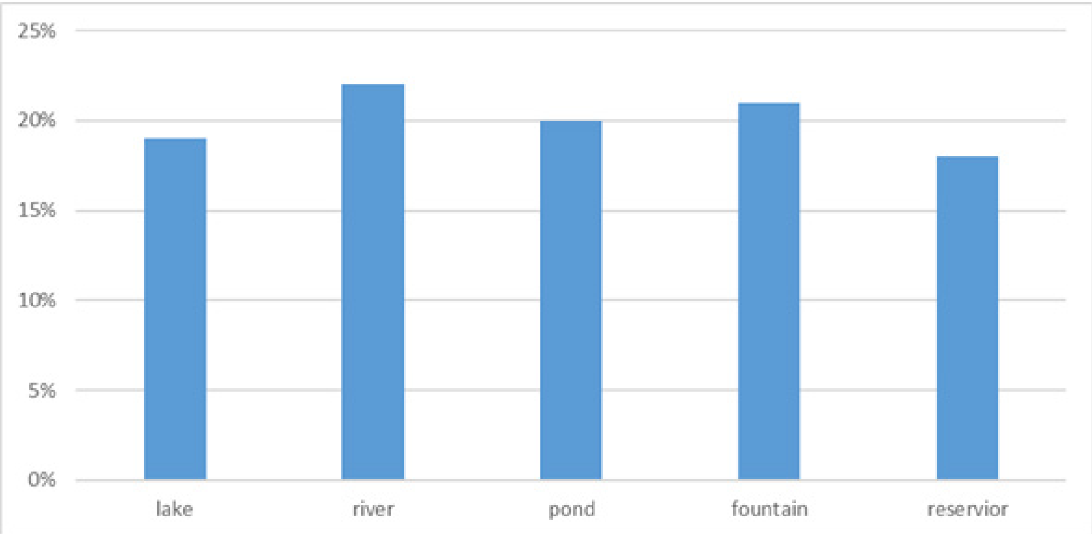
Variables	Options	Frequency	Percentage
How long do you usually stay in the blue space	10 minutes	108	10%
	30 minutes	502	48%
	1-2 hours	337	32%
	Half a day	107	10%
Frequency of visits to blue spaces	Everday	93	9%
	1-3times/week	645	61%
	1-2times/month	229	22%
	<1time/month	87	8%
Quality of nearby blue space	Very good	514	49%
	Good	337	32%
	Not good	203	19%
Activities that generally take place in blue spaces (multiple choice)	Walking	316	20.3%
	Boating	306	19.7%
	Fishing	327	21.0%
	Swimming	326	21.0%
	Doing Yoga	124	8.0%
	Other social activities	157	10.1%

The time spent visiting the blue spaces, the time spent in them, and the activities carried out in them reflect Wuhan respondents' habits of using them. It is also clear that they generally visit the blue spaces more frequently, and that most people consider the nearby blue spaces to be of good quality, all of which factors reflect the need to study the accessibility of the blue spaces in Wuhan. It is clear that the blue spaces are an essential and important element in the daily lives of the people of Wuhan, so their accessibility and fair distribution are particularly important.

In addition to the general tables above, this study presents each questionnaire result in a more intuitive histogram, and focuses on two results that are strongly correlated with the analysis of blue space accessibility. Others Although the results of the analysis are not strongly correlated with accessibility, there is still a certain significance for the use of Wuhan blue space. So this study put them in the annex at the end of the thesis.

Fig. 35

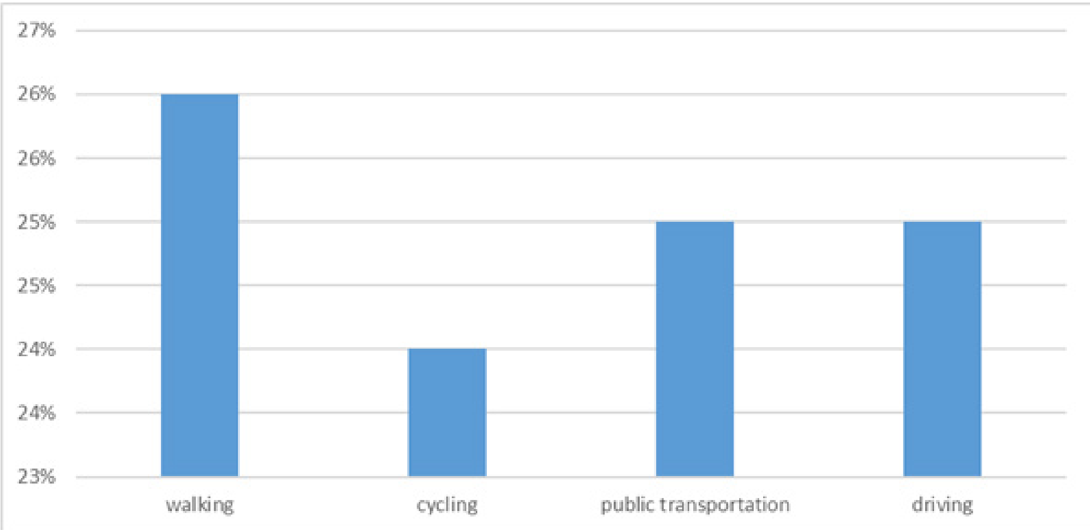
Types of blue spaces frequently visited



From the analysis results, it can be seen that the blue space most visited by respondents in Wuhan is the river. It is speculated that because the river runs through the entire urban area of Wuhan and has many tributaries, it is the most important type of blue space in Wuhan. The next most popular are fountains, ponds, lakes, and finally, reservoirs. But in fact there is no very noticeable gap in their popularity. Therefore, this study believes that all of the above types are worthy of research on accessibility analysis.

Fig. 36

Common ways to go to blue spaces



From the analysis results, it can be seen that most respondents in Wuhan choose to walk to the blue space (26%), followed by public transportation and driving (25% each), and finally cycling (24%). But overall there aren't too many gaps in each option. Therefore, this study decided to use a threshold value including walking and vehicle distances in the accessibility analysis: 10km. and it is divided into easy-to-reach distances (≤1km), difficult walking distances (2.5km), and traffic-reachable distances (5km). km) and hard-to-reach distances (10 km).

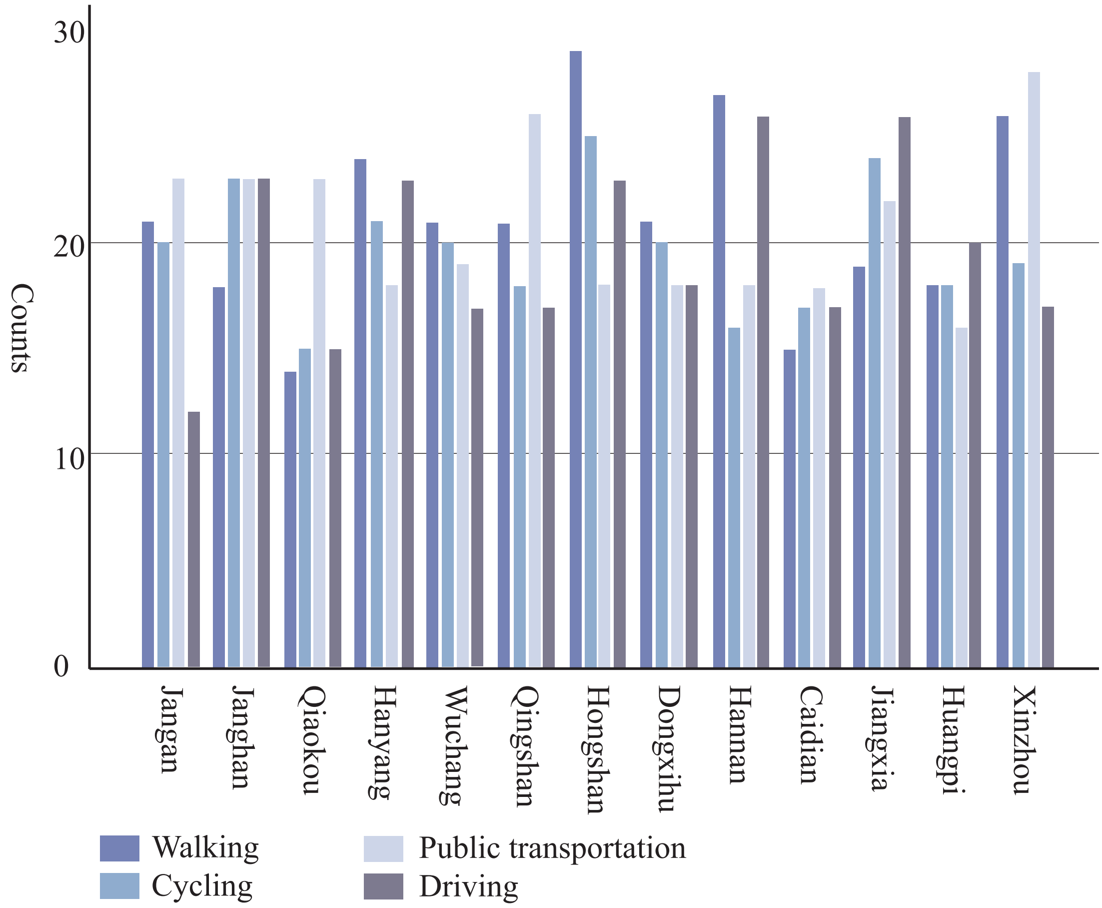
5.3.1.3

Cross-tabulation analysis

Fig. 37

Ways to get to the Blue Space for respondents from different districts

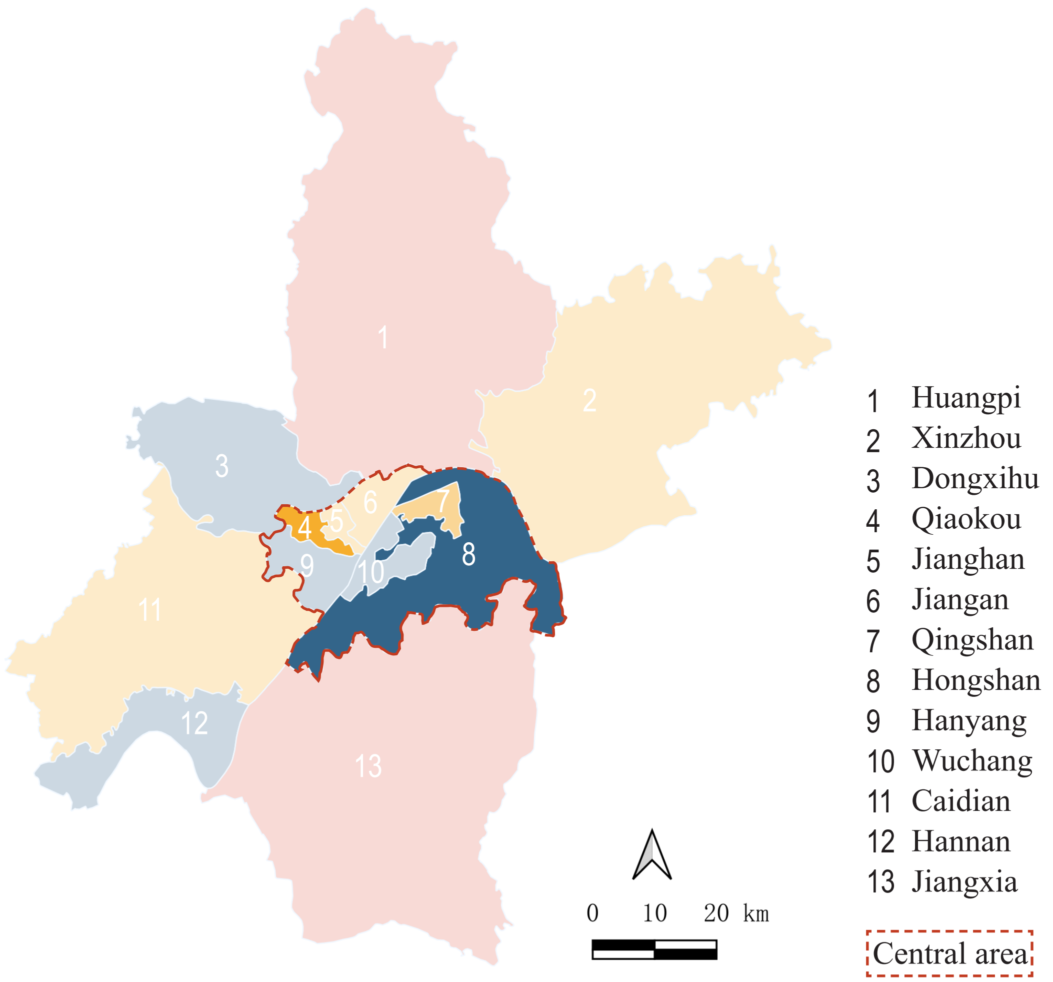
Source： Cross-tabulation of questionnaire results



The analysis shows that respondents in the city centre prefer to walk or take public transport to reach the blue spaces, presumably related to the accessibility of the road network and the distance to the blue spaces, while respondents in Huangpi and Jiangxia districts tend to choose to drive (but there is no significant gap), presumably related to the fact that there are fewer blue spaces and less accessible public transport in these areas.

Map. 02

Ways to get to the Blue Space for respondents from different districts

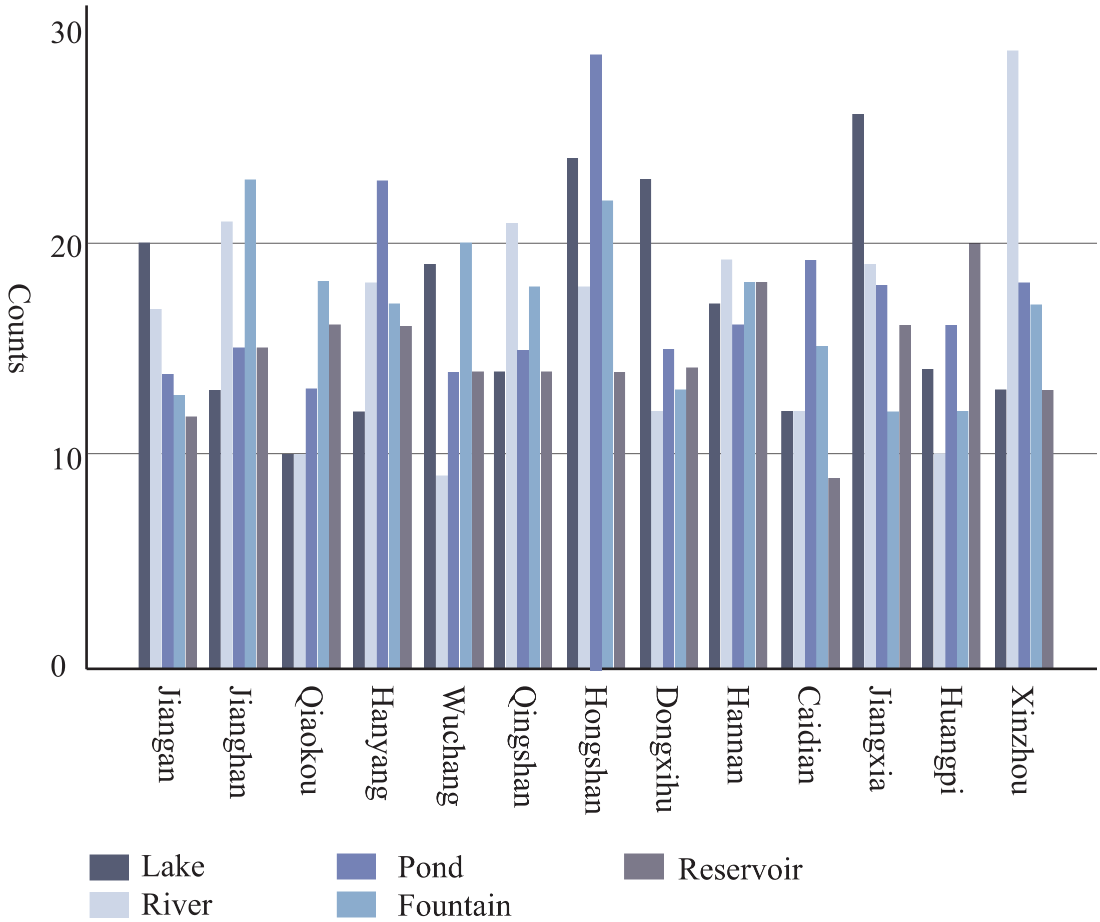


		The most popular way to travel		
		Walking	Public transportation	Driving
Gap with second choice (%)	0-3 Opacity 25%			
	4-6 Opacity 50%			
	7-9 Opacity 75%			
	10-12 Opacity 100%			

Fig. 38

Types of blue spaces most frequently visited by respondents from different districts

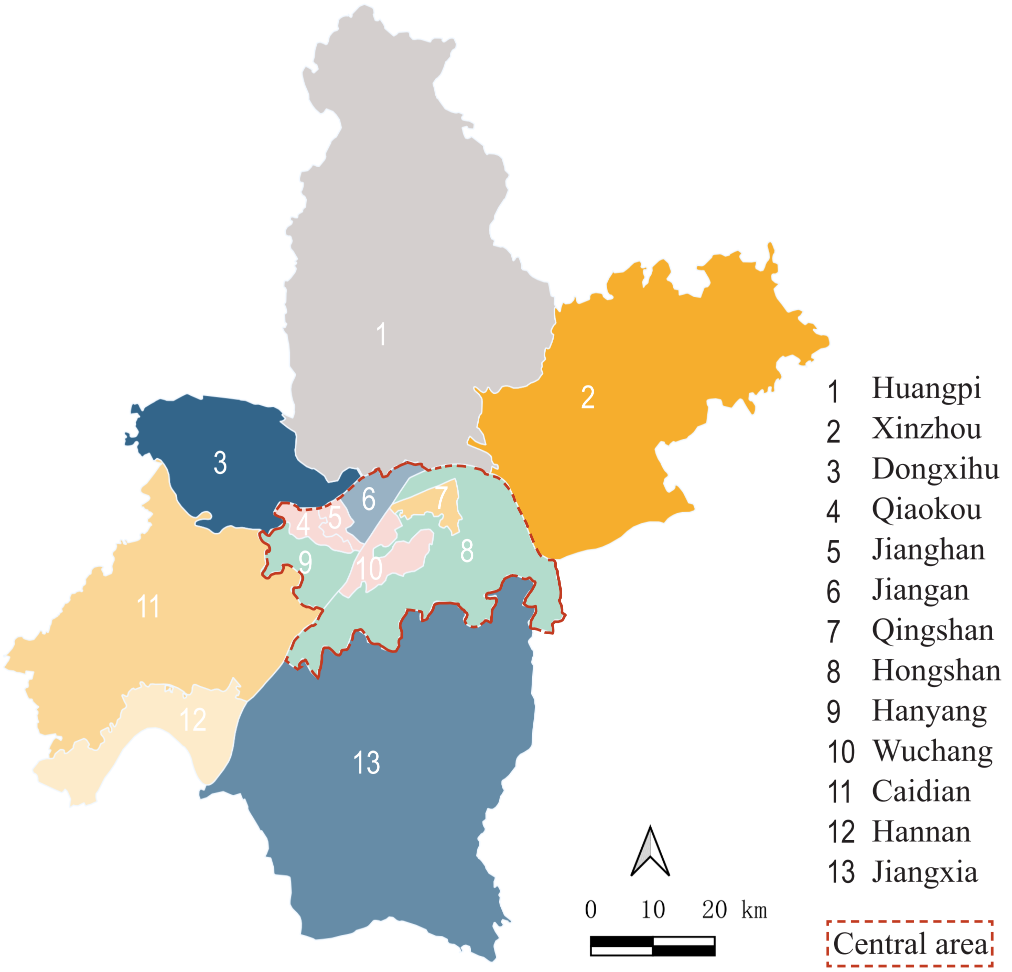
Source: Cross-tabulation of questionnaire results



The analysis shows that respondents in the city centre prefer to visit ponds and fountains, with residents in these areas visiting rivers more often as the Han River runs through Wuhan from the northeast to the southwest. The location of both lakes and reservoirs also correlate with the spatial distribution of blue, and the results suggest that the questionnaire has some credibility.

Map. 03

Types of blue spaces most frequently visited by respondents from different districts

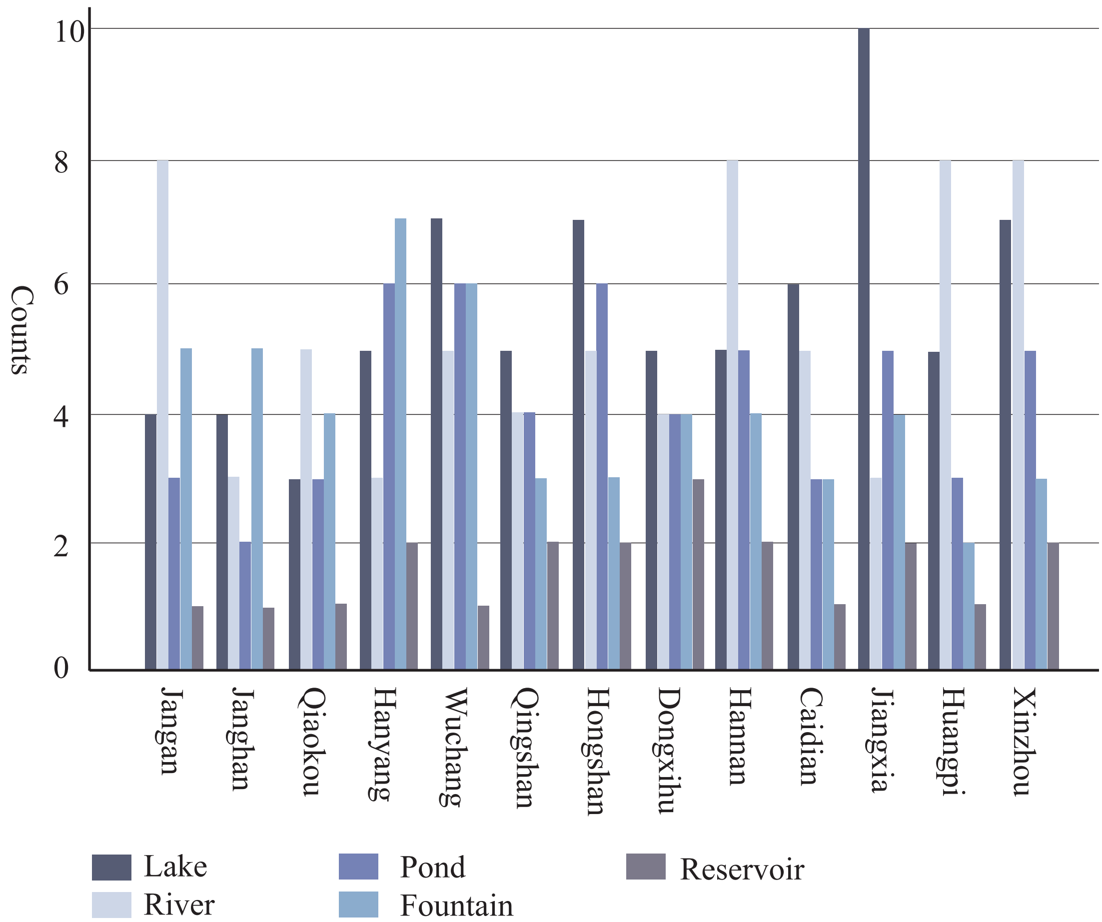


		The most popular blue space type				
		Lake	River	Pond	Fountain	Reservoir
Gap with second choice (%)	0-3 Opacity 25%	●	●	●	●	●
	4-6 Opacity 50%	●	●	●	●	●
	7-9 Opacity 75%	●	●	●	●	●
	10-12 Opacity 100%	●	●	●	●	●

Fig. 39

Types of blue spaces most frequently visited by respondents from different districts who chose to walk

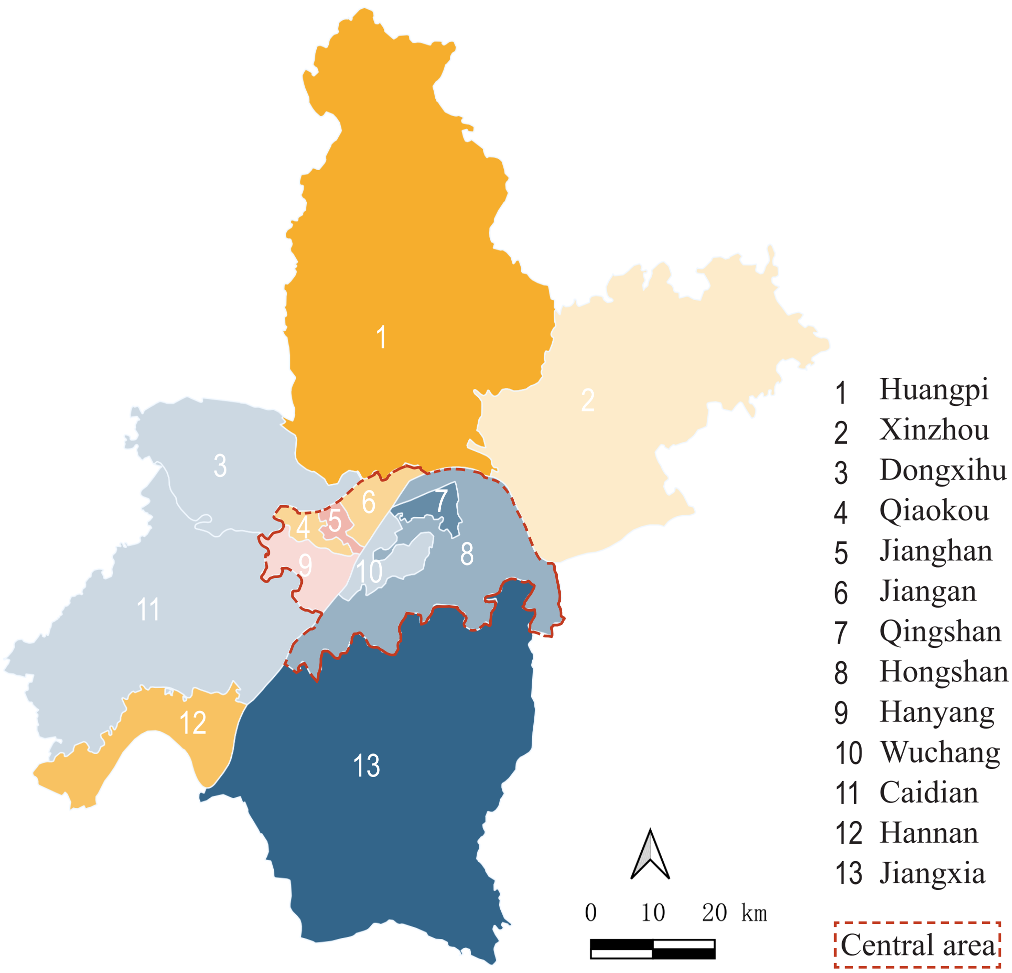
Cross-tabulation of questionnaire results



The results of the analysis show that the types of blue controls that most respondents who chose to walk preferred to visit were lakes, rivers and fountains. The results of this analysis differ slightly from those of the previous one, and it is speculated that in addition to the distribution of blue spaces, there is also a strong relationship with the distance from the blue space to the community points.

