Postprint: A Study on the Accessibility of Public Library Geospatial Layouts

Authors: Xu Wei, Li Zhuozhuo, Qiu Zhen

Date: 2023-07-26T00:00:00+00:00

Abstract

[Purpose/Significance] The geospatial layout of public libraries influences readers' travel modes and costs to reach the library, which subsequently affects their experience and frequency of library visits. [Method/Process] Grounded in travel chain theory and field theory, this study analyzes the convenience of public library access from the perspective of geospatial layout. It examines the dynamic relationships and quantitative evaluations among urban public transportation systems, living facility distributions, and public library network layouts, and presents a case study of Suzhou's urban public library layout using ArcGIS. [Results/Conclusions] The study proposes strategies for establishing interactive relationships with public transportation, integrating extra-library spaces, and extending services into readers' living circles to enhance the convenience of public library geospatial layout.

Full Text

Abstract

[Objective/Significance] The geospatial layout of public libraries affects readers' modes of travel and associated costs, which in turn influences their experience and frequency of library visits. [Method/Process] Based on trip-chaining theory and field theory, this study examines the geospatial layout of public libraries to analyze the convenience of reader access. It explores the dynamic relationships and quantitative evaluation between urban public transportation, living facility distribution, and public library network layouts, using ArcGIS to conduct a case study of Suzhou's urban public library configuration. [Result/Conclusion] The study proposes strategies for establishing interactive relationships with public transportation, integrating library services into external spaces, and extending services into readers' daily life circles to enhance the convenience of public library geospatial layouts.

Keywords: geospatial layout; public library network; accessibility; trip-chaining; field theory

2 Public Library Location Selection and Library Users

2.1 Requirements for Public Library Location Selection

China's *Indicators for Public Library Construction Land Use* and *Standards for Public Library Construction* stipulate that public libraries should be located in areas with concentrated populations and convenient public transportation. A location that is densely populated, easily accessible, environmentally sound, relatively quiet, safe, and hygienic serves as the prerequisite for public libraries to achieve high social benefits. In the process of urbanization, newly built public libraries are generally planned for cultural centers in new districts, following a so-called "rolling development" model—leveraging old city development to expand new districts. This approach aligns with the "people-oriented" philosophy of public facilities while meeting energy conservation and emission reduction requirements.

2.2 Public Library User Groups

Various nodes in the public library network system are distributed across different districts and community streets, all freely open to the public. Some studies distinguish the primary user groups of each public library based on geographic proximity, using location as a variable to analyze proportions of nearby versus distant users. Typically, these studies examine different social groups (e.g., urban/rural, religious, ethnic, socioeconomic status) for specific services (such as healthcare, green spaces, post offices, libraries, food). Demographic data are aggregated by spatial units like postal code areas, census tracts, floating catchment areas, residential addresses, or service/facility catchment areas, followed by GIS-based distance measurements (Euclidean network). Other research maps main-branch library locations in GIS to generate Thiessen polygons, creating hypothetical proximity-based coverage areas (catchments), but finds that some users do not utilize the library nearest their residence. Further investigation reveals that public transportation networks distort these hypothetical areas, and travel time from access points like bus routes or subway stations influences users' decisions about which library is most convenient. Therefore, identifying each public library's primary user group follows the principle of proximity, considering nearby communities as the main readership while not excluding the possibility of users from greater distances.

2.3 Readers' Modes of Travel to Libraries

Readers have limited tolerance for travel distance and time to libraries. Public library surveys indicate that over 95% of readers arrive by bicycle, public transport, or walking. City size influences primary travel modes and travel time:

larger cities see more public transport users, while smaller cities have more cyclists and pedestrians. Appropriate travel time should be within 30 minutes. Readers' acceptable distance to libraries is also affected by available transportation modes. For convenience, libraries should have accessible transportation nearby, preferably close to subway stations and bus routes, and equipped with public bicycle rental points.

3 Trip-Chaining Theory in Public Library Spatial Convenience

3.1 Trip-Chaining

Spatial accessibility can be defined by three elements: origin, destination, and their relationship. Distance between origin