Map. 04

Types of blue spaces most frequently visited by respondents from different districts who chose to walk

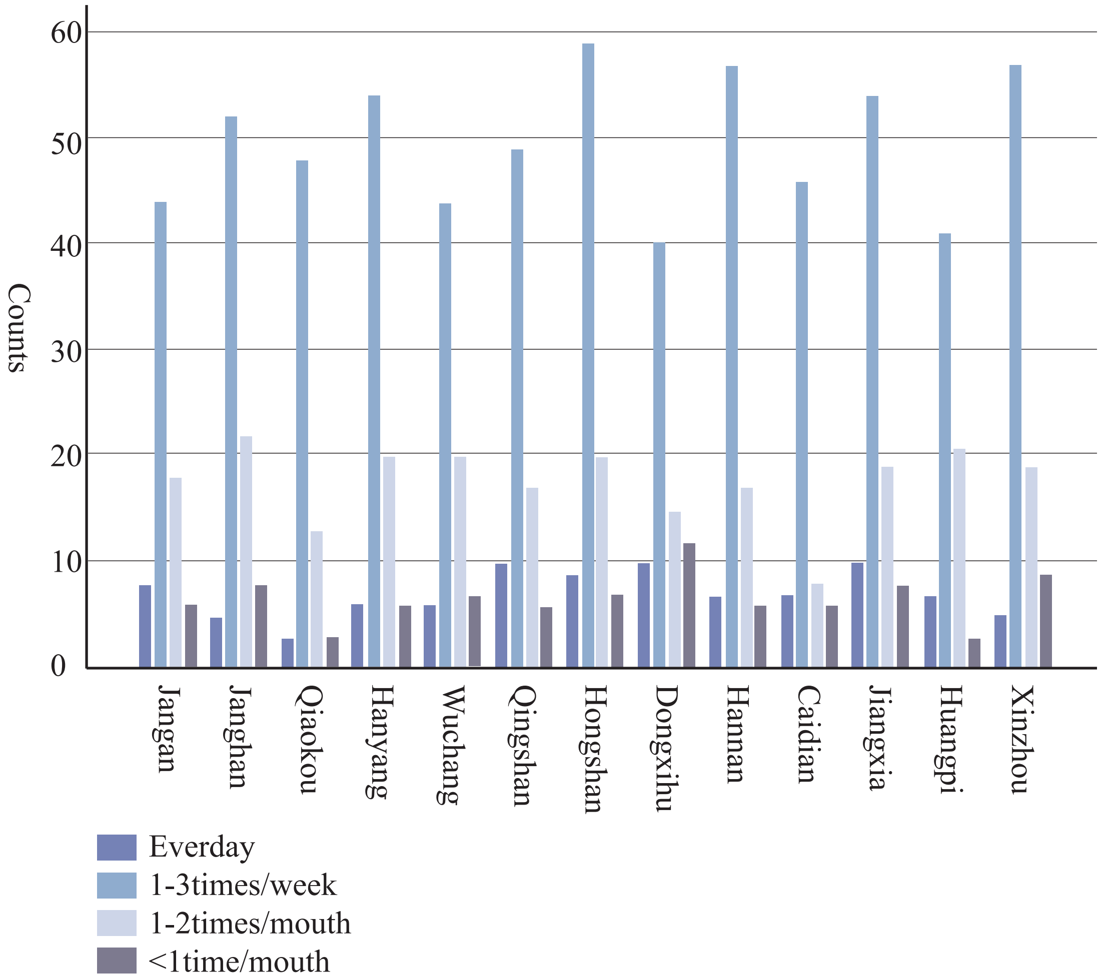


		The most popular blue type (walking)		
		Lake	River	Fountain
Gap with second choice (%)	0-5 Opacity 25%	●	●	●
	6-10 Opacity 50%	●	●	●
	11-15 Opacity 75%	●	●	●
	16-21 Opacity 100%	●	●	●

Fig. 40

Frequency of visits to Blue Space by respondents from different districts

Sources:
Cross-tabulation of questionnaire results



The following crossover analysis, although less relevant to accessibility, still has some impact on the use of blue space in Wuhan. So this study places them all in the annex at the end of the article.

For example, this cross-tab shows that most respondents visit the blue space 1-3 times a week, which means that most people visit the blue space at least once a week, that is a very positive frequency, presumably because Wuhan It is a city rich in water bodies, and the existence of blue space is a very important part of residents' daily life.

5.3.2

Accessibility measurements for different types of blue spaces

After analysing the results of the questionnaire and identifying the key indicators that influence the accessibility of blue spaces in Wuhan, this study analyses the accessibility of different types of blue spaces.

The main types of blue spaces analysed in this study are fountains, ponds, rivers and lakes, as these are more popular and closer to residential areas and have a greater impact on daily life. Also considering that a proportion of respondents still choose reservoirs, this study includes reservoirs in the category of lakes in the accessibility analysis, as a category of artificial lakes.

Considering that there was no great disparity between the respondents' choice of walking and car travel modes, a range of 10 km was chosen for this study as the distance residents could reach the blue space and it was divided into: easily accessible distance (≤1 km), difficult walking distance (2.5 km), transport accessible distance (5 km) and difficult to reach distance (10 km).

For the accessibility analysis of all blue space types this study used the OD cost matrix analysis method, which, as stated in the previous literature review, is currently the most common method used to study blue space exposure. Considering that network analysis along streets is more accurate than linear analysis, this study used OD cost matrix analysis based on network analysis to measure the distance from community points to different types of blue spaces as a way to measure the accessibility of different types of blue spaces in Wuhan.

5.3.2.1

Analysis of the accessibility of fountains

In studying the accessibility analysis of fountains in Wuhan, the main GIS data used were: Poi of eight popular fountains, Wuhan's road network, and Wuhan's community points.

The main analysis steps were as follows:

- In Arcgis.10.8 software for the topology of the road network in Wuhan, in detail, first extract the layers of the road network needed for this time (primary roads, secondary roads, tertiary roads, pavements, etc.), then some of the two-lane road network to create a buffer zone, extract the median, so that it becomes a single line. Then all the road networks were topologised, mainly fixing overlapping road networks, suspension points and pseudo-knots to make the network better connected and to facilitate the accessibility analysis done later.

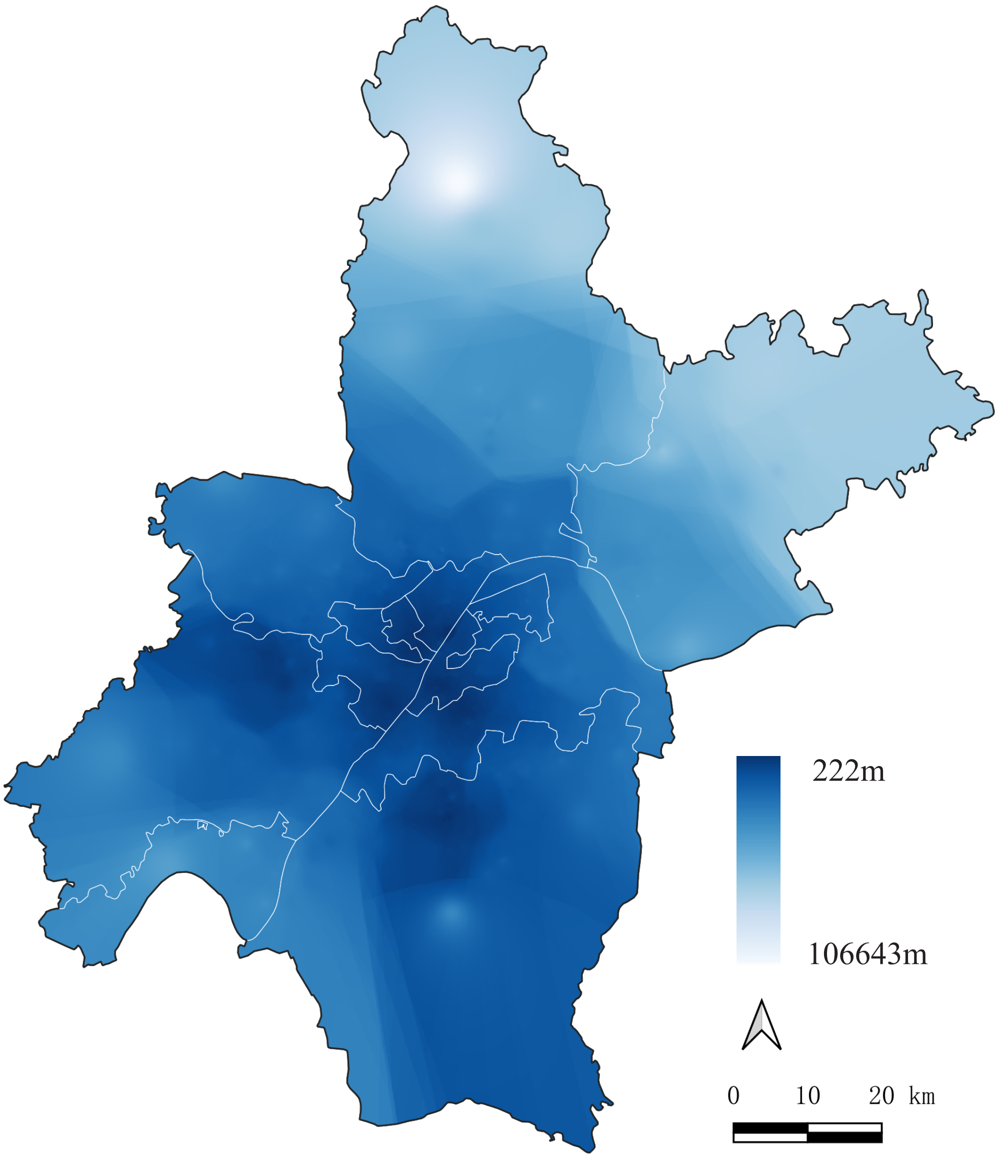
- The OD cost matrix was created, setting the starting point as a community point, the destination point as the POI of the fountain and capturing all points of interest on the nearest road network for the accessibility analysis.

- Run the OD cost matrix method with inverse distance weights to get the detailed distance (nearest to furthest distance) from the community point to the fountain.

- Create a 1km*1km grid, run the partition statistics method, attach the distance from the community point to the fountain point to each cell and calculate the mean and minimum values for each cell distance to better analyse which areas are within the 10km threshold and to detail them into easy to reach distances (≤1km), difficult walking distances (2.5 km), transport accessible distances (5 km) and difficult to reach distances (10 km). The partition statistics are then further applied to the administrative areas to give a more visual indication of which administrative districts have better fountain accessibility.

Map. 05

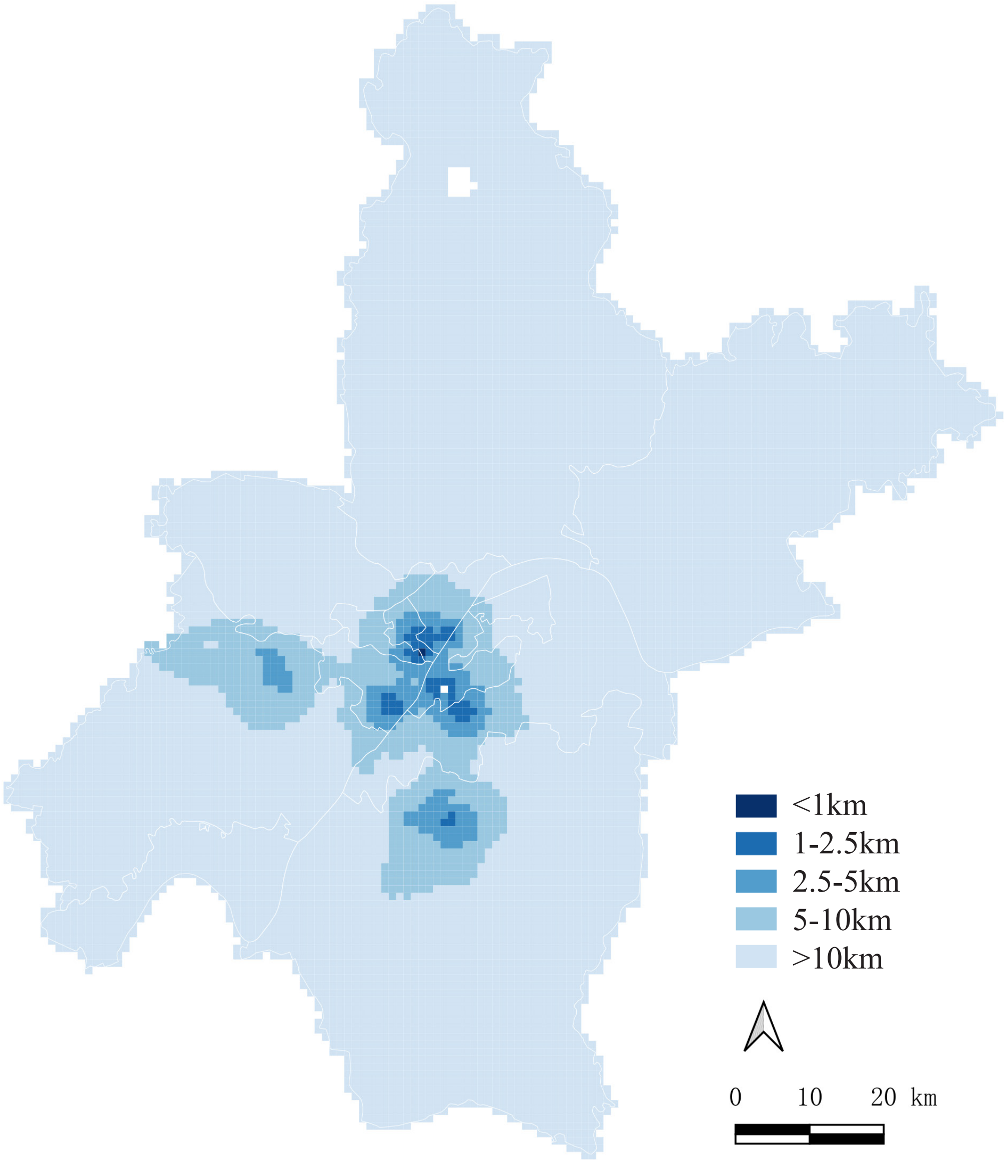
Analysis of fountain accessibility



Running the OD cost matrix method with inverse distance weights gives detailed distances from the community points to the fountains: from a minimum distance of 222m to a maximum distance of 106,643m.

Map. 06

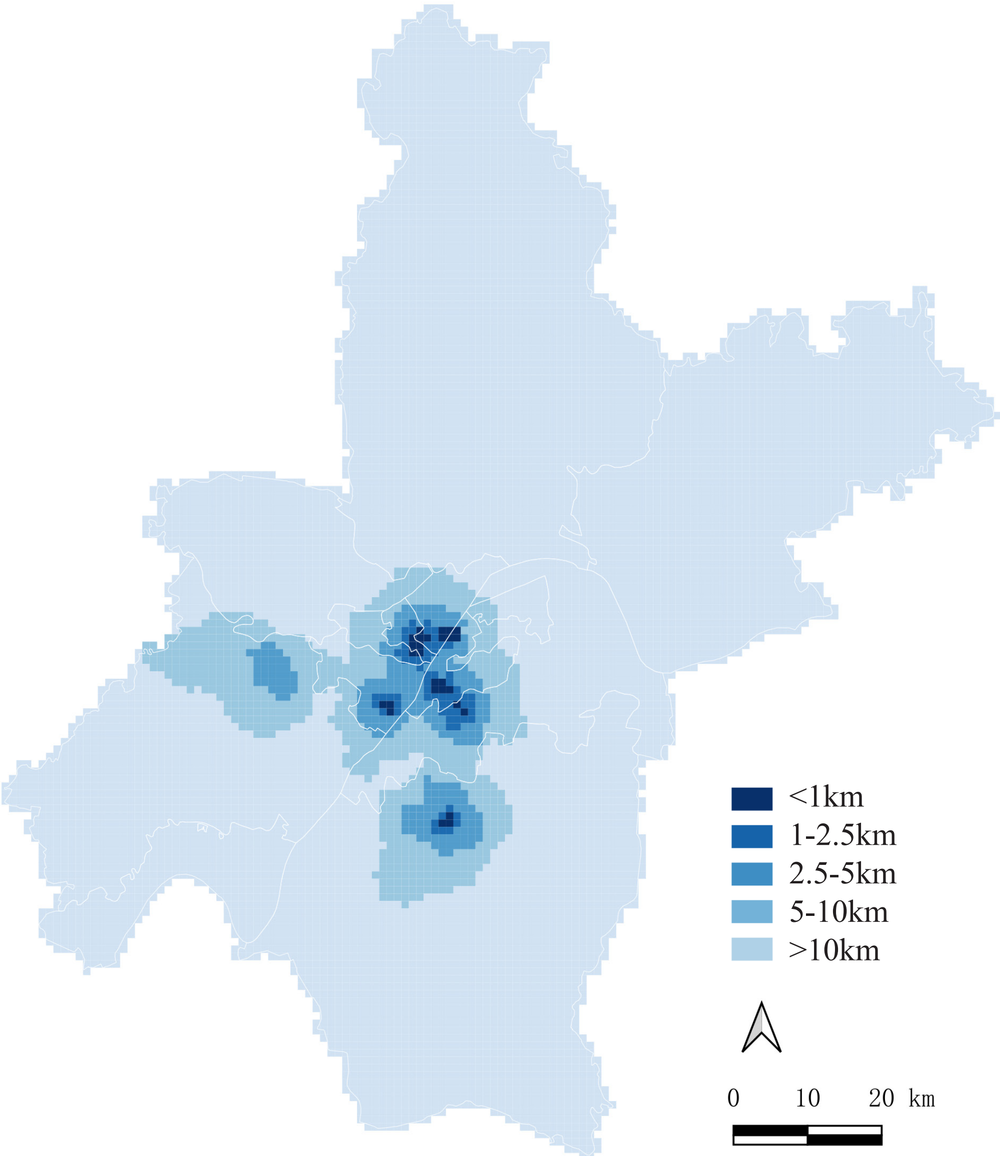
Analysis of fountain accessibility（Mean value)



10 kilometres was chosen as the distance that residents could reach the blue space and it was divided into: easy to reach distance (≤ 1 km), difficult to walk distance (2.5 km), transport accessible distance (5 km) and difficult to reach distance (10 km). The mean value of the distance for each grid cell in a 1km*1km grid was found to derive the accessibility of the fountain within different thresholds.

Map. 07

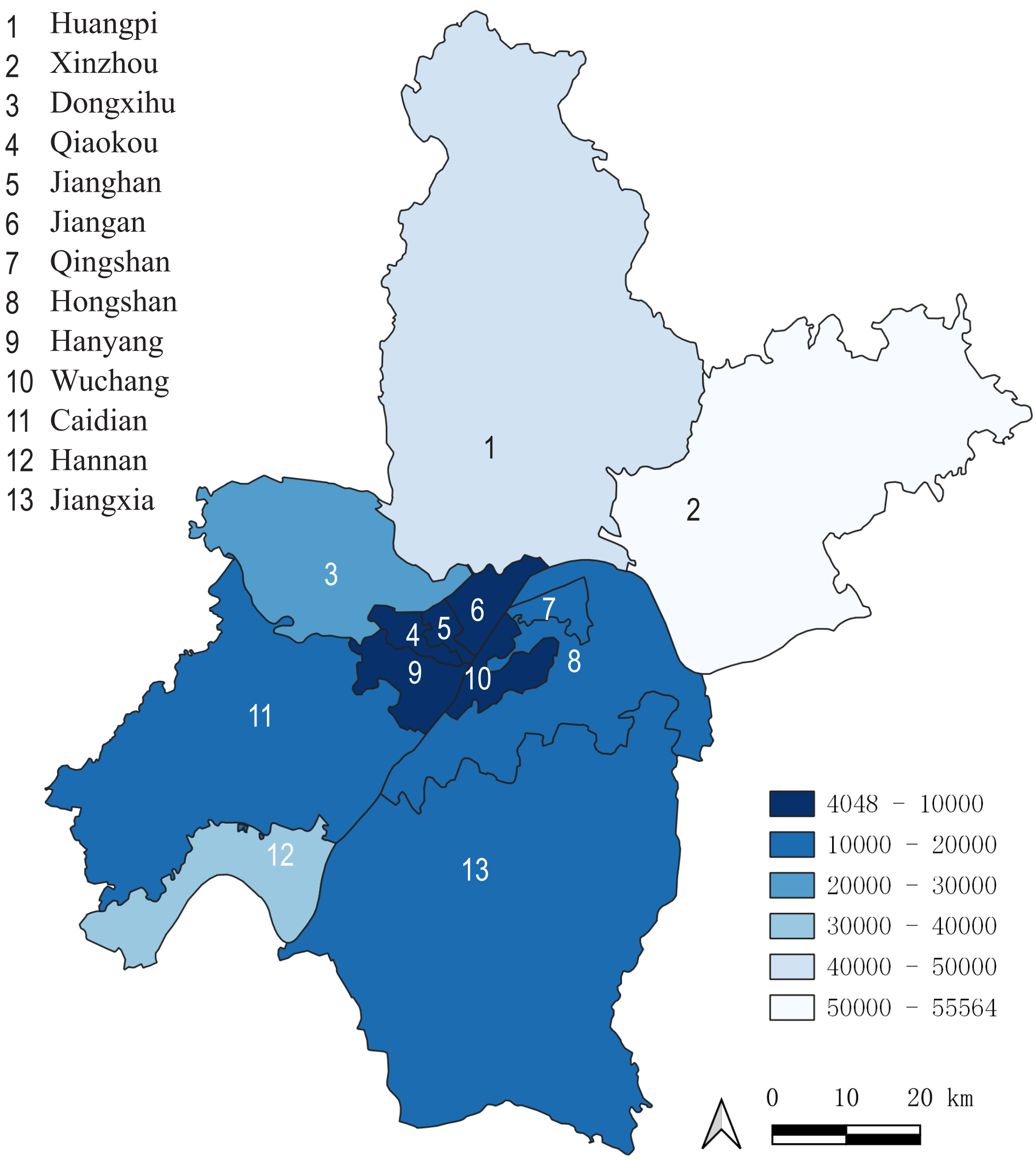
Analysis of fountain accessibility (Minimum value)



The minimum value of the distance is then found for each grid cell in the same way in a 1 km * 1 km grid, yielding the accessibility of fountains within different thresholds. It can be seen that the city centre area has the best fountain accessibility.

Map. 08

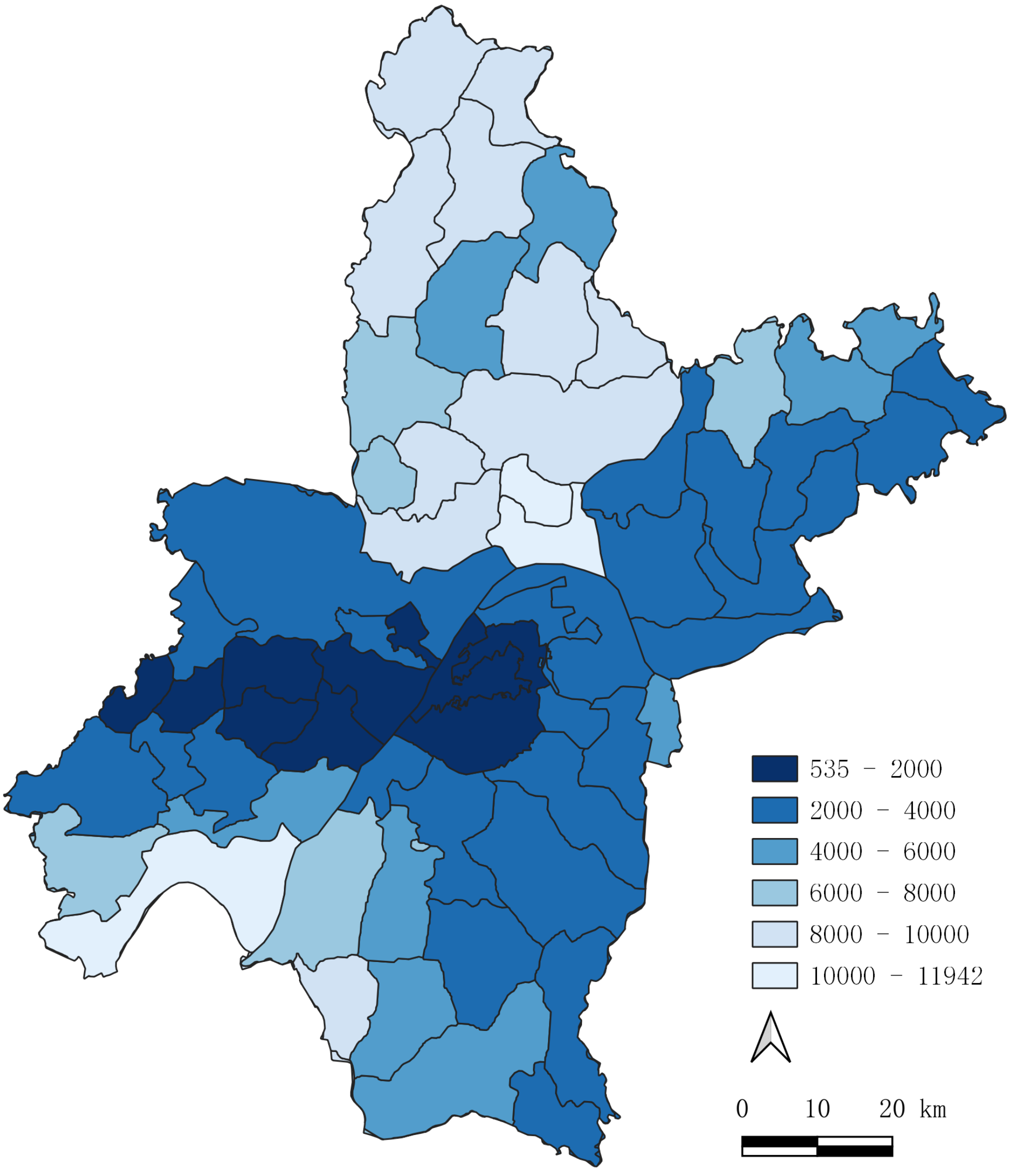
Administrative districts accessibility of fountains (Mean value)



The distances for each administrative district were counted using the zoning statistics and the mean values were derived. This map shows that Qiaokou, Jianghan, Jiangan, Hanyang and Wuchang districts have better access to the fountains, which are all concentrated in the city centre.

Map. 09

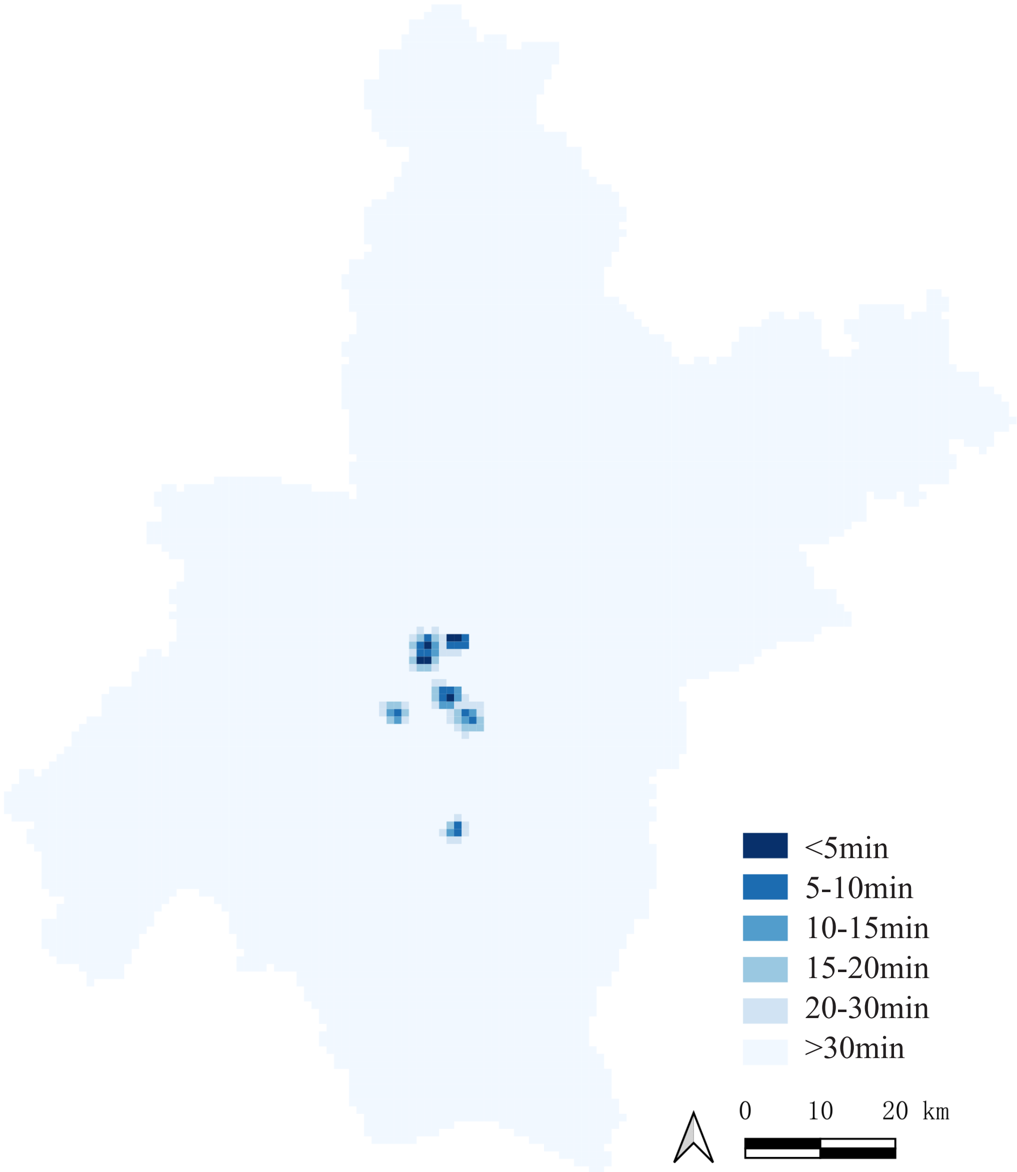
Township accessibility of fountains (Mean value)



Using the same method to calculate more detailed township-level fountain accessibility, it can be seen that the city centre has the best fountain accessibility and the north-western Huangpi district has poorer fountain accessibility.

Map. 10

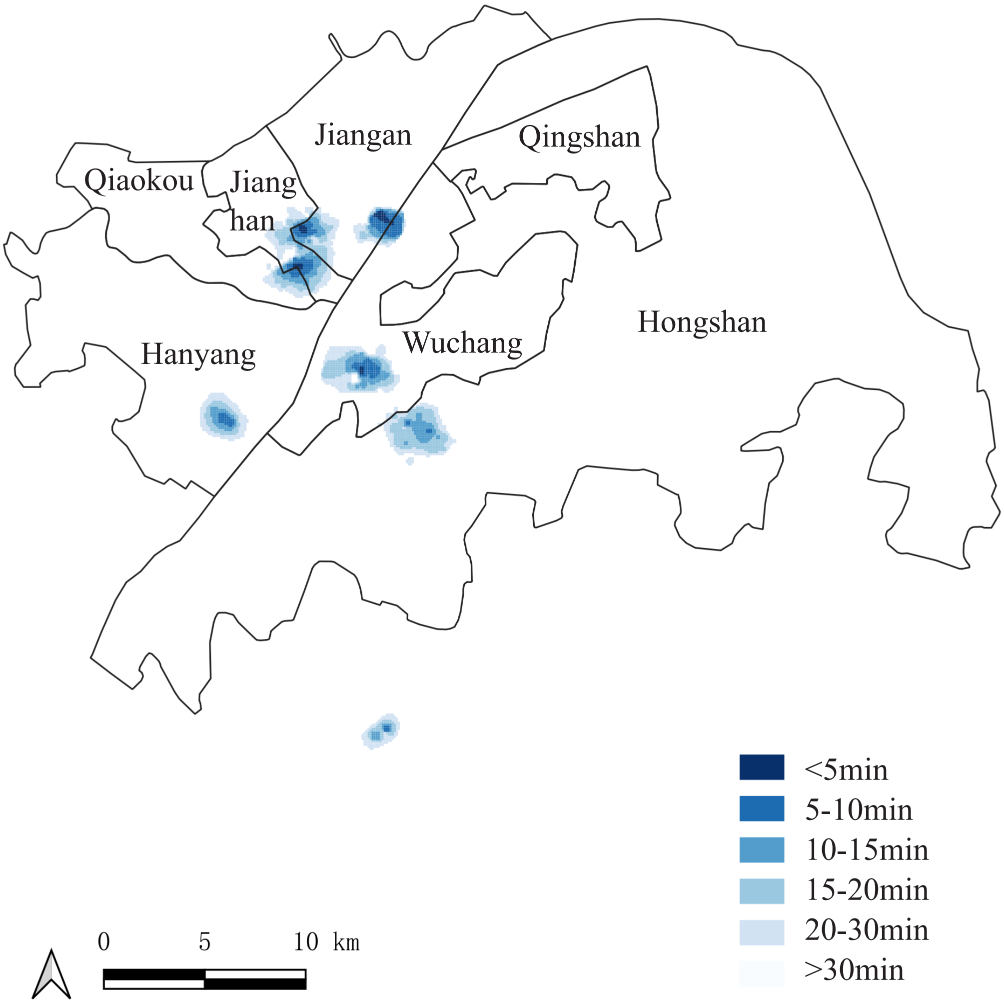
Fountain walkability in 1km*1km grid (Minumum value)



When this study wanted to examine the walkability of fountains in isolation, it was evident that the results of measuring the walkability of fountains in a 1 km * 1 km grid were not clear.

Map. 11

Fountain walkability in 100m*100m grid (Minumum value)



So afterwards this study created a more detailed 100*100m grid and enlarged the study area to the city centre area to derive the pedestrian accessibility of the fountain, the results did not have a large impact overall, so for the subsequent blue space types this study will not separately look at pedestrian accessibility.

5.3.2.2

Analysis of the accessibility of ponds

The main GIS data used in the study of pond accessibility analysis in Wuhan are: the AOI of Wuhan ponds, the road network of Wuhan, and the community points of Wuhan.

The main analysis steps are as follows:

- The topology of Wuhan's road network was carried out in Arcgis.10.8 software. In detail, the road network layers needed for this time were first extracted (primary roads, secondary roads, tertiary roads, pavements, etc.), then a buffer zone was created for some of the two-lane road network and the median was extracted to make it single-lane. Then all the road networks were topologised, mainly fixing overlapping road networks, suspension points and pseudo-knots to make the network better connected and to facilitate the accessibility analysis done later.

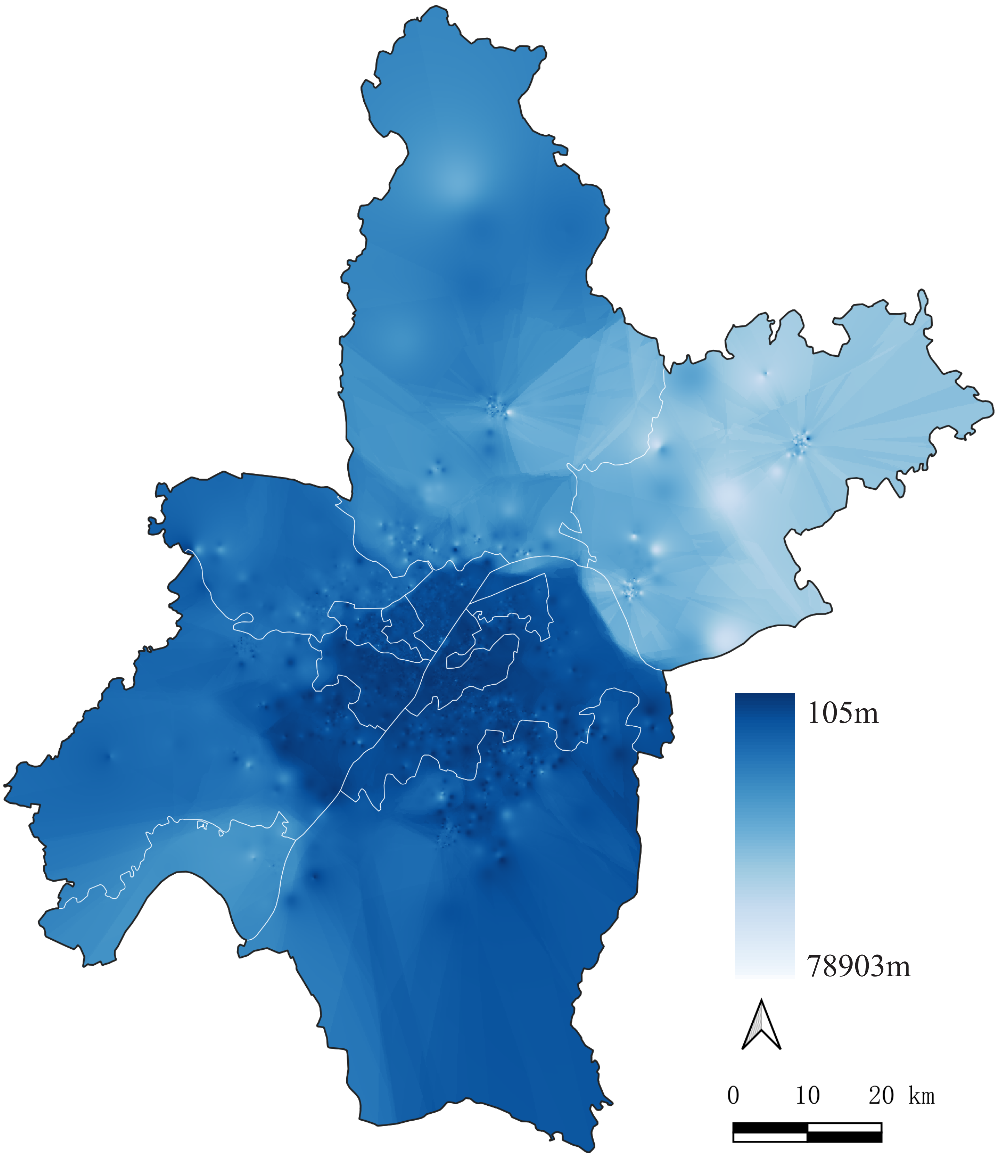
- The OD cost matrix was created, with the starting point set as a community point and all points of interest captured on the nearest road network for the accessibility analysis, and the destination point set as the intersection of the road and the ponds edge.

- Run the OD cost matrix method with inverse distance weights to get the detailed distance (nearest to furthest distance) from the community point to the ponds.

- Create a 1km*1km grid, run the partition statistics method, attach the distance from the community point to the pond to each cell and calculate the mean and minimum values for each cell distance to better analyse which areas are within the 10km threshold and to detail them into easy to reach distances (≤1km), difficult walking distances (2.5 km), transport accessible distances (5 km) and difficult to reach distances (10 km).The partition statistics are then further applied to the administrative areas to give a more visual indication of which administrative districts have better ponds accessibility.

Map. 12

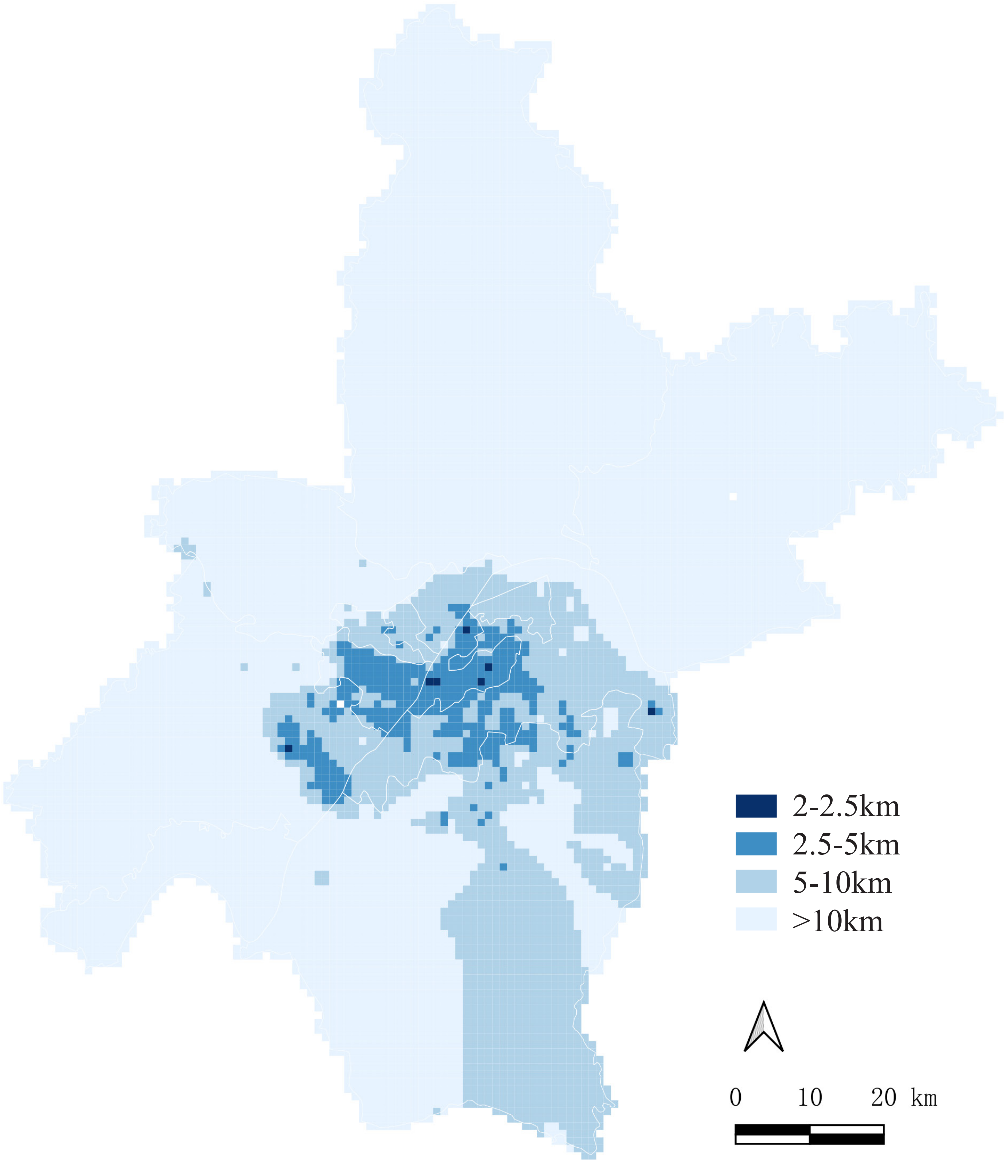
Analysis of ponds accessibility



Running the OD cost matrix method with inverse distance weights gives detailed distances from the community points to the ponds: from the shortest distance 105 meters to a maximum distance of 78903 meters.

Map. 13

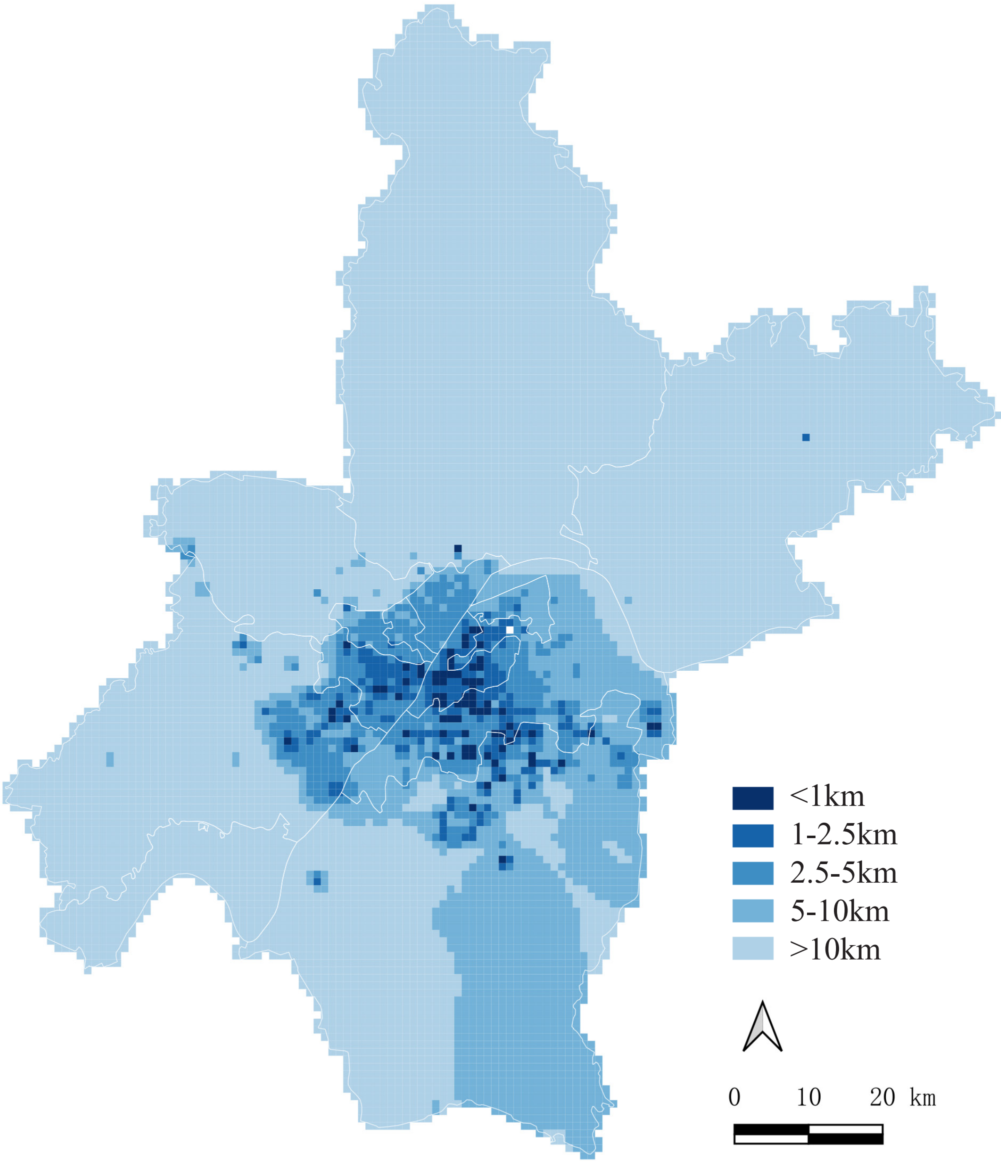
Analysis of ponds accessibility（Mean value)



10 kilometres was chosen as the distance that residents could reach the blue space and it was divided into: easy to reach distance (≤ 1 km), difficult to walk distance (2.5 km), transport accessible distance (5 km) and difficult to reach distance (10 km). The mean value of the distance for each grid cell in a 1km*1km grid was found to derive the accessibility of the ponds within different thresholds.

Map. 14

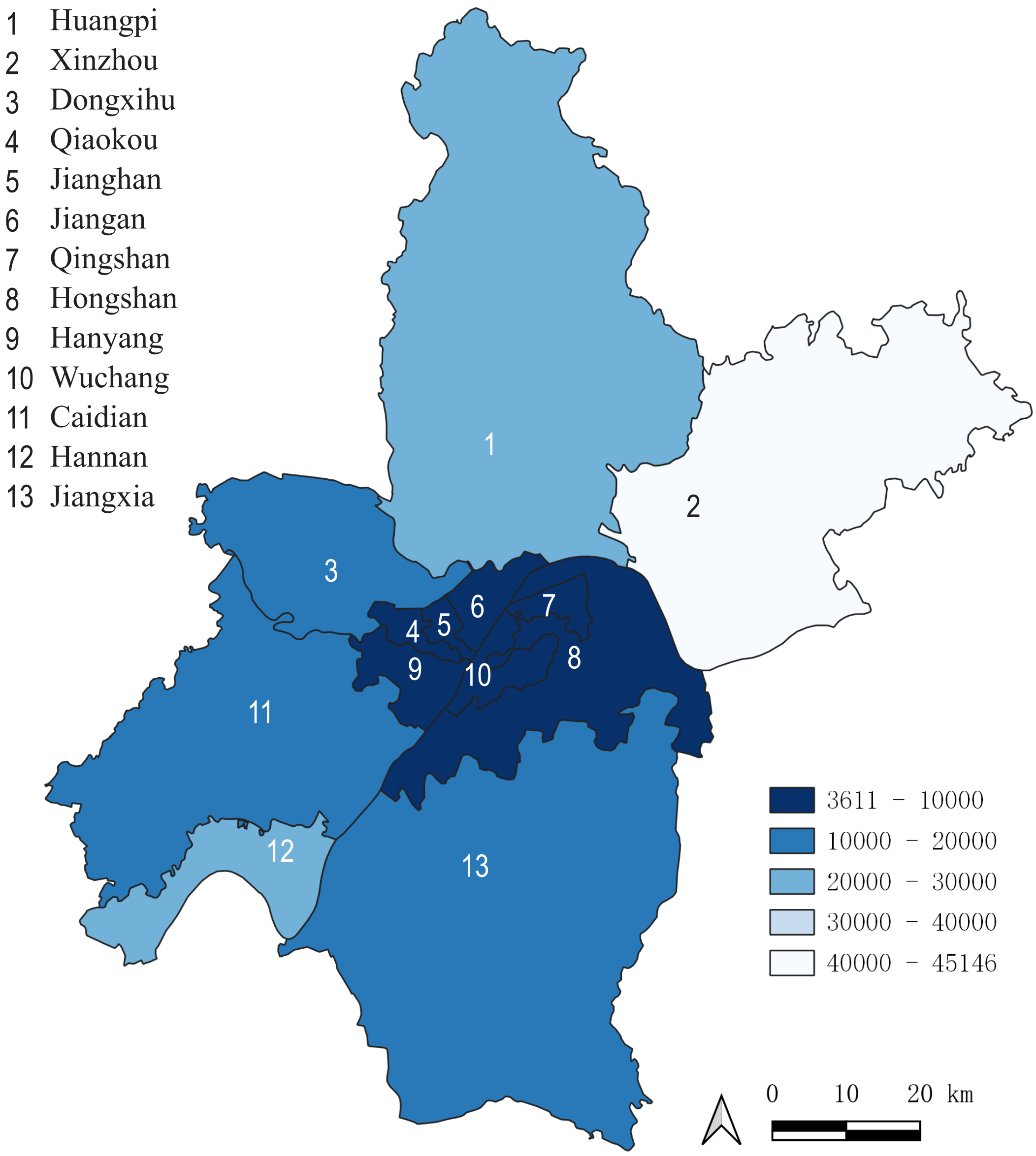
Analysis of ponds accessibility (Minimum value)



The minimum value of the distance is then found for each grid cell in the same way in a 1 km * 1 km grid, yielding the accessibility of ponds within different thresholds. It can be seen that the city centre area also has the best ponds accessibility.

Map. 15

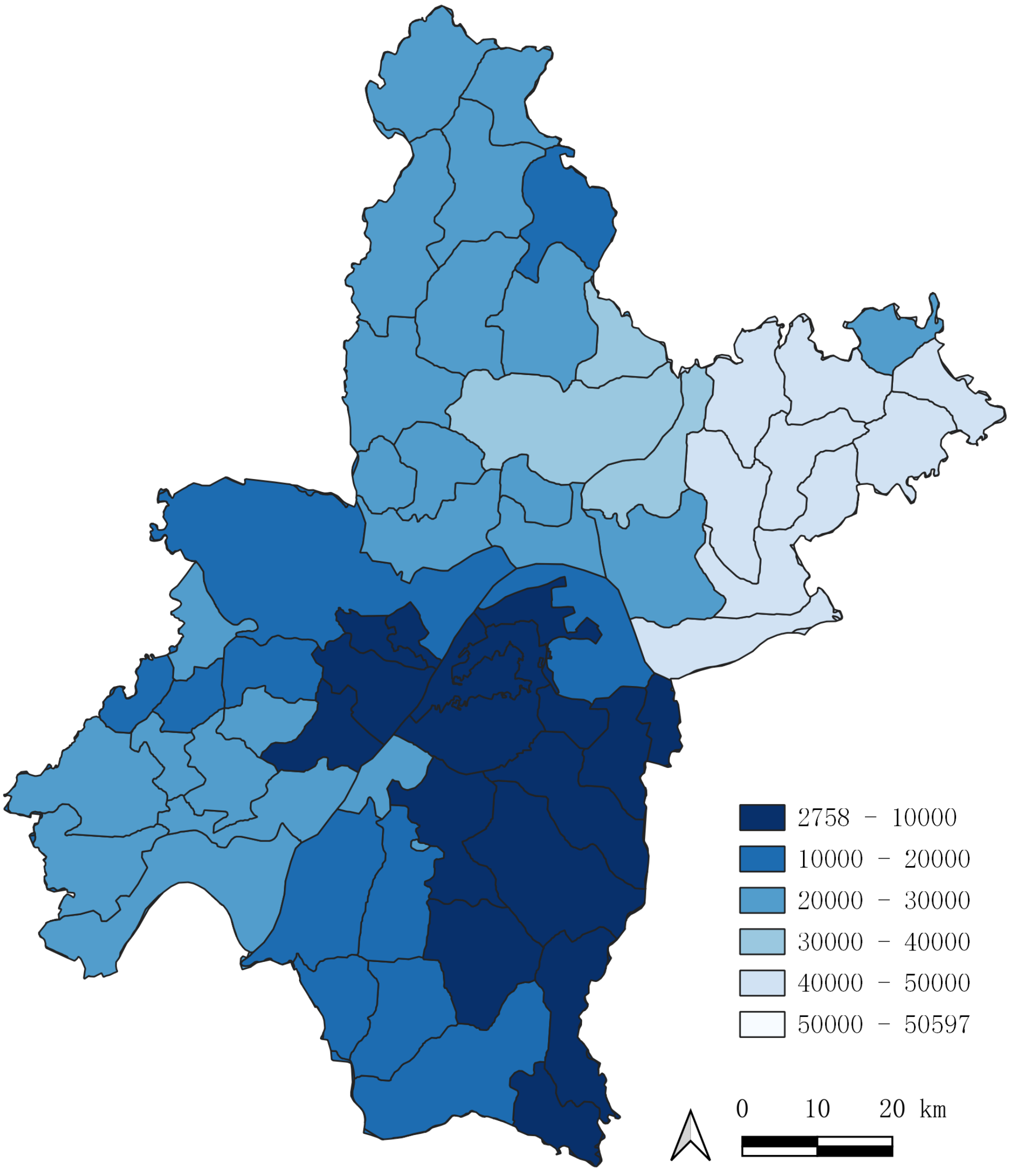
Administrative districts accessibility of ponds (Mean value)



The distances were counted to each administrative district and the mean values were obtained. This map shows that the Qiaokou, Jianghan, Jiangan, Qingshan, Hongshan, Hanyang and Wuchang districts have better access to the ponds, which are concentrated in the city centre.

Map. 16

Township accessibility of ponds (Mean value)



Using the same method to calculate pond accessibility at a more detailed township level, it can be seen that ponds in the city centre and south-east are better accessible and ponds in the north-east are less accessible.

5.3.2.3

Analysis of the accessibility of rivers

The main GIS data used in the study of rivers accessibility analysis in Wuhan are: the AOI of Wuhan rivers, the road network of Wuhan, and the community points of Wuhan.

The main analysis steps are as follows:

- The topology of Wuhan's road network was carried out in Arcgis.10.8 software. In detail, the road network layers needed for this time were first extracted (primary roads, secondary roads, tertiary roads, pavements, etc.), then a buffer zone was created for some of the two-lane road network and the median was extracted to make it single-lane. Then all the road networks were topologised, mainly fixing overlapping road networks, suspension points and pseudo-knots to make the network better connected and to facilitate the accessibility analysis done later.

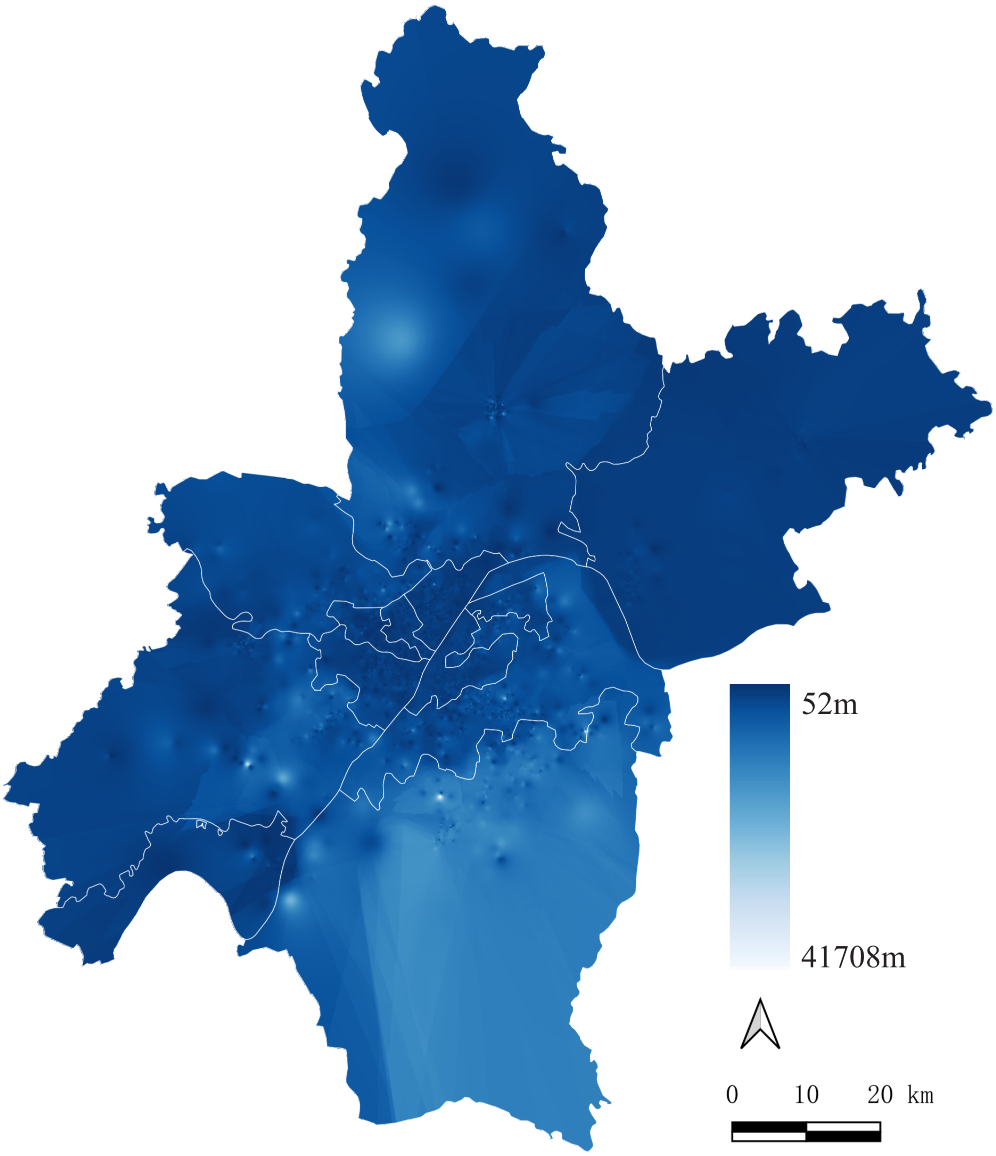
- The OD cost matrix was created, with the starting point set as a community point and all points of interest captured on the nearest road network for the accessibility analysis, and the destination point set as the intersection of the road and the rivers edge.

- Run the OD cost matrix method with inverse distance weights to get the detailed distance (nearest to furthest distance) from the community point to the rivers.

- Create a 1km*1km grid, run the zonal statistics method, attach the distance from the community point to the rivers to each cell and calculate the mean and minimum values for each cell distance to better analyse which areas are within the 10km threshold and to detail them into easy to reach distances (≤1km), difficult walking distances (2.5 km), transport accessible distances (5 km) and difficult to reach distances (10 km). The partition statistics are then further applied to the administrative areas to give a more visual indication of which administrative districts have better ponds accessibility.

Map. 17

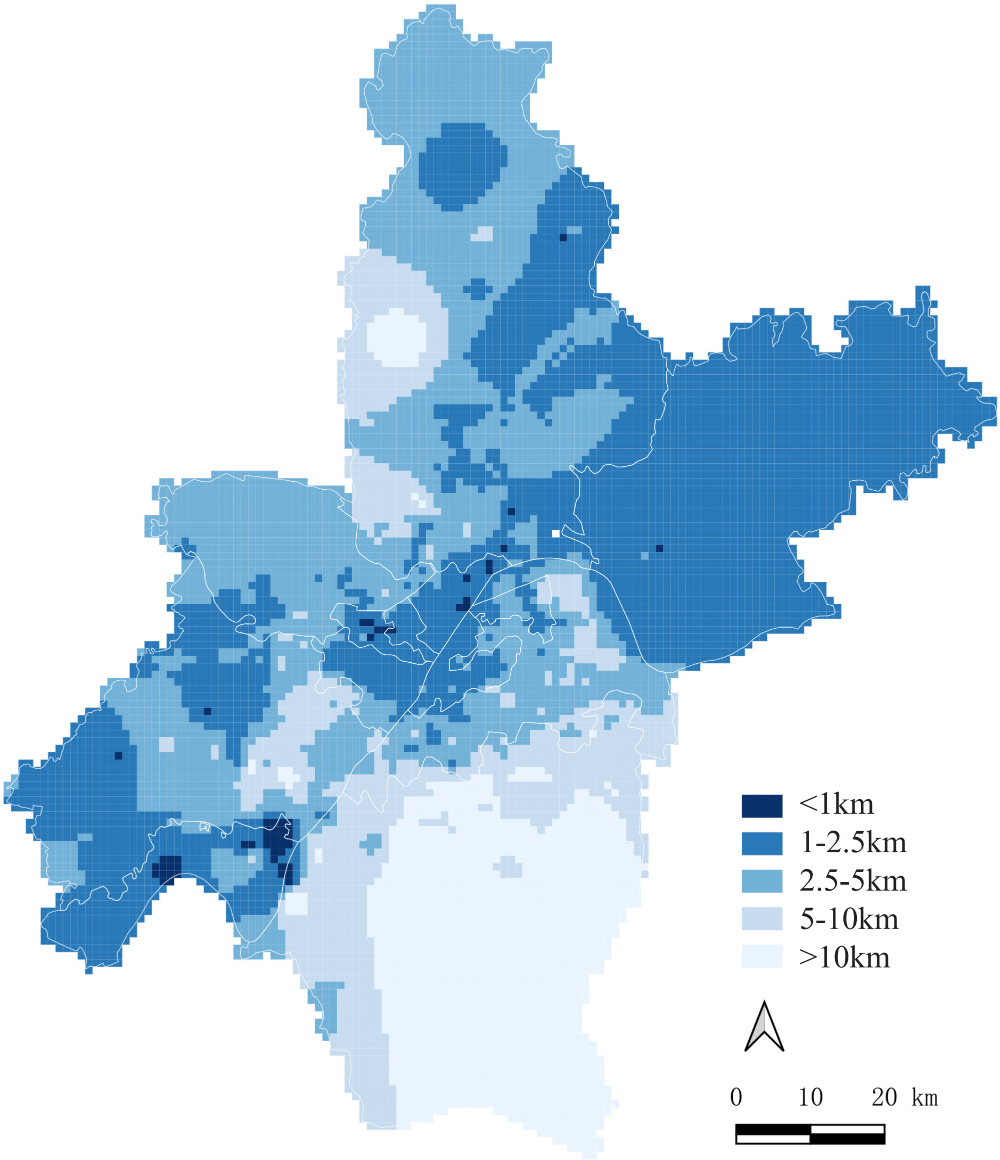
Analysis of rivers accessibility



This study calculated the different distance from the community points to rivers, based on the network, from the shortest distance 52 meters to a maximum distance of 41708 meters.

Map. 18

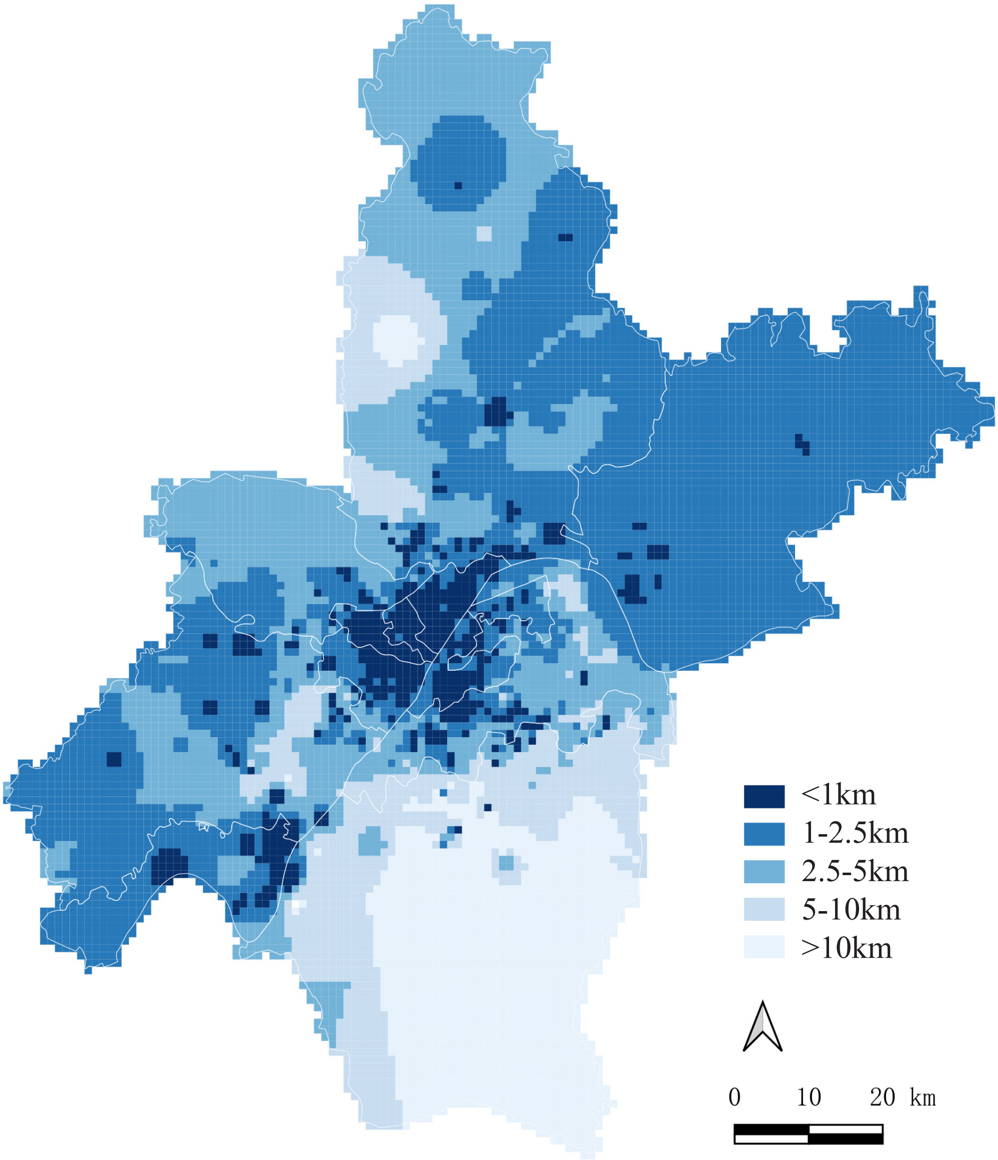
Analysis of rivers accessibility（Mean value)



10 kilometres was chosen as the distance that residents could reach the blue space and it was divided into: easy to reach distance (≤ 1 km), difficult to walk distance (2.5 km), transport accessible distance (5 km) and difficult to reach distance (10 km). The mean value of the distance for each grid cell in a 1km*1km grid was found to derive the accessibility of the rivers within different thresholds.

Map. 19

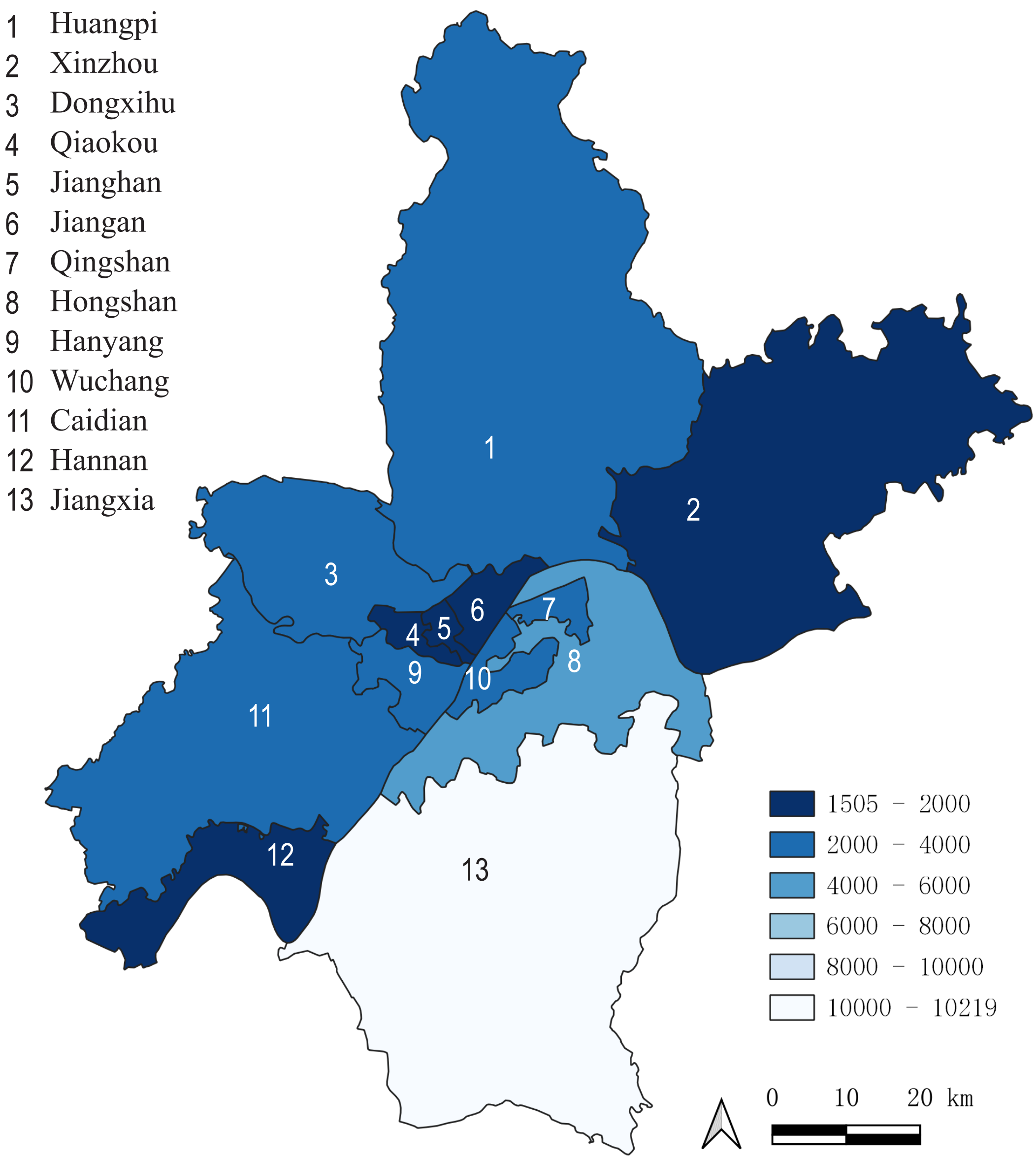
Analysis of rivers accessibility (Minimum value)



The minimum value of the distance is then found for each grid cell in the same way in a 1 km * 1 km grid, yielding the accessibility of rivers within different thresholds. It can be seen that the city centre area also has the best rivers accessibility.

Map. 20

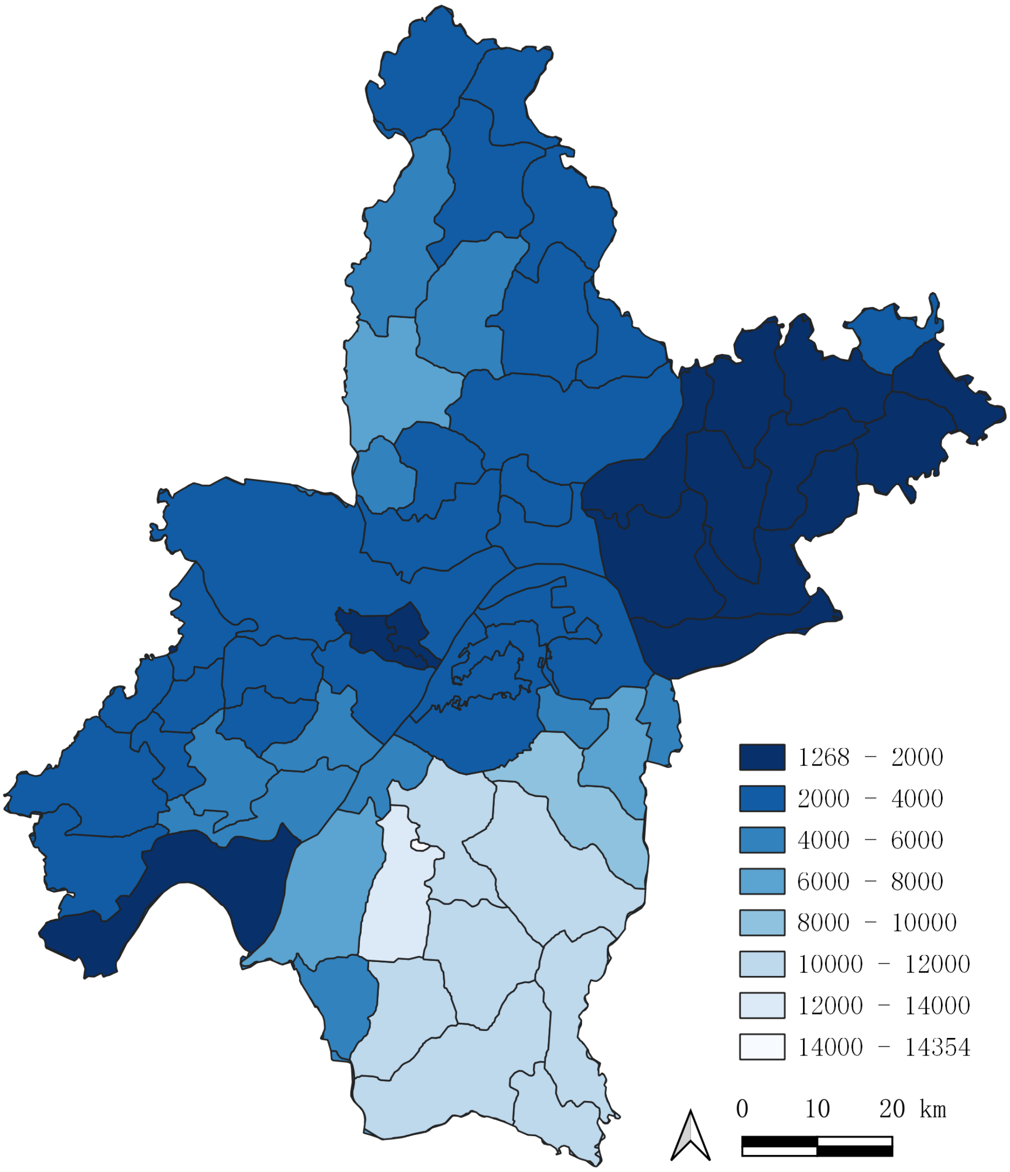
Administrative districts accessibility of rivers (Mean value)



The distances were counted to each administrative district and the mean values were obtained. This map shows that the Qiaokou, Jianghan, Jiangan, Xinzhou and Hannan districts have better access to the rivers, They are located in the north-east, in the city centre and in the south-west because of the rivers that run through the city.

Map. 21

Township accessibility of rivers (Mean value)



Using the same method to calculate rivers accessibility at a more detailed township level, it can be seen that the north-eastern part of the city is the most accessible because of the presence of many tributaries there.

5.3.2.4

Analysis of the accessibility of lakes

The main GIS data used in the study of lakes accessibility analysis in Wuhan are: the AOI of Wuhan lakes and reservoirs (as artificial lakes), the road network of Wuhan, and the community points of Wuhan.

The main analysis steps are as follows:

- The topology of Wuhan's road network was carried out in Arcgis.10.8 software. In detail, the road network layers needed for this time were first extracted (primary roads, secondary roads, tertiary roads, pavements, etc.), then a buffer zone was created for some of the two-lane road network and the median was extracted to make it single-lane. Then all the road networks were topologised, mainly fixing overlapping road networks, suspension points and pseudo-knots to make the network better connected and to facilitate the accessibility analysis done later.

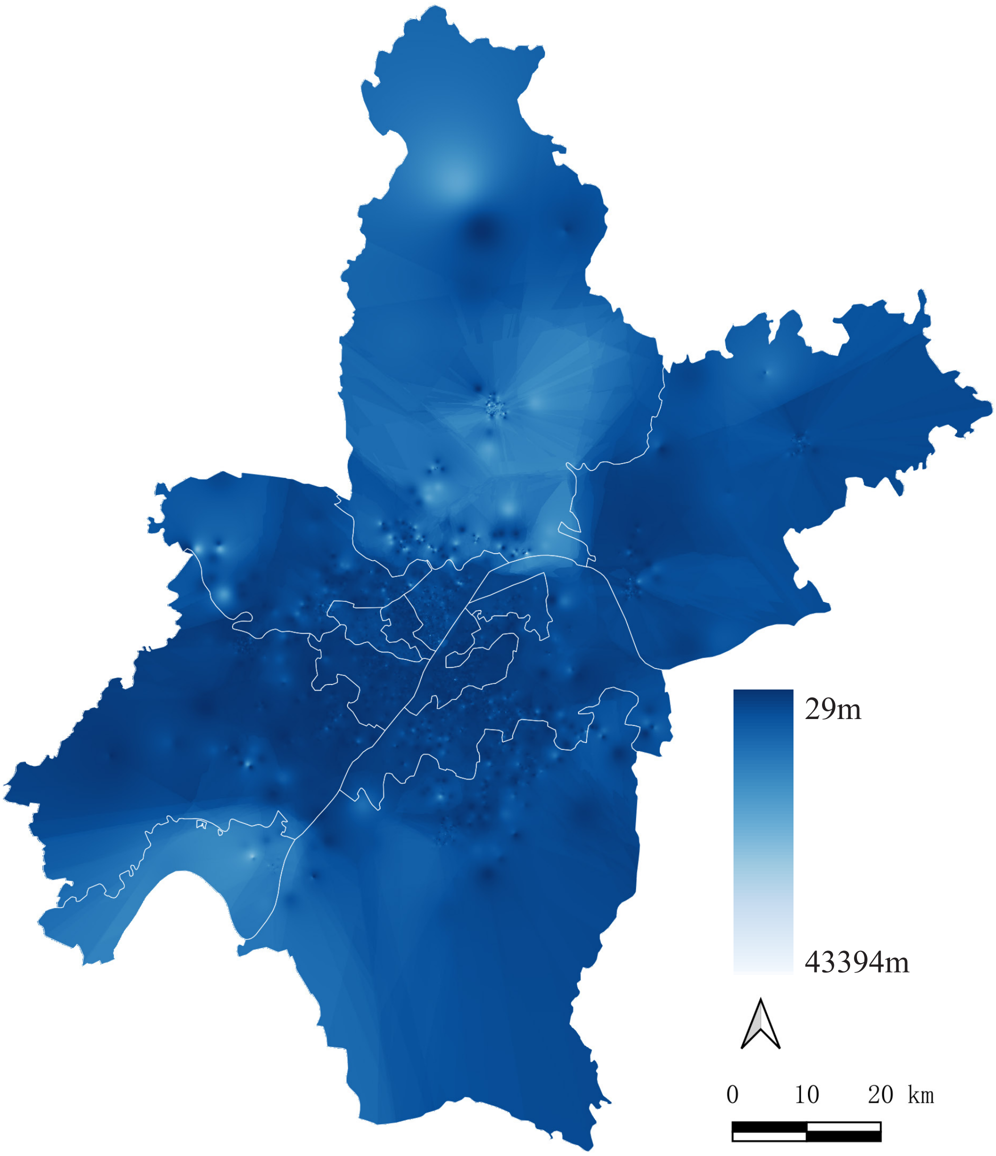
- The OD cost matrix was created, with the starting point set as a community point and all points of interest captured on the nearest road network for the accessibility analysis, and the destination point set as the intersection of the road and the lakes.

- Run the OD cost matrix method with inverse distance weights to get the detailed distance (nearest to furthest distance) from the community point to the lakes.

- Create a 1km*1km grid, run the partition statistics method, attach the distance from the community points to the lakes to each cell and calculate the mean and minimum values for each cell distance to better analyse which areas are within the 10km threshold and to detail them into easy to reach distances (≤1km), difficult walking distances (2.5 km), transport accessible distances (5 km) and difficult to reach distances (10 km). The partition statistics are then further applied to the administrative areas to give a more visual indication of which administrative districts have better lakes accessibility.

Map. 22

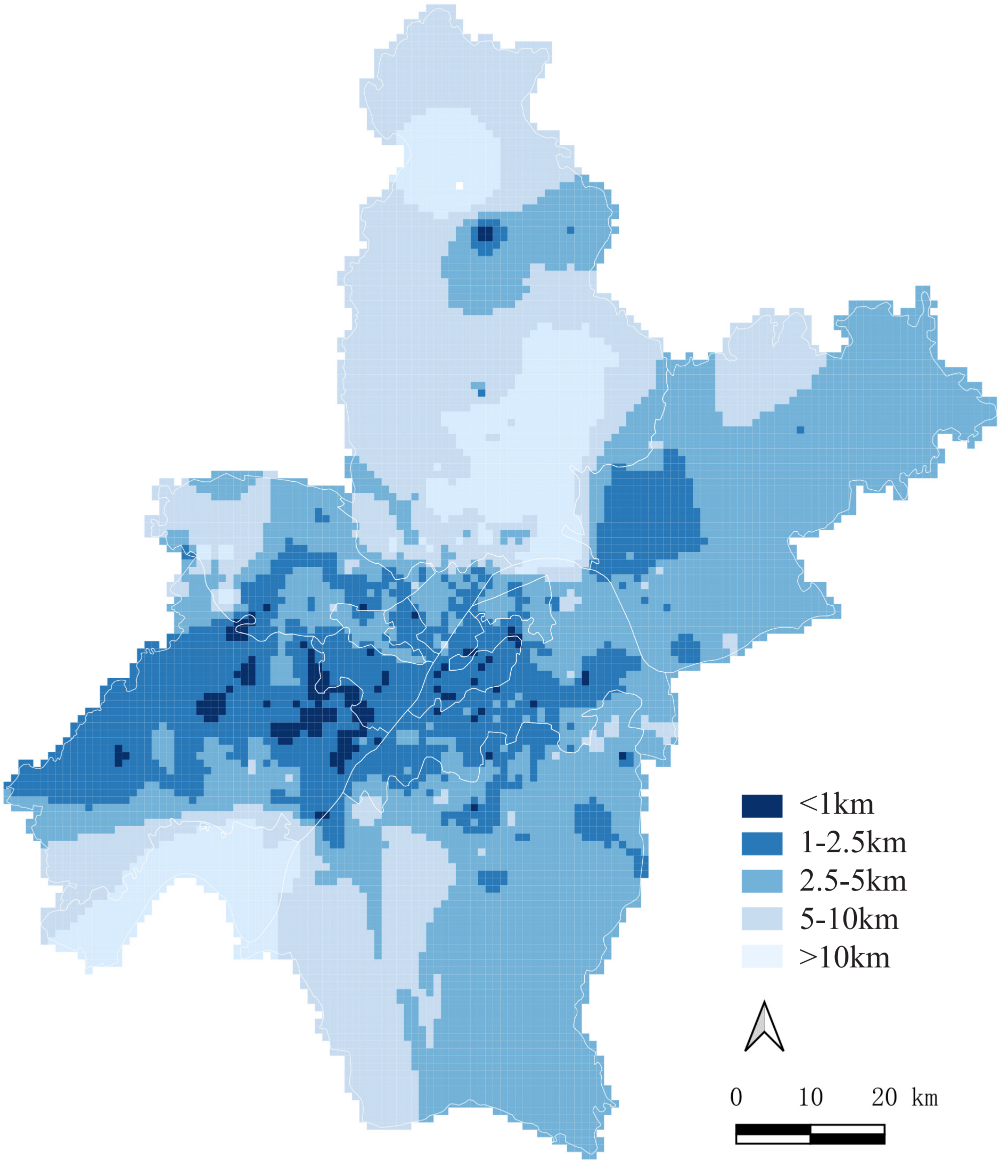
Analysis of lakes accessibility



This study calculated the different distance from the community points to lakes, based on the network, from the shortest distance 29 metres to a maximum distance of 43394 meters.

Map. 23

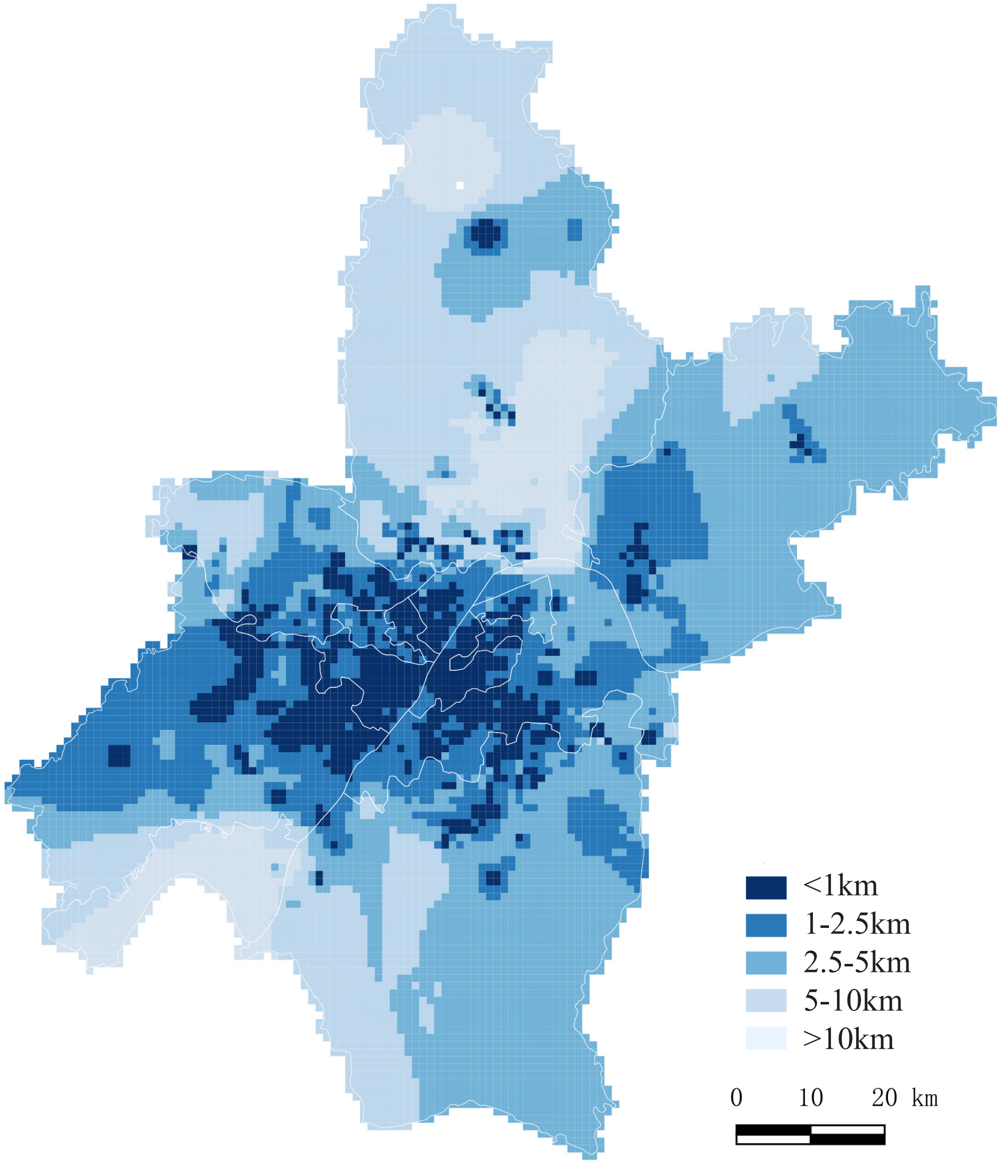
Analysis of lakes accessibility （Mean value）



10 kilometres was chosen as the distance that residents could reach the blue space and it was divided into: easy to reach distance (≤ 1 km), difficult to walk distance (2.5 km), transport accessible distance (5 km) and difficult to reach distance (10 km). The mean value of the distance for each grid cell in a 1km*1km grid was found to derive the accessibility of the lakes within different thresholds.

Map. 24

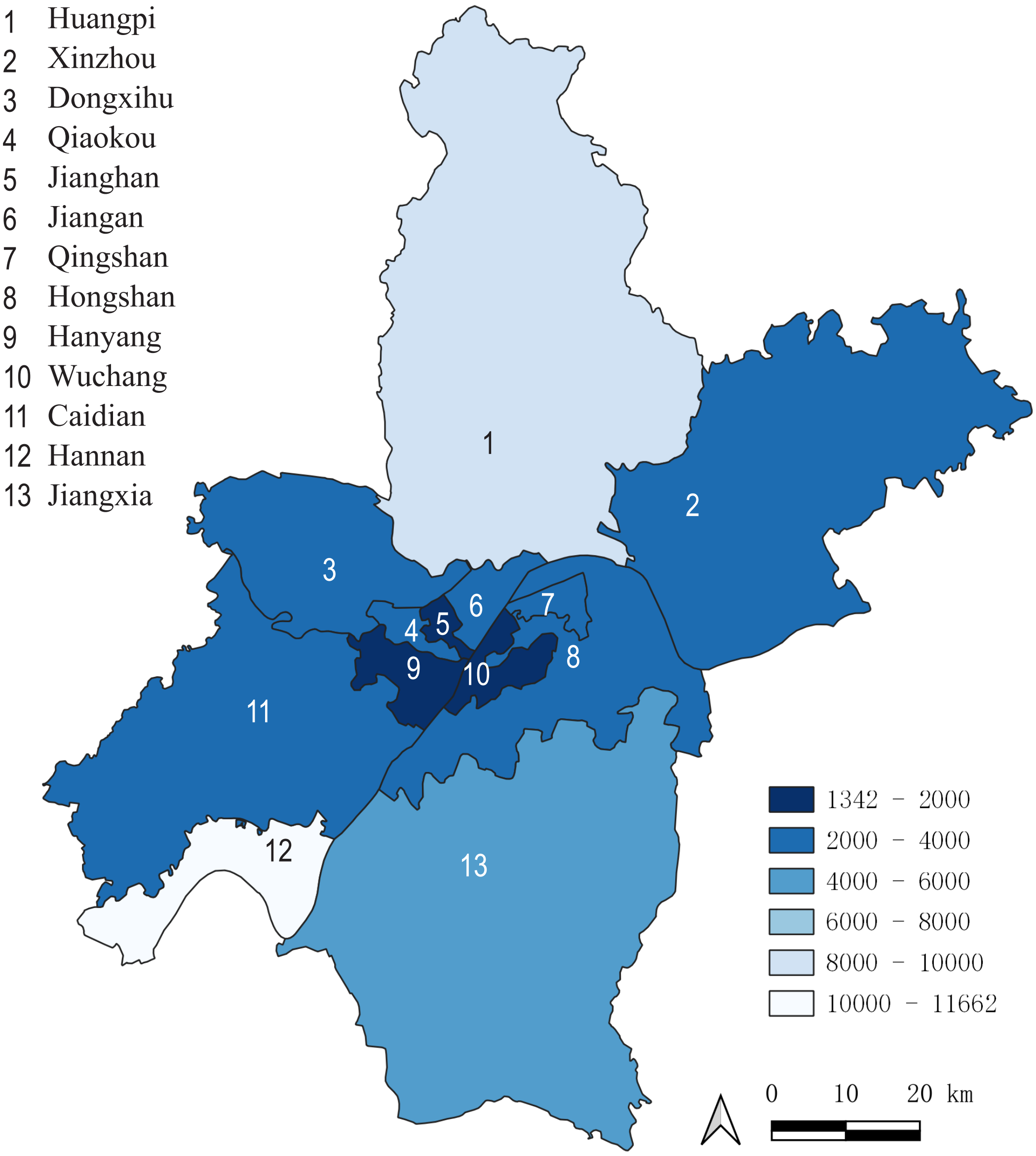
Analysis of lakes accessibility (Minimum value)



The minimum value of the distance is then found for each grid cell in the same way in a 1 km * 1 km grid, yielding the accessibility of lakes within different thresholds. It can be seen that the city centre area also has the best lakes accessibility.

Map. 25

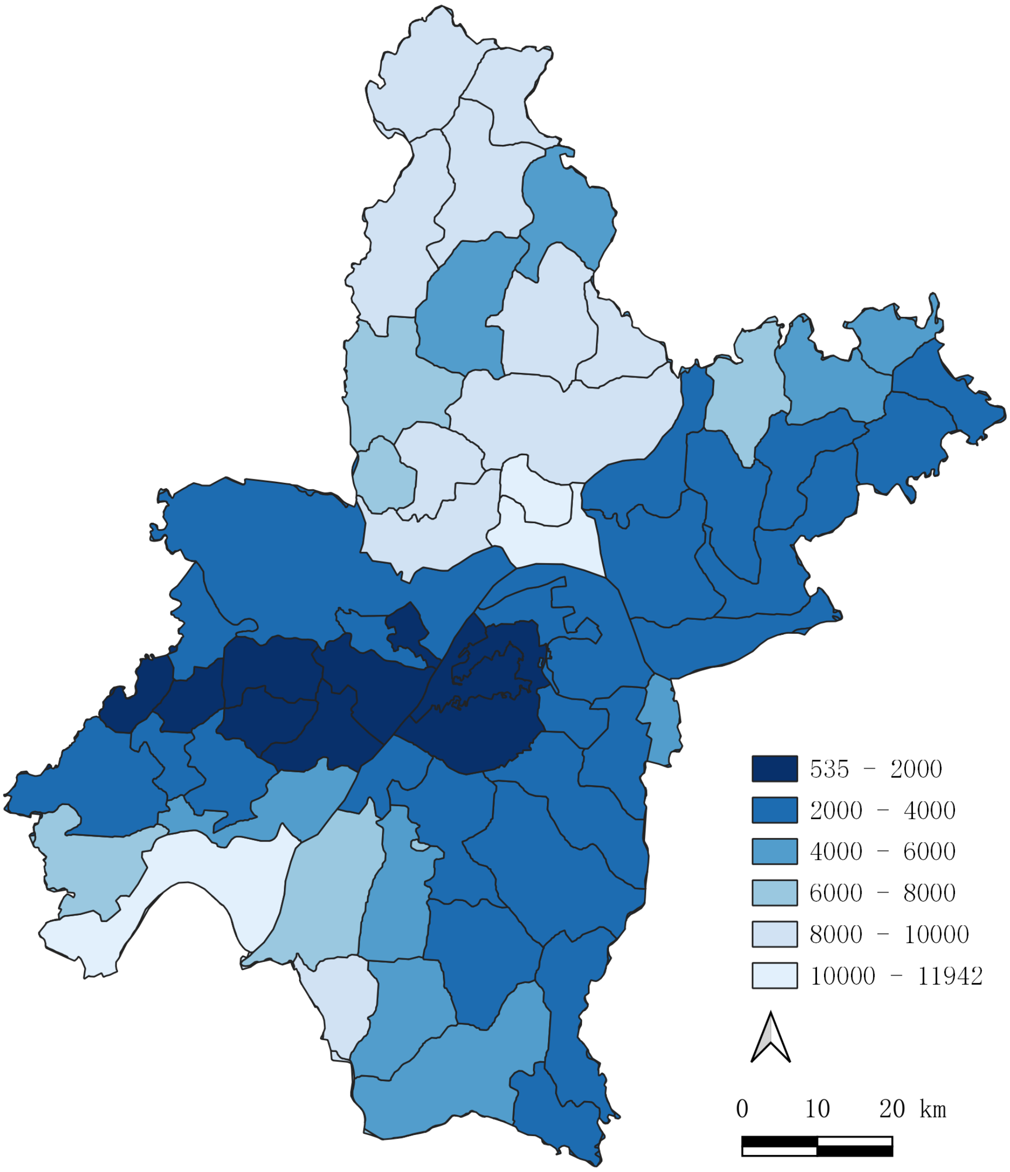
Administrative districts accessibility of lakes (Mean value)



The distances were counted to each administrative district and the mean values were obtained. This map shows that the Jianghan, Hanyang and Wuchang districts have better access to the lakes, which are concentrated in the city centre.

Map. 26

Township accessibility of lakes (Mean value)



Using the same method to calculate lakes accessibility at a more detailed township level, it can be seen that the city centre and the western side of the city (Caidian and East-West Lake districts) have better accessibility to the lakes, while the north-western part is less accessible.

5.3.2.5

Steps for different types of accessibility analysis

Fountains: POI

Fig. 41

Step 1

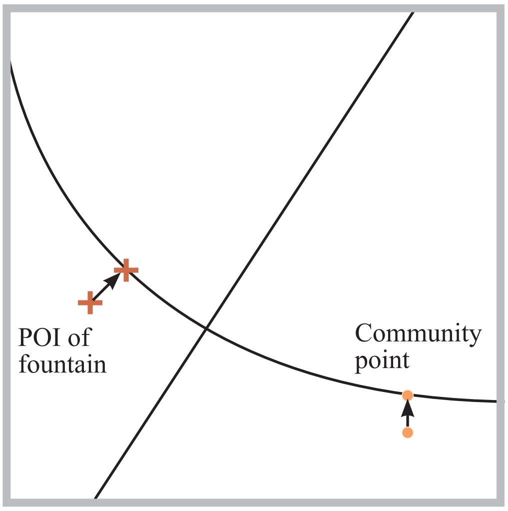
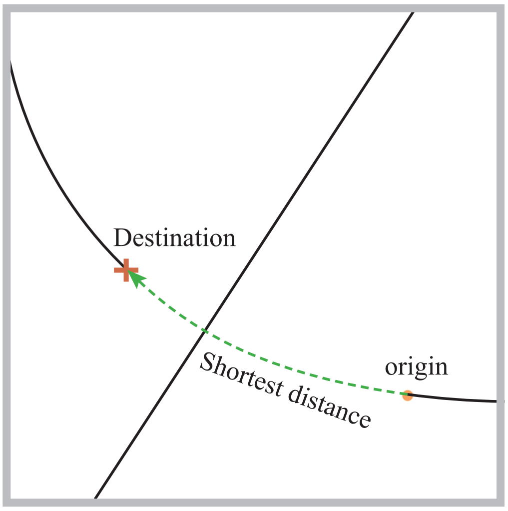


Fig. 42

Step 2



Ponds: AOI

Fig. 43

Step 1

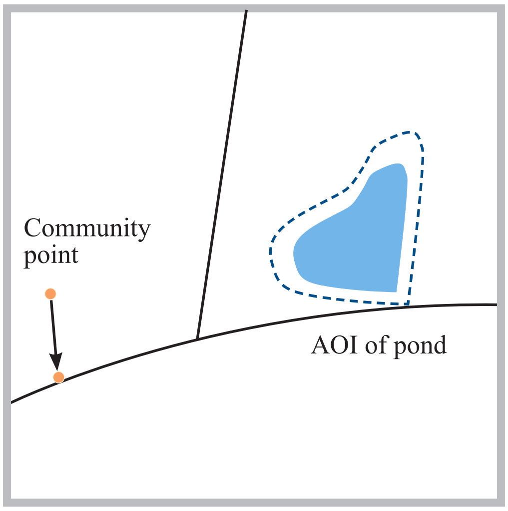
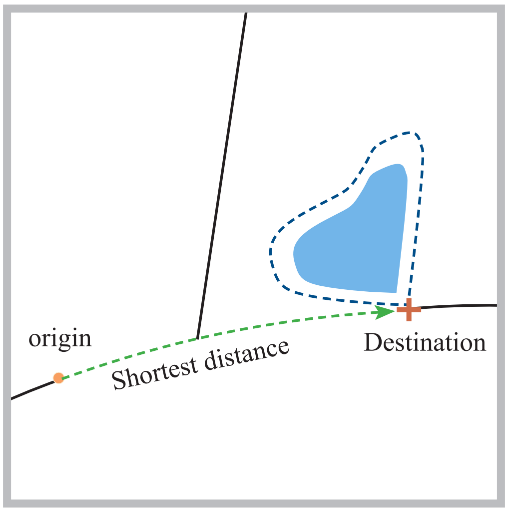


Fig. 44

Step 2



Rivers: AOI

Lakes: AOI

Fig. 45

Step 1

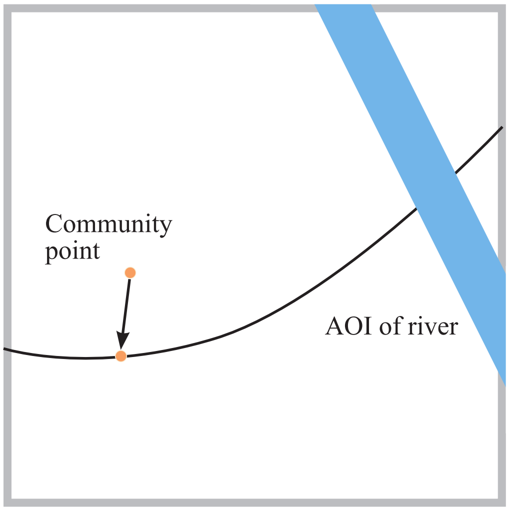


Fig. 46

Step 2

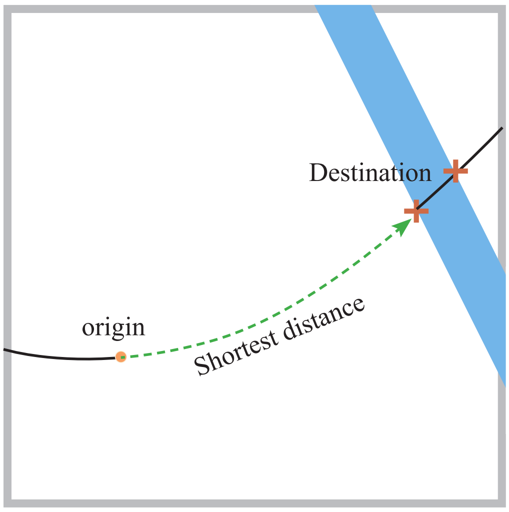


Fig. 47

Step 1

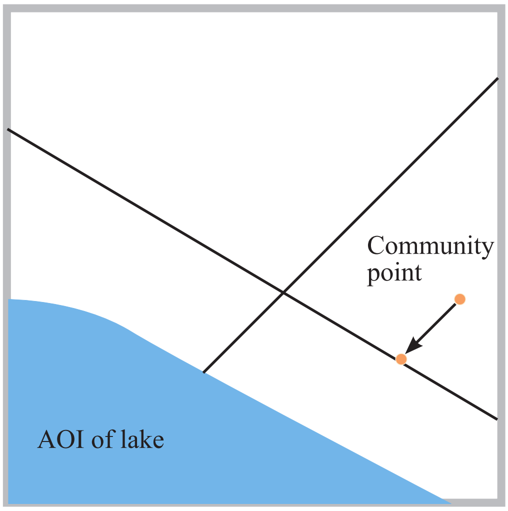
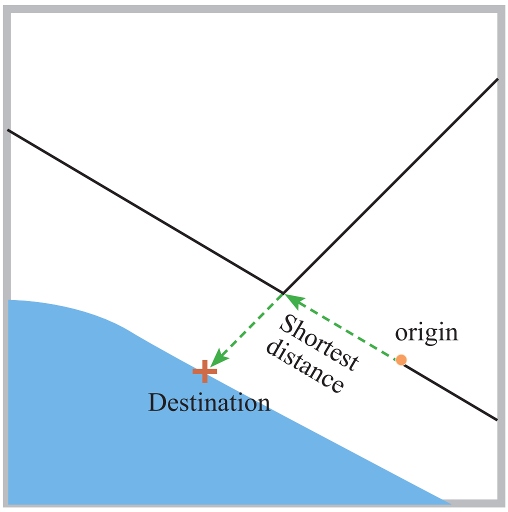


Fig. 48

Step 2



5.4

Data sources

This section provides a detailed explanation of the data sources used in this study. In detail, the data collected in this study were divided into questionnaire data and geographic information data. The questionnaire data was used to obtain key indicators affecting the accessibility of the Wuhan UBS, and the geo-information data was used for the processing of the blue spatial accessibility analysis.

5.4.1

Questionnaire data

The questionnaire for this study was published based on China's questionnaire-starred survey platform (https://www.wjx.cn/) and the respondents were all local residents. The questionnaire consisted of two main parts:

(1) respondents' attributes, including gender, age, economic status and address;

(2) UBS accessibility factors, including mode of travel (walking, cycling, taking public transport and driving), time spent walking to the UBS, time and frequency of visits to the UBS, activities undertaken at the UBS and the type and quality assessment of the UBS.

A total of 1054 valid questionnaires were collected at the end.

5.4.2

Geographical Information System data

The first GIS data for this study is community point data. There are three sources of housing data for Chinese cities: local official data, tax assessor data and real estate websites (Li et al., 2019). The community data for this study is namely from Anjuke (www.anjuke.com), the largest online platform for real estate rental services in China. Specifically, a web crawler technique was used to capture the community information listed on the website, including name, location (latitude and longitude), floor area, total number of households, house price and green ratio. After eliminating some communities with incomplete attributes, 7196 communities were finally obtained (Map. 27).

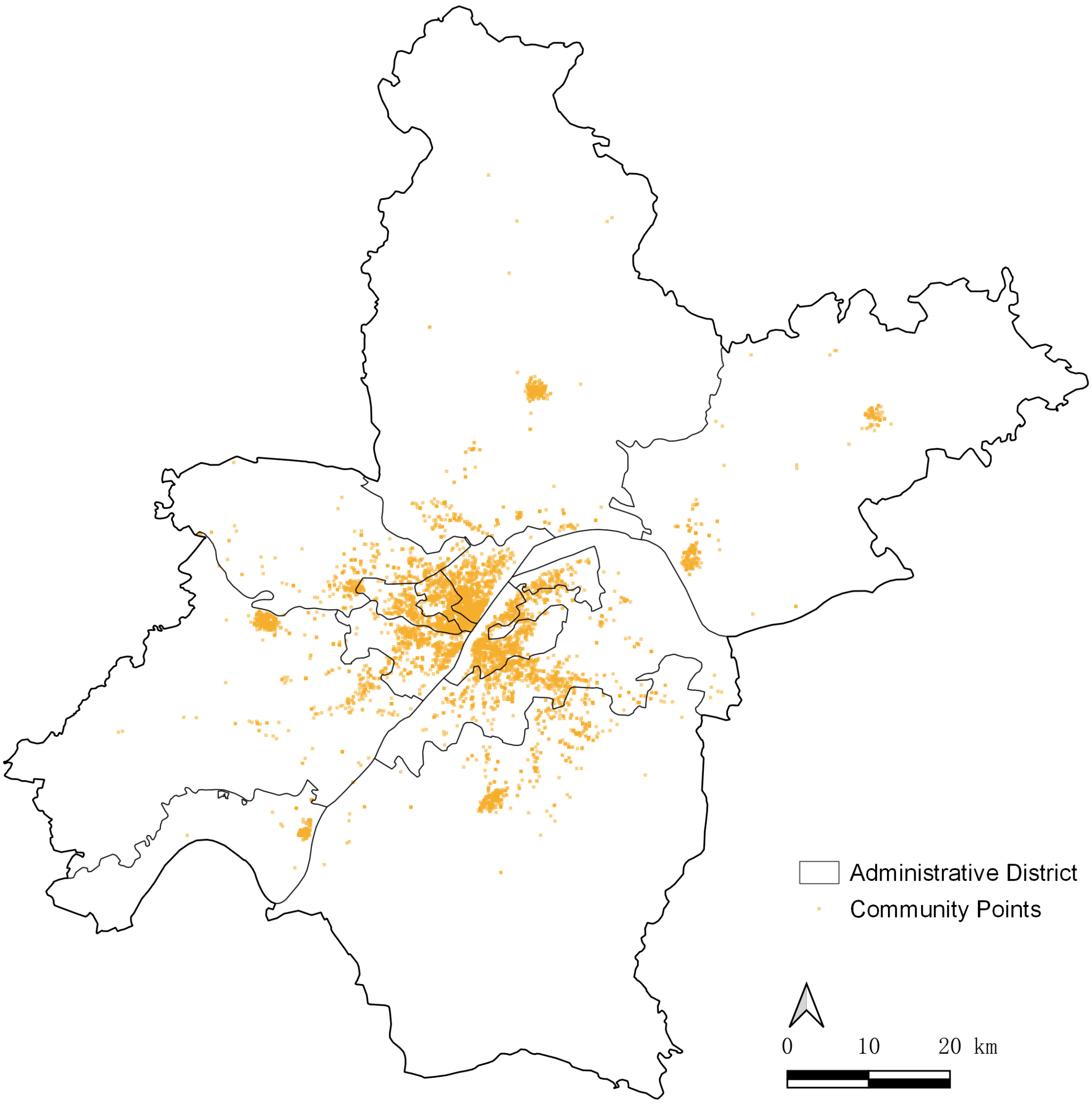
The second GIS data for this study is the geographical location of the different types of blue spaces. Specifically, the blue space data is derived from blue patches extracted from the 2020 Land Survey database and digitised by manual visualisation into rivers, lakes, ponds, reservoirs, etc (Map. 28).

In addition, this study also adds the type of fountains whose points of interest were obtained from the Wuhan Local News Report website, through which eight of Wuhan's most popular fountain points of interest were selected, their names, opening hours and public comments on them (Fig. 49-56), and finally their coordinates were manually digitised and imported into GIS software (Map. 29).

Finally, this study downloaded road network data (Map. 30) covering the study area from Openstreetmap (http://www.openstreetmap.org), where blue spaces provide the blue services needed by residents and the road network makes them available and accessible. This data covers all major streets, neighbourhood/community roads and most branches of the city. Prior to using the data, this study examined it through topology and connected it through road nodes and constructed the road network in ArcGIS 10.8 software to obtain network structure data with nodes and edges to facilitate network distance analysis.

Map. 27

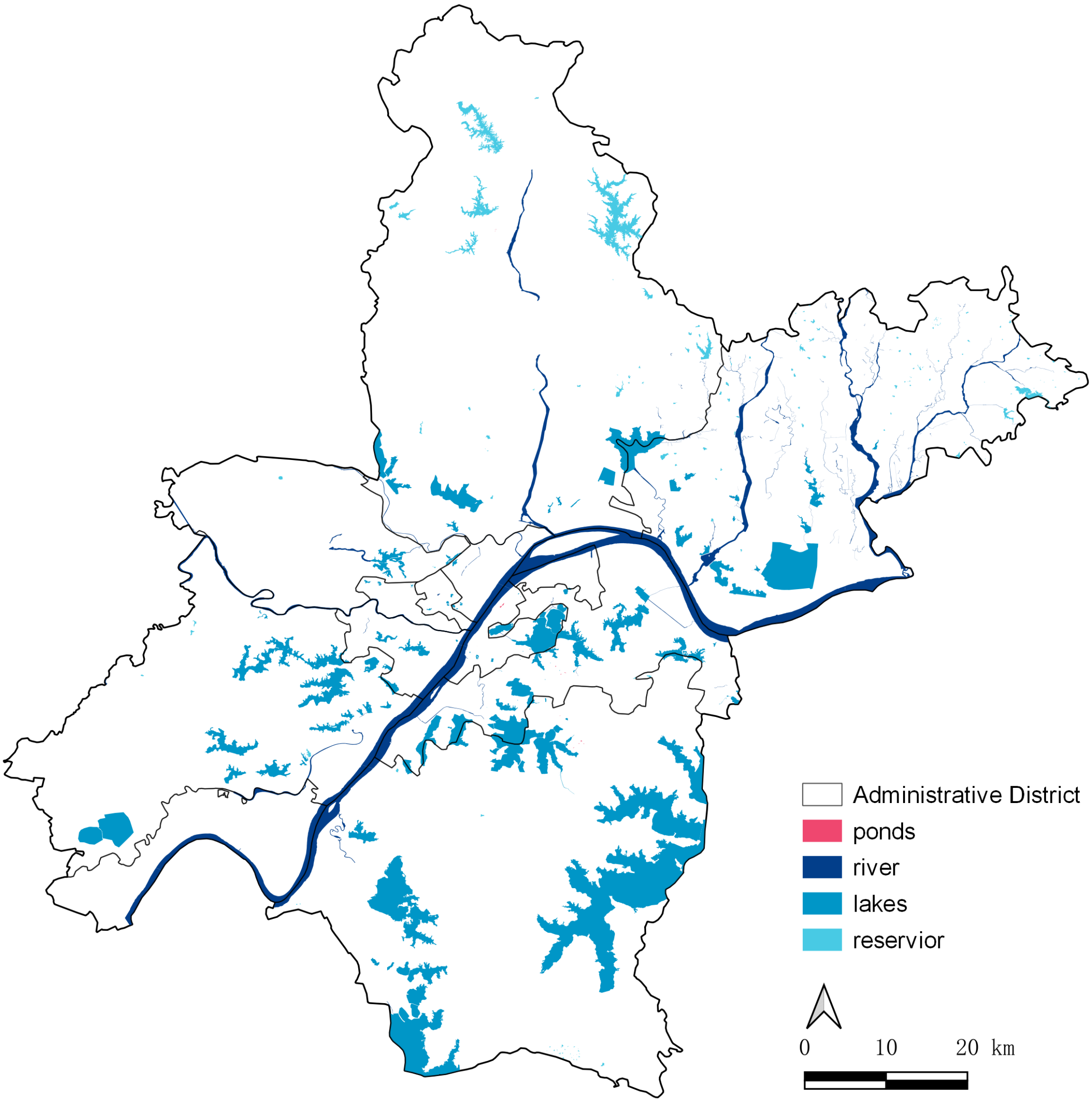
Community spots in Wuhan City



The yellow points are community points in Wuhan, crawled using web crawler technology from Anjuke, the largest rental website in China.

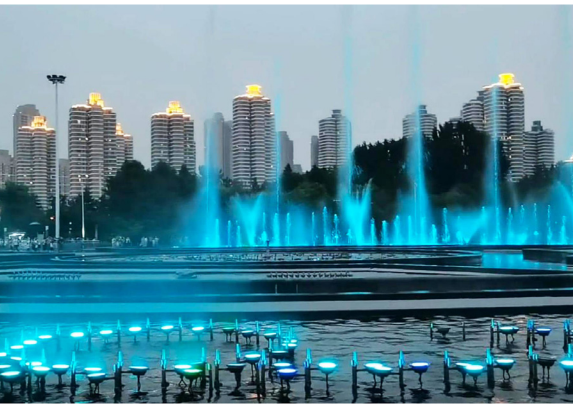
Map. 28

Blue Spaces in Wuhan City



Wuhan's blue spatial data is derived from the blue patches extracted from the 2020 Land Survey database and digitized into rivers, lakes, ponds, reservoirs, etc. by manual visualization.

Fig. 49



Wuhan International Expo Center Musical Fountain (the most intelligent)

Opening time:
June-October
Every Friday: 19:20-19:35
Every Sunday: 09:30-09:45
Mr. Liu:
My children especially like this fountain, jumping around, and then when the fountain sprayed to the highest also kept screaming, happy as can be!

Fig. 50

Wuchang Shouyi Square Fountain (the coolest and most colorful)

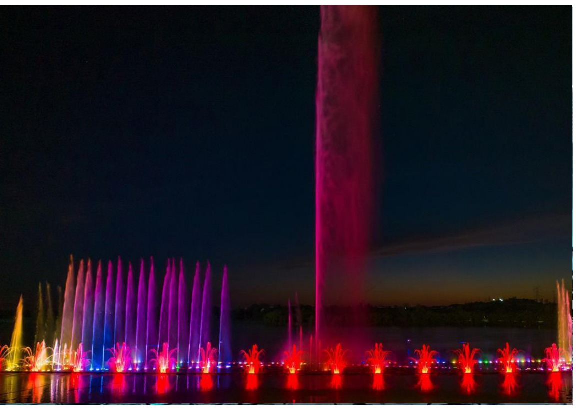
Opening time:
May-October
Every Tuesday to Sunday: 19:30-19:50
Changjiang Daily reporter:
This fountain is a perfect combination of sound, electricity and light.

Fig. 51

Fetching water building fountain park （the most sentimental）

Opening hours:
19:30-20:00 daily
Grandma Chen:
This fountain every day, we live near here, every day will look at the fountain, take a walk and talk about the day before going home.

Fig. 52



Wuhan Houguan Lake National Wetland Park Musical Fountain

Opening hours:
Friday and Saturday night 19:50-20:20
News reporter:
Large musical fountain and water curtain light and shadow such as beating notes dynamic, dazzling night scenery is pleasing to the eye.

Fig. 49-56

Popular fountains

Sources:
https://www.163.com/dy/article/GG55CF6805288POO.html
https://www.sohu.com/a/550150605_497382
https://www.wuhan.com/travel/105592.html
http://www.zhongshanpark.com/news/15.html

Fig. 53

Wuhan Tiandi Fountain (the most noisy)

Opening time：

Daily: 11:30-14:00 17:30-21:00

Ms. Yang：

I can basically see the fountain every day when I pass by here, quite a few adults with children over here to see the fountain, don't look at it small, but it's super popular! I will often take my girl to play here after work, she always run around the fountain.

Fig. 54

Jiangxia Central Grand Park Musical Fountain (one of the largest)

Opening time：

May-October： Every Friday 20:00-20:30

October-May： Every Saturday 19:00-19:30

Jiangxia District Reporter:

It's one of the largest musical fountain in Wuhan City, Jiangxia District, a beautiful card, beautiful lights and water type, not only make the local people of Jiangxia proud, but also attracts many foreign tourists.

Fig. 55

Wuhan Zhongshan Park Musical Fountain

Opening time：

Monday to Friday 10:30, 16:00

Saturday, Sunday 10:30, 16:00, 19:30

Ms. Liu:

On New Year's Day we spent the holiday locally, but I didn't expect the park at our doorstep to be so exciting, the children and the elderly were very happy.

Fig. 56

Wuhan University of Technology Musical Fountain

Opening time:

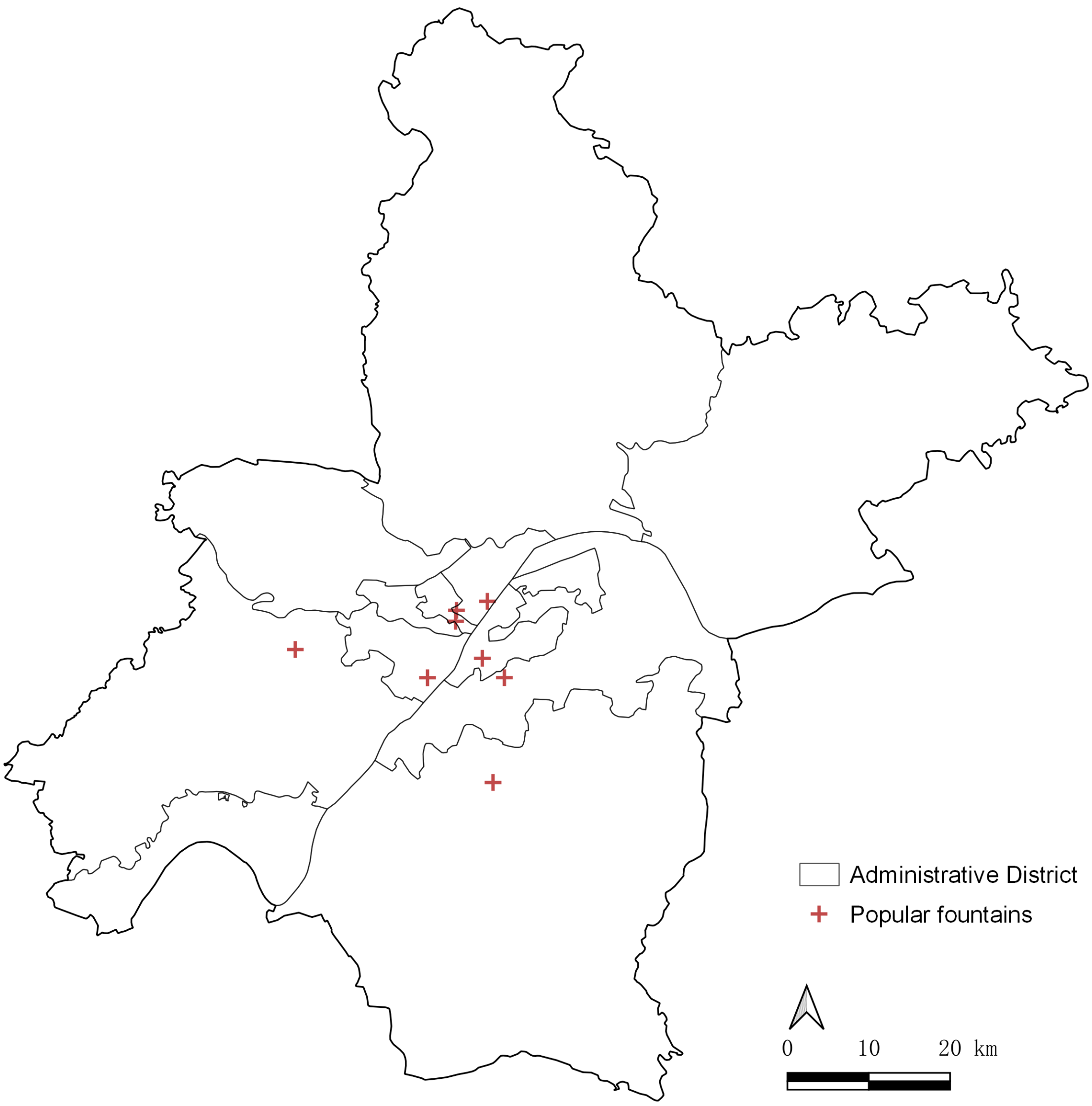
Friday 19:30-20:00

Student Yang:

From the library can see the hot spring is particularly happy, every time the fountain open not only students, nearby residents will also walk over to see the fountain.

Map. 29

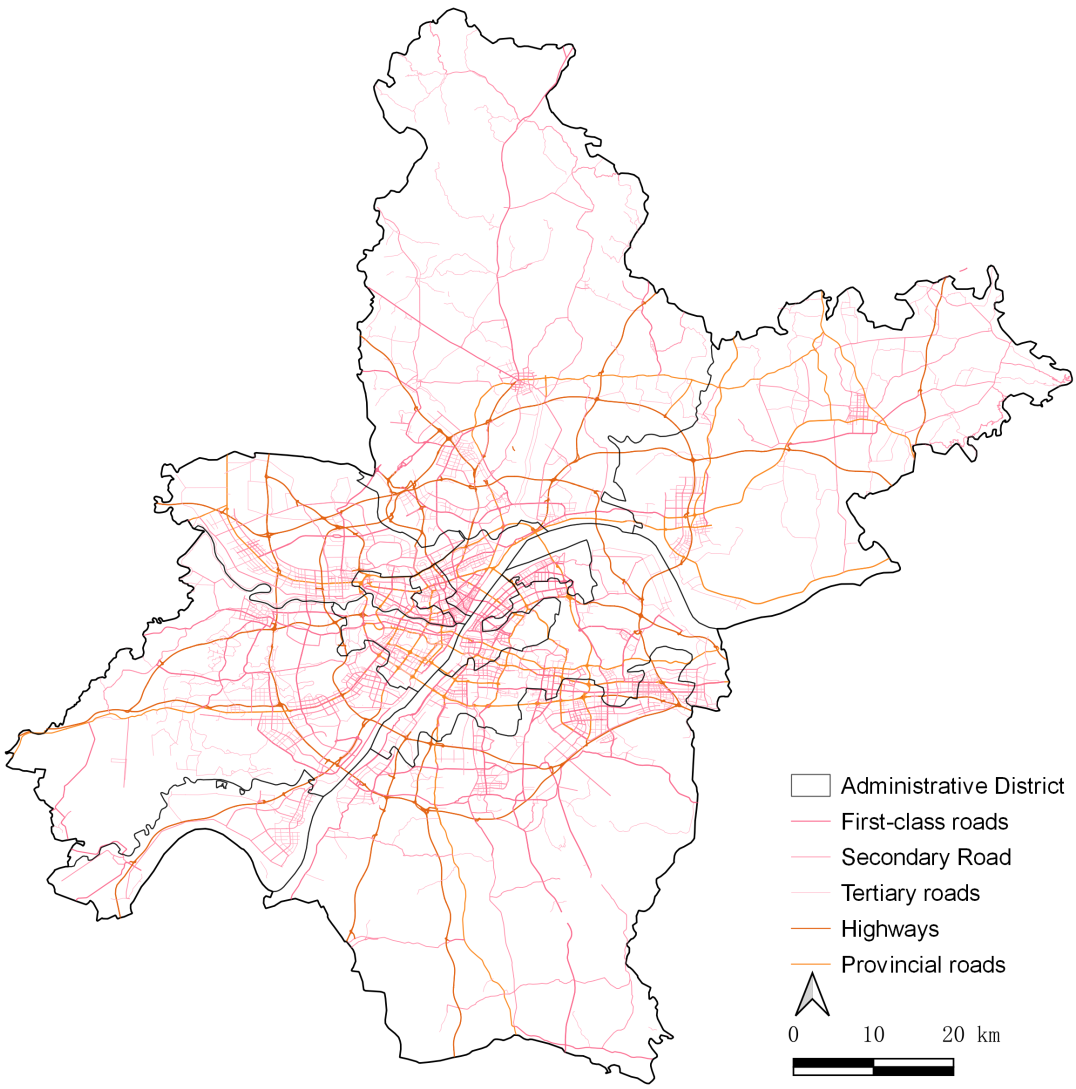
Points of Interest in Wuhan fountains



The 8 most popular fountain points of interest in Wuhan were obtained from local news reporting websites in Wuhan. After obtaining their names, opening hours and public comments on them, their coordinates were manually digitised and imported into GIS software.

Map. 30

Road Network in Wuhan City



Road network data covering the study area was downloaded from Openstreetmap and manually classified for this study. Blue spaces provide the blue services that residents need, while the road network makes them available and accessible. And before using this data, this study performed road network topology in ArcGIS 10.8 software to obtain network structure data with nodes and edges to facilitate network distance analysis.

chapter 6

Discussion and conclusion

6.1

Discussion on the relationship between blue space accessibility and income

Table. 09

2020 Wuhan City Sub-district GDP

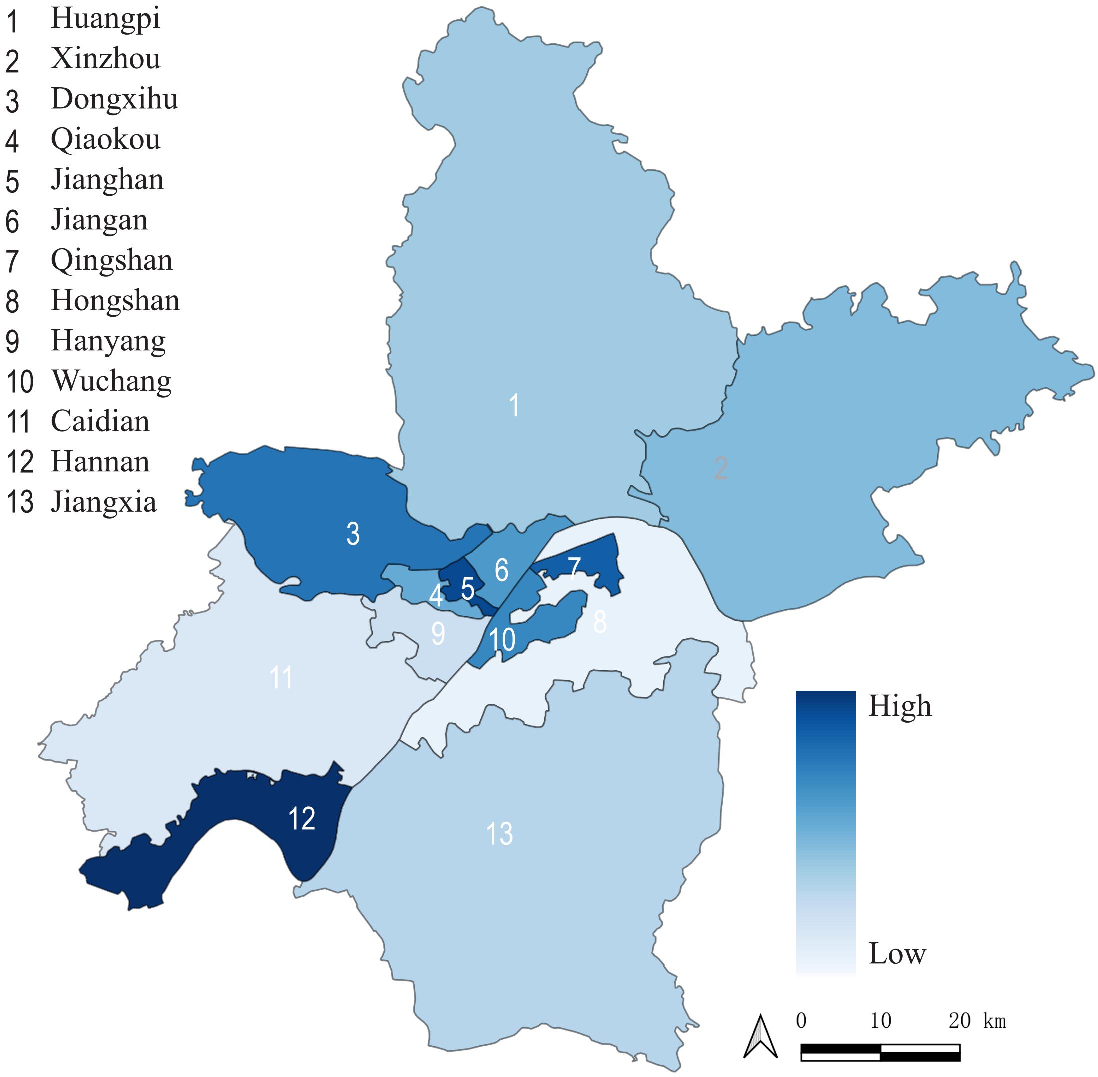
Source：2021 Wuhan Statistical Yearbook

District	GDP in 2020 (100 million yuan)	GDP / per (10000 yuan)	GDP per capita ranking
Jiangan	1247.04	12.92	6
Jianghan	1319.06	20.36	2
Qiaokou	801.16	12.02	7
Hanyang	699.01	8.35	11
Wuchang	1492.93	13.66	5
Qingshan	761.47	16.44	3
Hongshan	1036.16	5.99	13
Dongxihu	1370.17	16.20	4
Hannan	1650.31	34.29	1
Caidian	371.34	6.70	12
Jiangxia	842.04	8.64	10
Huangpi	1013.28	8.80	9
Xinzhou	888.57	10.33	8

After analyzing the accessibility of different types of blue space in Wuhan, this study will explore the correlation between its results and the economic development of different administrative regions in Wuhan. First, I found the data of different administrative regions and per capita GDP in Wuhan in 2020 from the 2021 Wuhan Statistical Yearbook, and displayed it in the form of a map (Map. 31).

Map. 31

2020 Wuhan per capita GDP ranking



It can be seen from the analysis results that Hannan District, as Wuhan Economic and Technological Development Zone, ranks first in per capita GDP, Jianghan District in the city center ranks second, Qingshan District, which is a chemical industry zone, ranks third, and Dongxihu District, an airport development zone, ranks fourth.

Table. 10

2020 Wuhan City Sub-district per capita disposable income

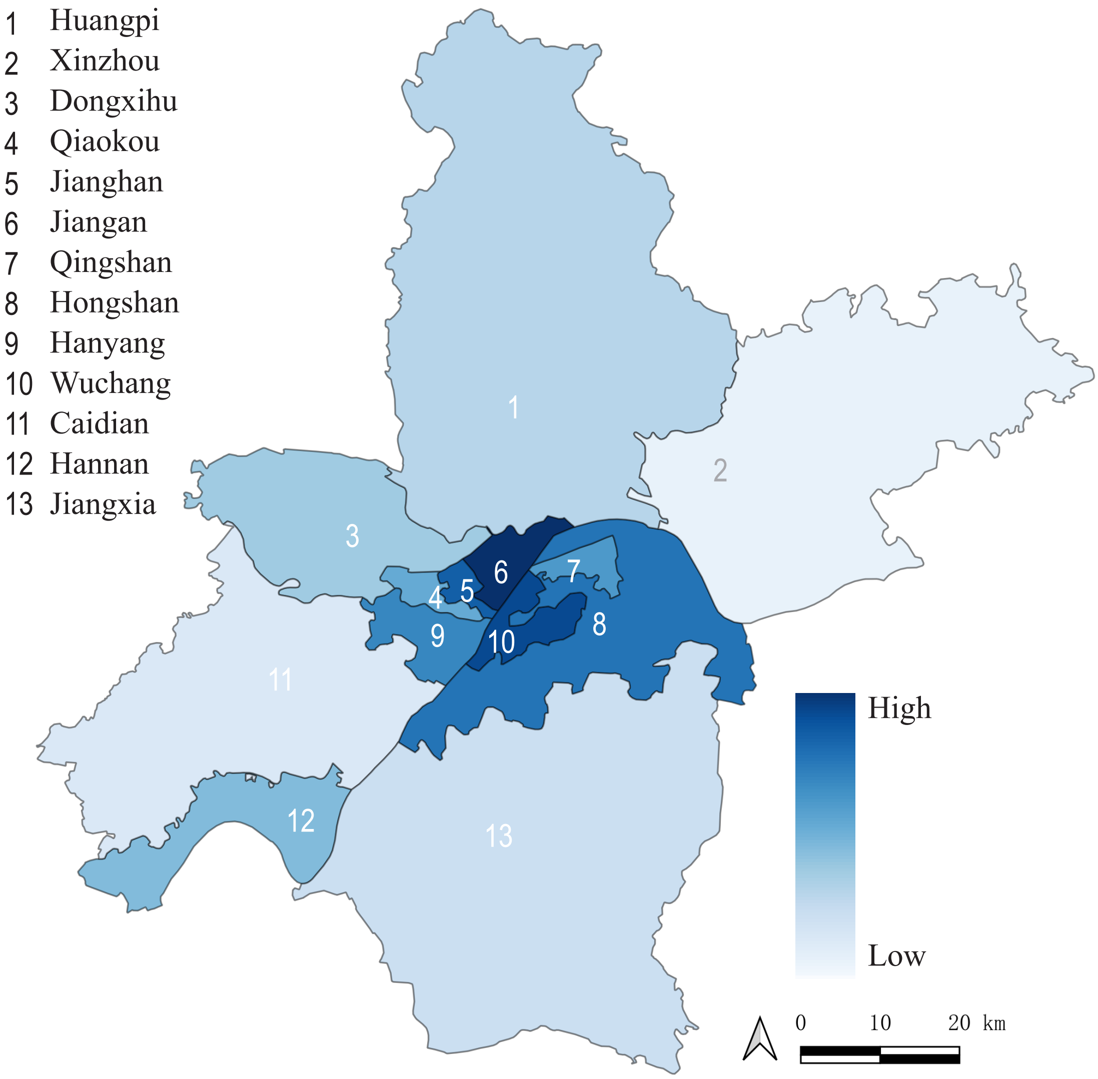
Source：2021 Wuhan Statistical Yearbook

District	disposable income / per (yuan)	Per capita disposable income ranking
Jiangan	57257	1
Jianghan	56090	3
Qiaokou	46631	7
Hanyang	51457	5
Wuchang	57109	2
Qingshan	50893	6
Hongshan	54779	4
Dongxihu	41244	9
Hannan	43902	8
Caidian	37359	12
Jiangxia	37382	11
Huangpi	38673	10
Xinzhou	34856	13

Although we often use per capita GDP to measure the development level of a region, in fact, the indicator of "per capita disposable income" reflects the wealth that ordinary people can get. This research also presents the data of per capita disposable income of different administrative regions in Wuhan in 2020 from the 2021 Wuhan Statistical Yearbook in the form of a map (Map. 32).

Map. 32

2020 Wuhan per capita disposable income ranking



This study finally decided to use the data of per capita disposable income to compare with blue space accessibility. As can be seen from the map, the per capita disposable in the downtown area is generally higher.

Table. 11

Mean distance to blue space for each district

Source：Summarized from the previous accessibility analysis

Districts	Mean distance to blue space(m)			
	fountain	pond	river	lake
Jiangan	8072	7547	1505	3120
Jianghan	4048	6812	1706	1688
Qiaokou	8351	8045	1628	2774
Hanyang	6498	5337	2299	1274
Wuchang	5832	3611	2254	1342
Qingshan	14777	7229	2961	2774
Hongshan	17165	9430	4249	2942
Dongxihu	21052	15497	3170	3985
Hannan	34274	26864	1884	11662
Caidian	19686	14869	3284	2899
Jiangxia	16824	11448	10220	4455
Huangpi	48822	26640	3475	8344
Xinzhou	55564	45146	1753	3815

From the accessibility analysis in Chapter 4, it can be concluded that the accessibility of different administrative areas to different types of blue space is different. For the four types of blue space, the accessibility of the downtown area is generally better. The next step is to do a correlation analysis between regional accessibility and regional per capita disposable income. First of all, in this study, the mean distance of each region to different blue space types is calculated on a table. It can be seen that the accessibility of lakes and rivers is higher than that of fountains and ponds, because their distances are generally shorter.

Fig. 57

Correlation analysis between fountains and per capita disposable income

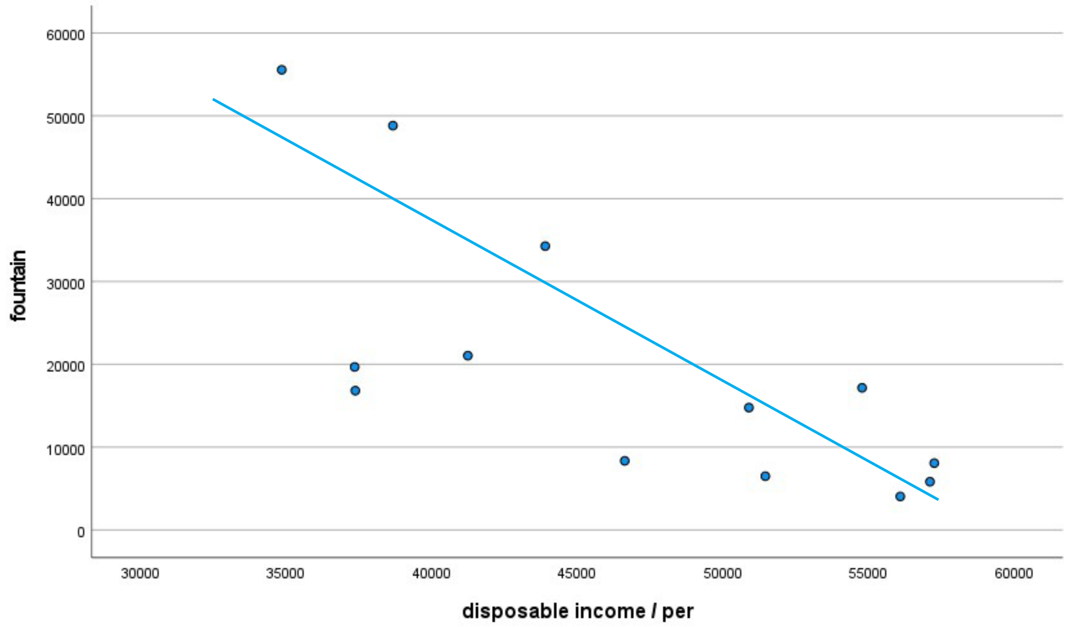


Fig. 58

Correlation analysis between ponds and per capita disposable income

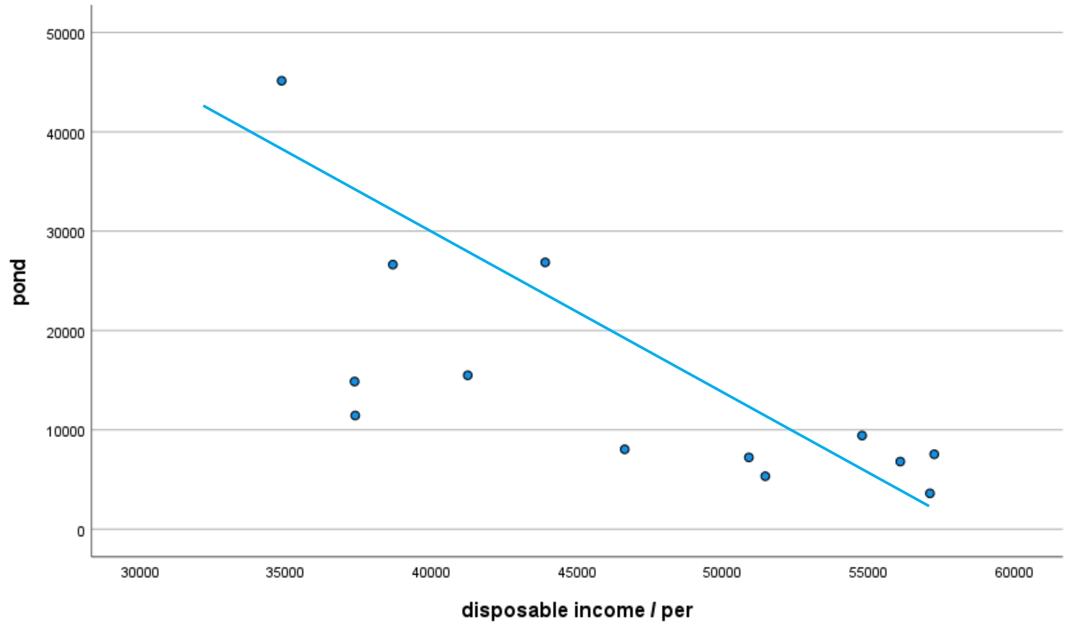


Fig. 59

Correlation analysis between rivers and per capita disposable income

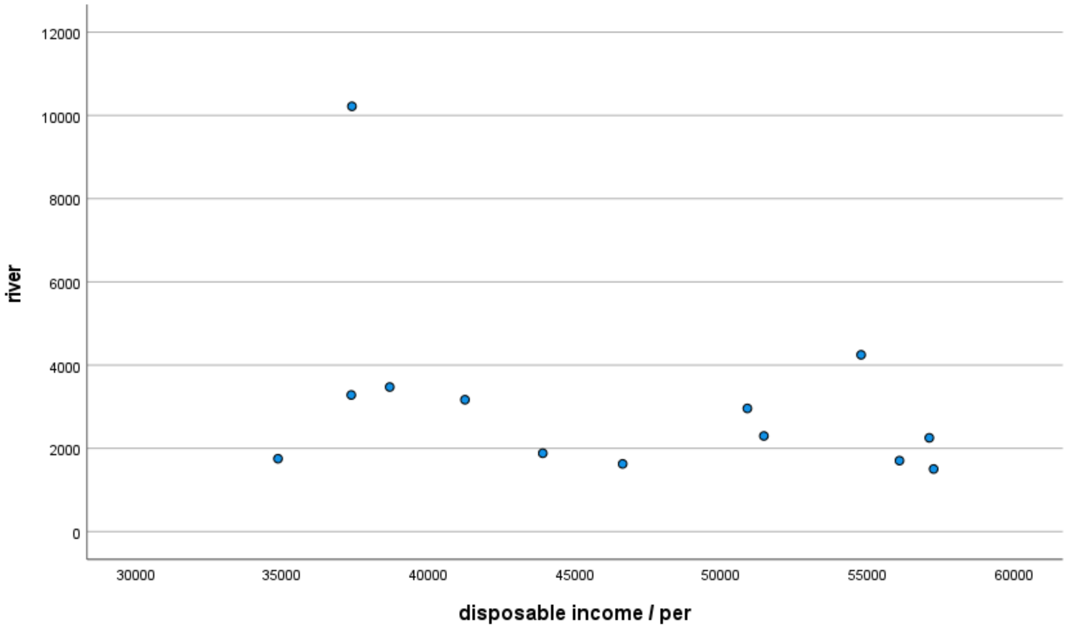
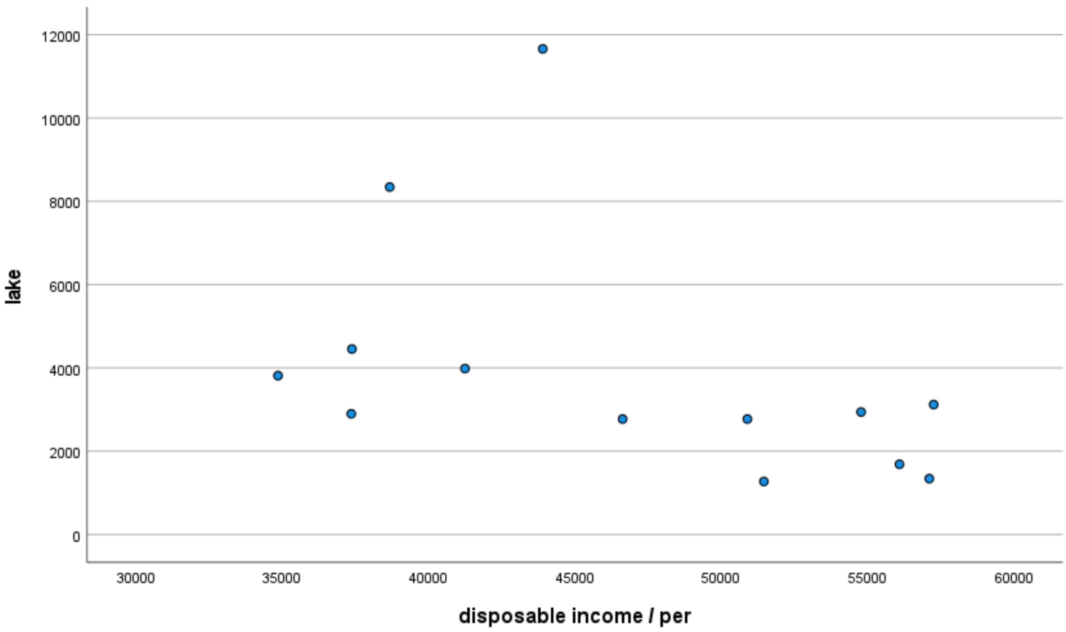


Fig. 60

Correlation analysis between lakes and per capita disposable income



This study uses SPSS data analysis software to study the relationship between the accessibility of different types of blue space and regional per capita disposable income in Wuhan.

Steps:

- Import the data of (Table. 10, 11) into SPSS, and conduct scatterplot analysis on fountain accessibility and income, pond accessibility and income, river accessibility and income, and lake accessibility and income, respectively. get (Fig.57-60).

- The Spearman coefficient was used to test the correlation of the scatter plot. The Spearman correlation coefficient > 0 was positive correlation, and < 0 was negative correlation. The closer it is to 1 and -1, the stronger the correlation. Generally speaking, a correlation coefficient above 0.7 indicates a very close relationship; a correlation coefficient between 0.4 and 0.7 indicates a close relationship; and a correlation coefficient between 0.2 and 0.4 indicates a general relationship.

Result:

- It can be seen that the accessibility of fountains and ponds(Fig57,58) is negatively linearly related to income, and their Spearman correlation coefficients are both -0.791, showing a strong correlation. This means that the higher the per capita disposable income, the shorter the distance (and the better the accessibility) to fountains and ponds.

- The accessibility of rivers and lakes(Fig59,60) is nonlinearly related to per capita disposable income. Their Spearman correlation coefficients are -0.418 and -0.579, respectively, and the correlation is not so strong. It is speculated that the primary factor determining the location of large lakes and rivers is not economic development, but geographical conditions are very important factors.

6.2

Conclusions on the accessibility of blue space in Wuhan

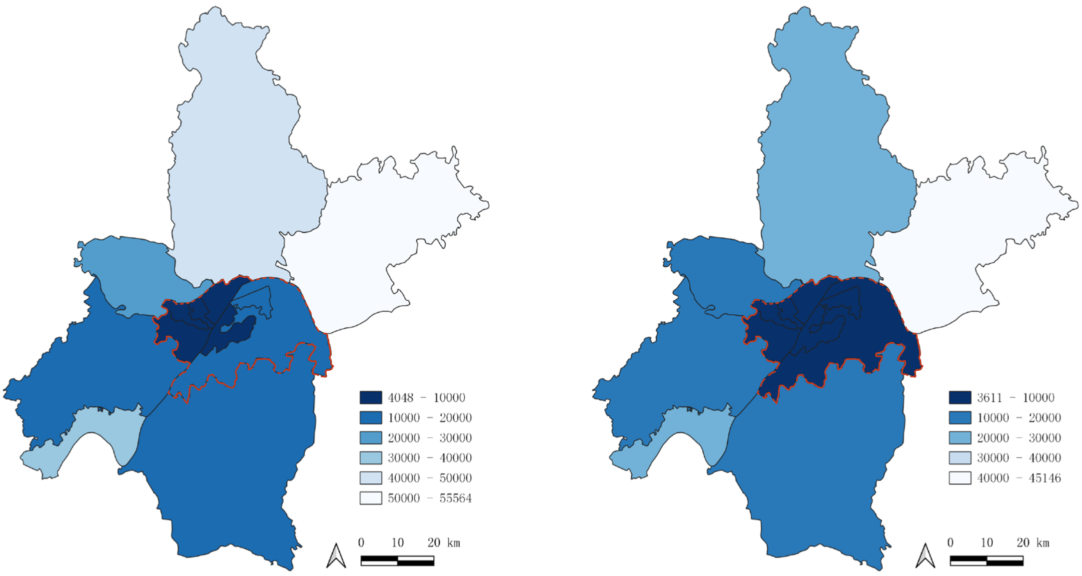
From the accessibility analysis results (Map.-) of this study, it can be concluded that residents living in the central area of Wuhan have relatively good accessibility to all types of blue spaces.

Among them, the accessibility of fountains (Map.) and ponds (Map.) has a large gap between districts, which means there is an unequal distribution. Considering that the darkest blue in the maps on the right represents the mean accessibility within 10km, this means that the other colored areas are all at inaccessible distances. And the accessibility of fountains is more different than that of ponds, which only exist in the very center of the central area, and they are also the districts with the highest per capita disposable income.

On the other hand, rivers (Map.) and lakes (Map.) show better and more equal accessibility, with only a few administrative districts having an accessibility distance of more than 10 km (hard-to-reach distance). And the darkest-colored regions show good walkability as their mean distance is less than 2000m. The best accessibility to the lake still exists in the city center, while the northeast, center, and southwest areas all show the best river accessibility. It is speculated that the river runs through the northeast to the southwest of Wuhan City and has many tributaries, and for large naturally formed blue spaces such as rivers and lakes, geographical factors have a greater impact on its location, while economic factors are less.

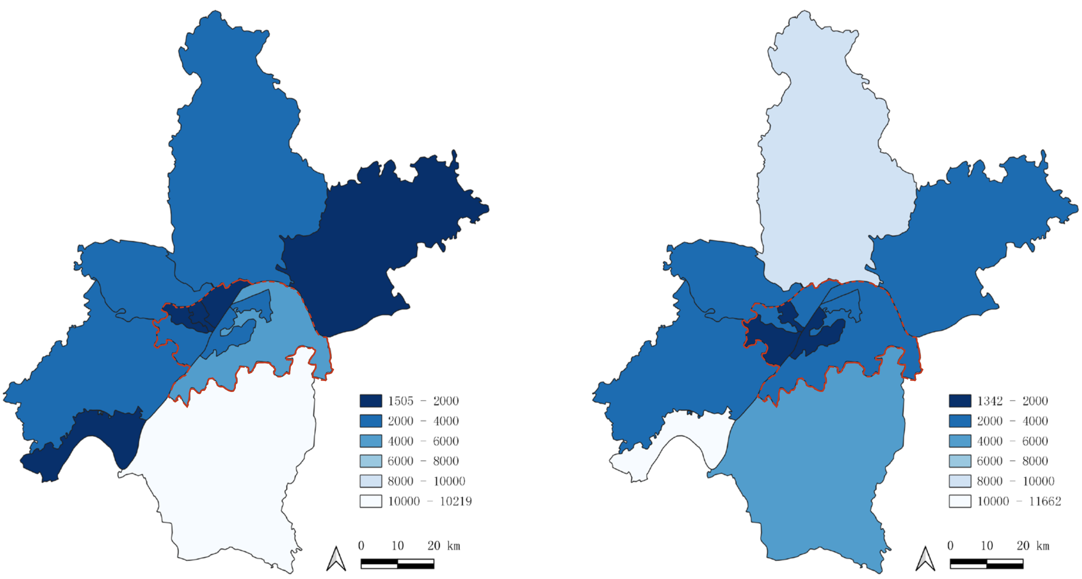
Map. 37

Administrative districts accessibility of fountains and ponds (Mean value)



Map. 38

Administrative districts accessibility of rivers and lakes (Mean value)



6.3

Advantages and limitations of the research

This study is one of the few studies in China that studies the accessibility and distribution equity of blue space in densely populated cities, and this study comprehensively considers different types and scales of blue space (fountains, ponds, rivers and lakes).) and analyzed the accessibility of Wuhan community points to it respectively, and obtained the accessibility difference between the administrative regions of Wuhan. The findings provide useful information for policy and planning to ensure adequate blue space and eliminate environmental inequalities.

The analysis of this study is not without limitations. First of all, in terms of questionnaire design, this study uses a semi-structured questionnaire instead of a structured questionnaire, and the number of respondents is not strictly controlled in proportion to the population base of different administrative regions. Therefore, the results of the questionnaire are relatively less rigorous and objective. Secondly, in terms of accessibility analysis, this study adopts a measurement range of 10km and divides it into easy-to-reach distances (≤1km), difficult walking distances (2.5km), traffic-reachable distances (5km) and difficult-to-reach distances The distance (10 km), this range includes both walking and transportation, however, in reality, the transportation modes that urban residents choose to enter the blue space can also be subdivided into cycling, public transportation and driving.

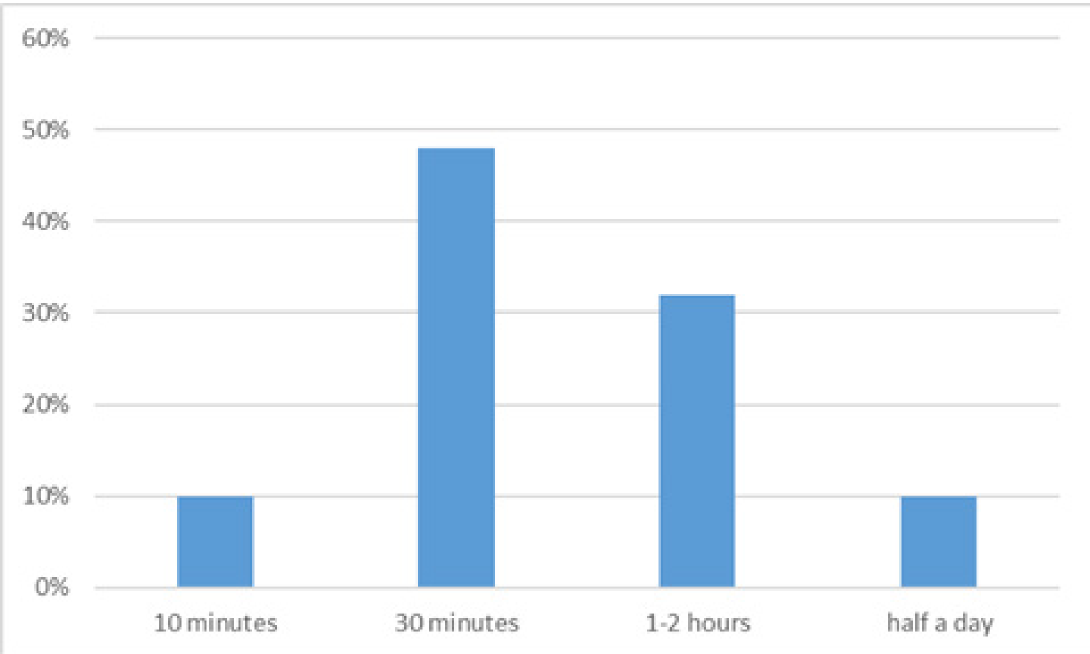
In conclusion, although this study is an important step towards understanding blue space accessibility and equity in dense cities in developing countries, there is still much room for research. If the method of questionnaire survey is designed in future research, the proportional sampling method should be used first to control the number and location of respondents to ensure the objectivity of the research results. Secondly, in terms of travel mode, the accessibility difference into blue space can be measured separately by different modes (such as walking, cycling, public transportation and driving, etc.). Finally, considering that different bodies of water may provide different services to people living nearby, special attention should be paid to including other sources of data on the blue quality of cities (eg water quality, etc.).

Annex

The annex contains a partial analysis of the results of the questionnaire for this study and some cross-analysis of the results.

Fig. 61

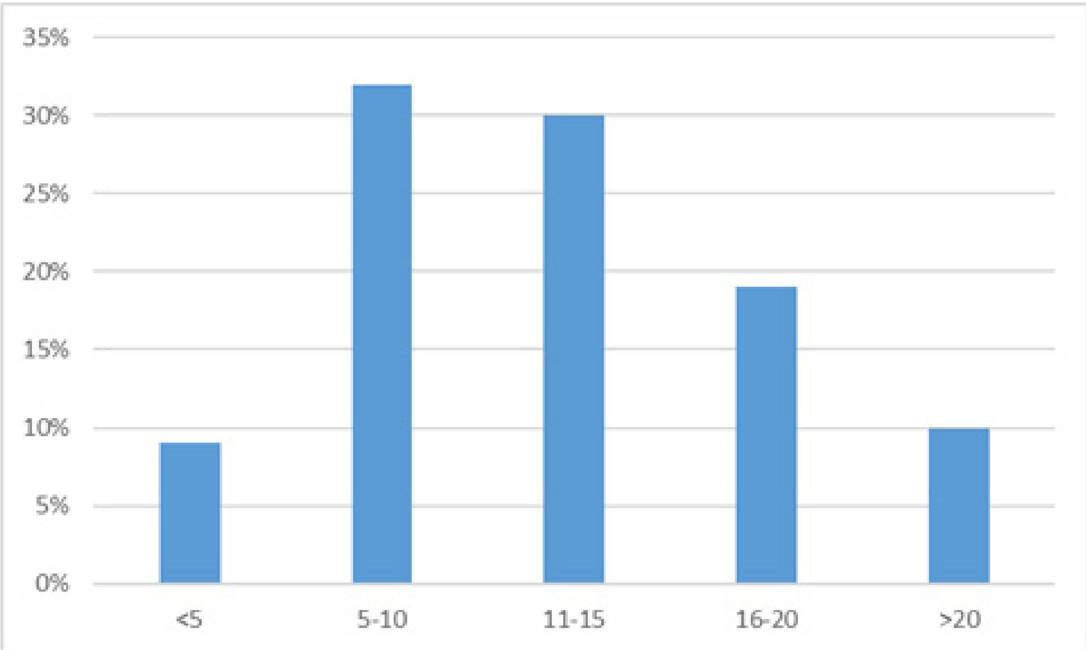
How long do you usually stay in the blue space



The majority of respondents chose to stay in the blue space for 30 minutes

Fig. 62

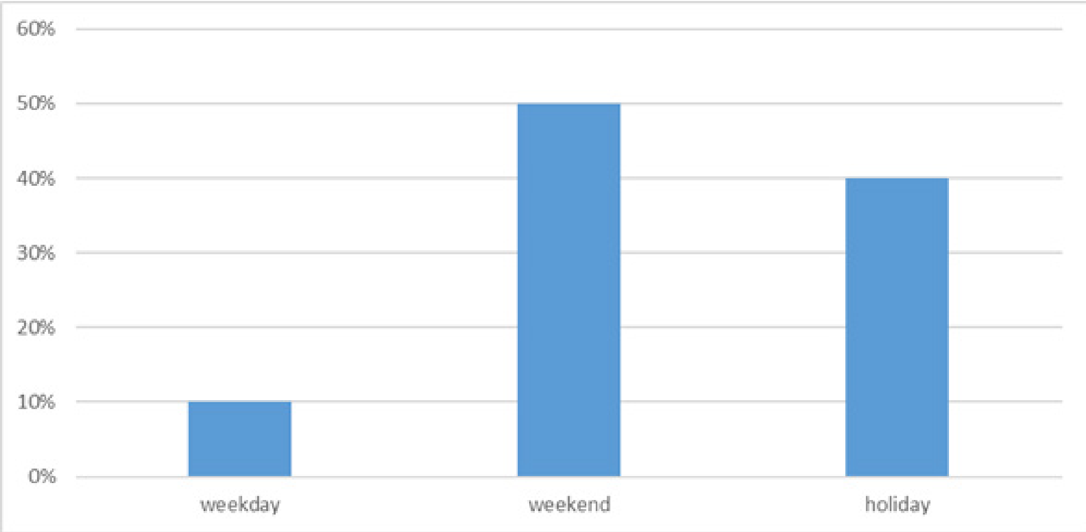
Walking time to blue space (minutes)



The majority of respondents live within 5-15 minutes walking distance of a blue space.

Fig. 63

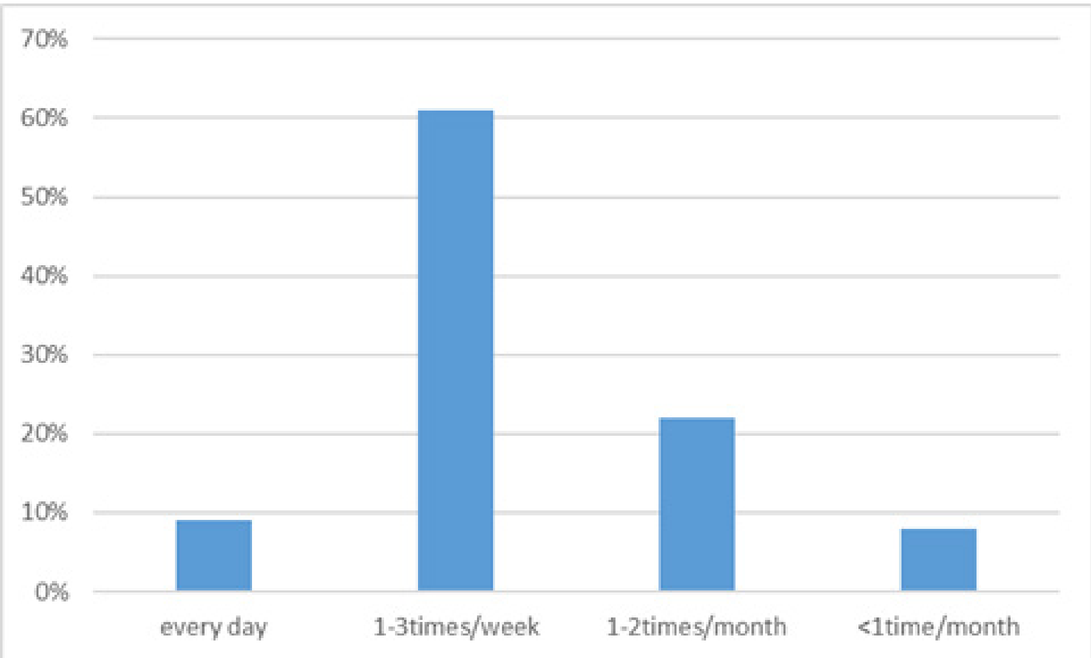
When do you usually visit Blue Space



The majority of respondents choose to visit Blue Space on weekends or holidays.

Fig. 64

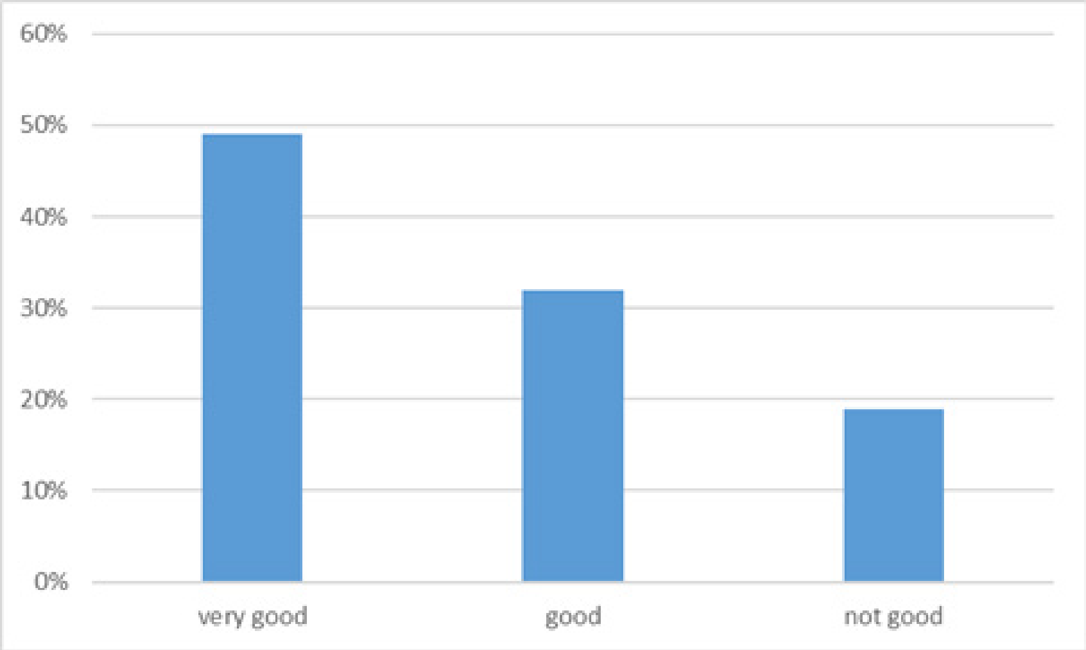
Frequency of visits to blue spaces



The majority of respondents visit Blue Space at least once a week. The probability is very frequent.

Fig. 65

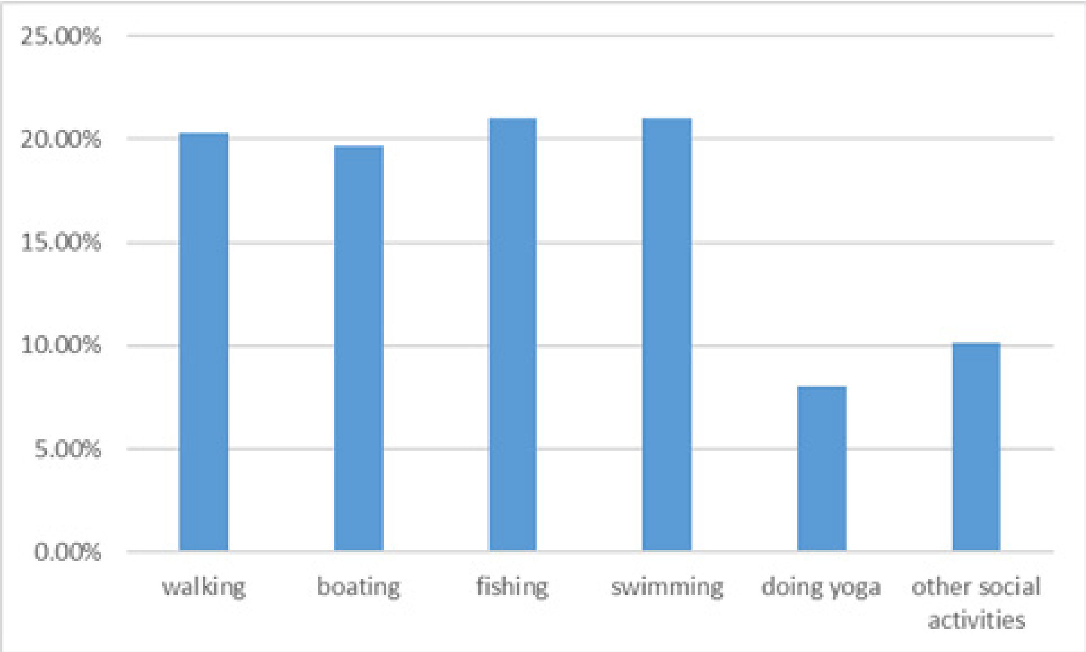
Quality of nearby blue space



The majority of respondents agreed that the quality of blue spaces nearby was good

Fig. 66

Activities that generally take place in blue spaces

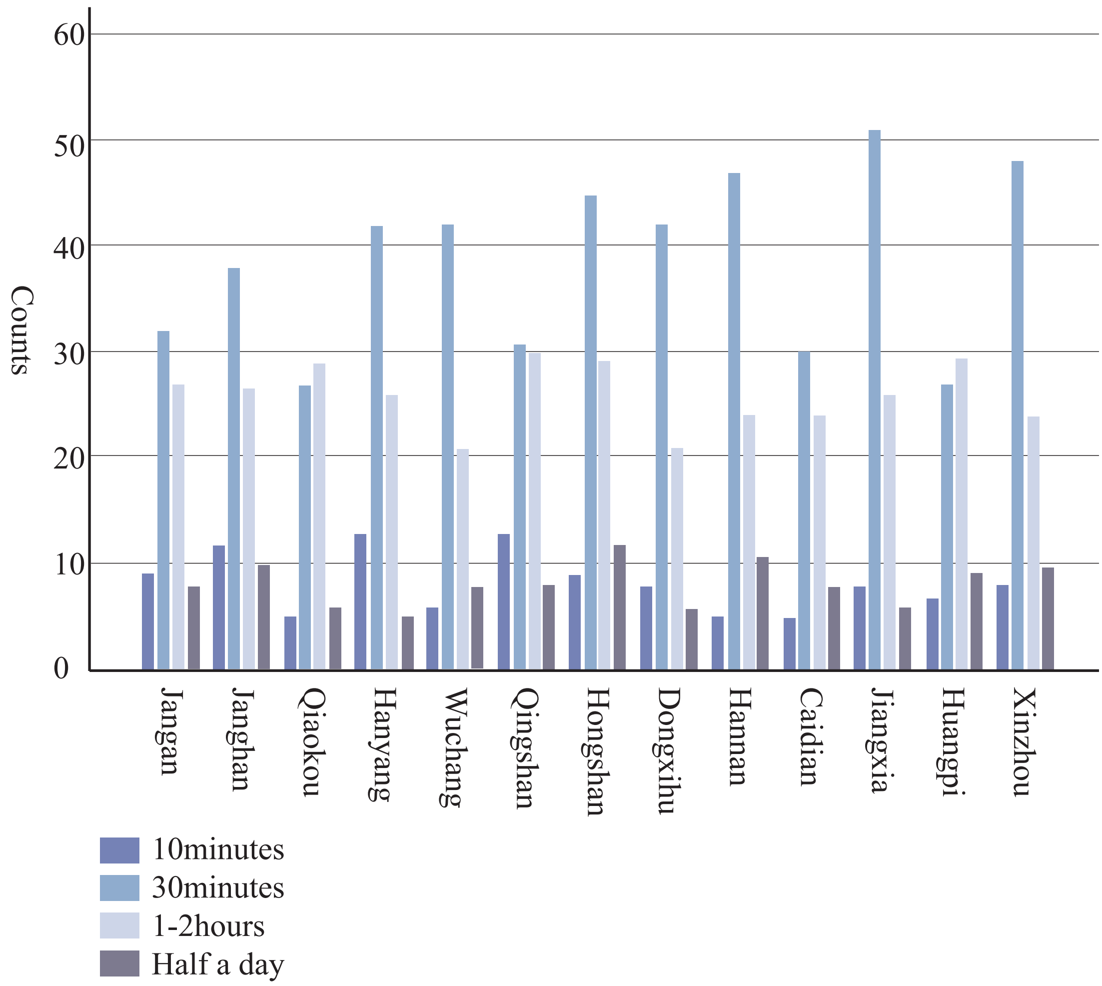


The question was an open-ended multiple choice question on the diversity of activities that respondents undertake in the vicinity of the Blue Space.

Fig. 67

Typical time spent in blue spaces by respondents from different districts

Sources:
Cross-tabulation of questionnaire results

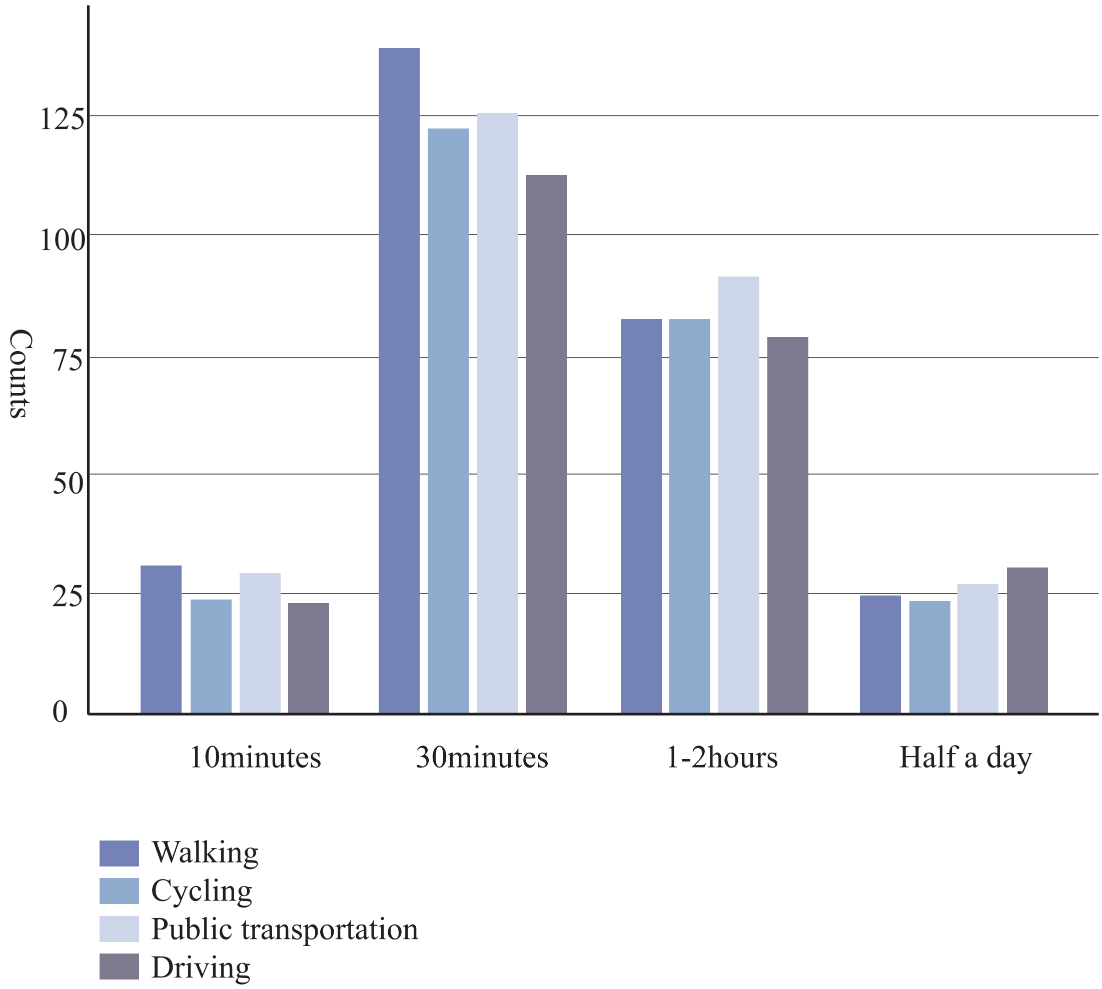


The results of this analysis show that a 30-minute stay was the majority choice of respondents in each district.

Fig. 68

The relationship between mode of travel and length of stay

Sources:
Cross-tabulation of questionnaire results

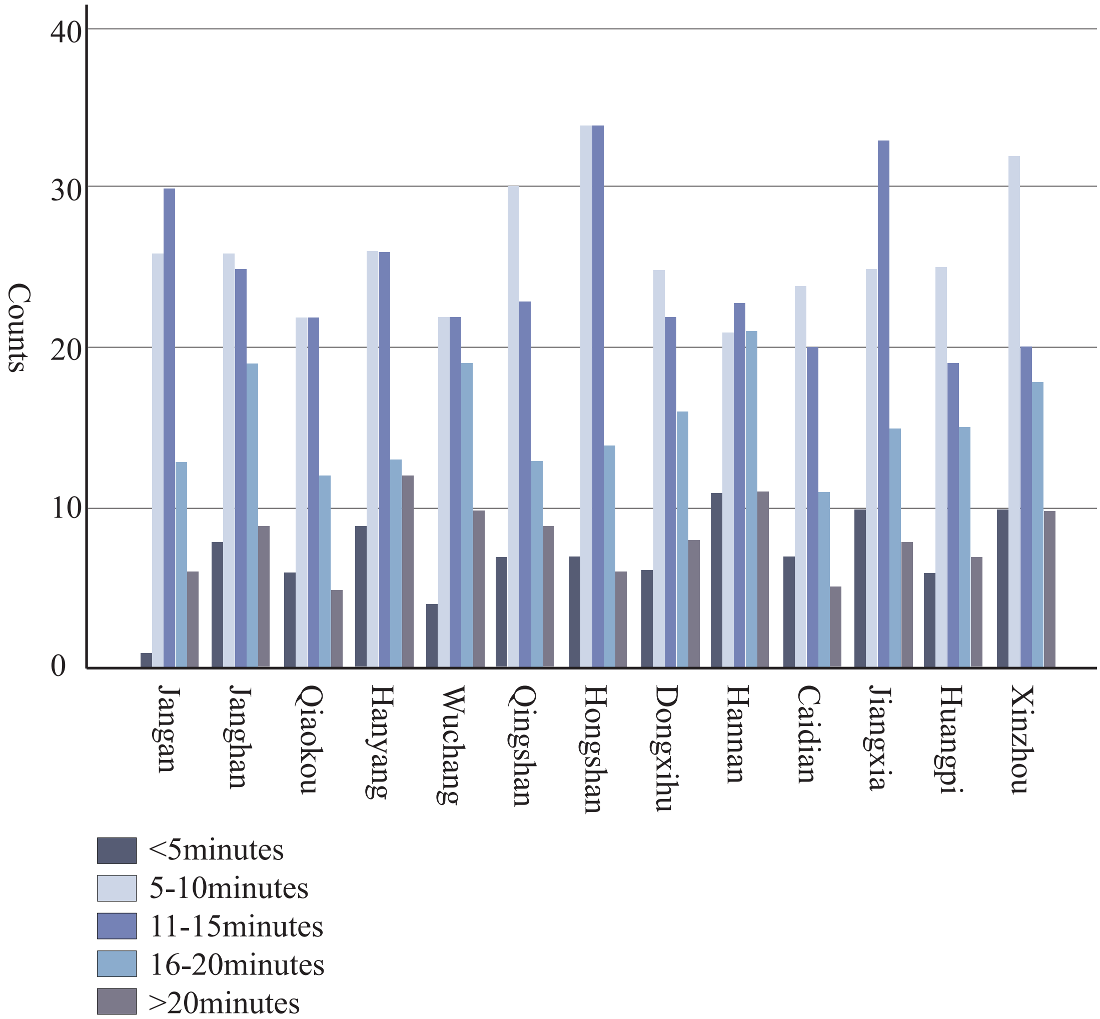


The largest number of people choose to stay in the blue space for 30 minutes, and most of them choose to walk to the blue space; those who stay for 10 minutes also mostly walk, those who stay for 1-2 hours mostly choose to take public transport, and those who stay for half a day mostly choose to drive to the blue space.

Fig. 69

Walking time to nearby blue spaces for respondents in different districts

Sources:
Cross-tabulation of questionnaire results

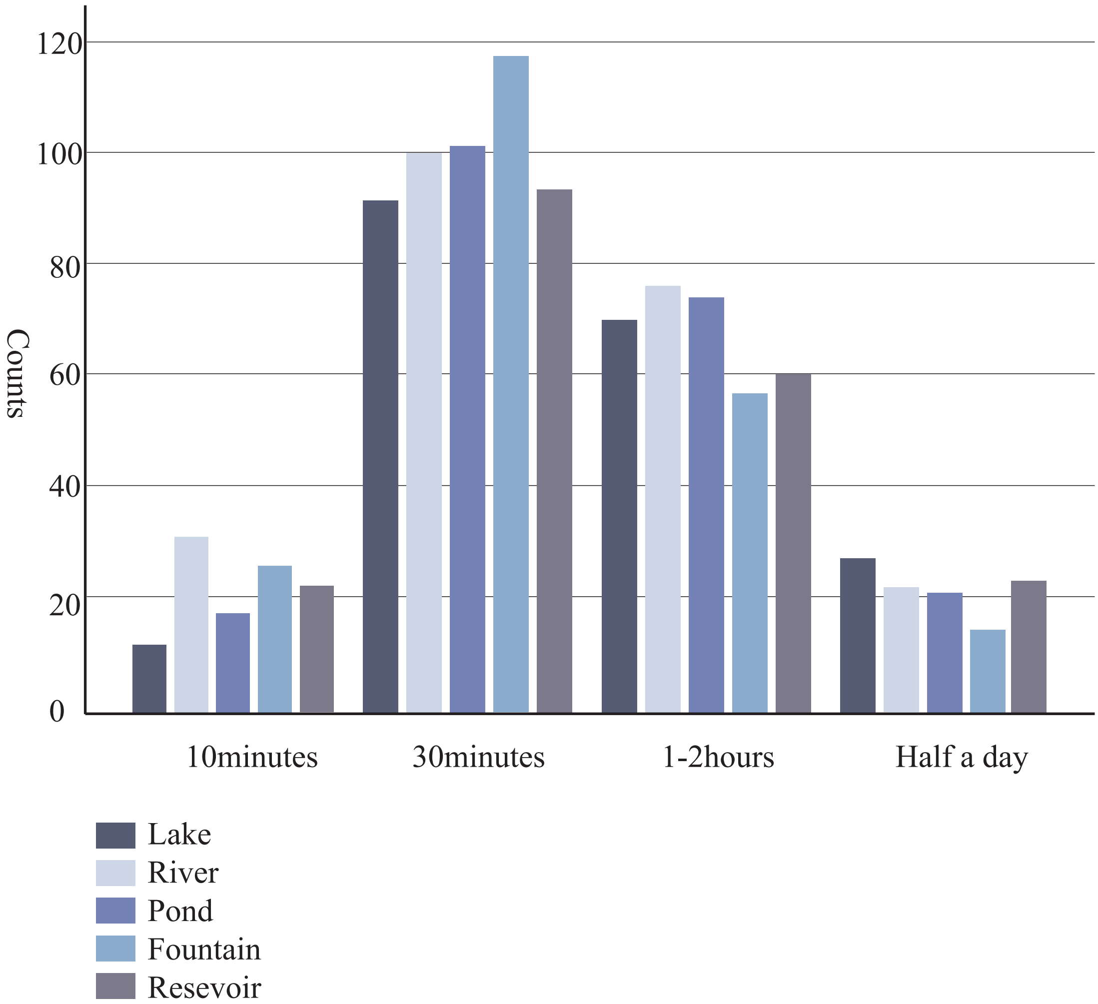


The majority of respondents in the districts live within a 5-15 minute walk of the nearest blue space.

Fig. 70

Relationship between respondents' length of stay and type of blue space

Sources:
Cross-tabulation of questionnaire results



The majority of respondents chose to spend ten minutes at the fountains, and generally the musical fountains were also played for around half an hour; the most frequent type of ten-minute stay was at rivers, presumably because they run through the whole city and so are often passed by; respondents often spent 1-2 hours at rivers, ponds and lakes, and those who spent half a day often stayed at lakes and reservoirs (artificial lakes), presumably because they could do activities such as fishing.

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Figures

Tables

Maps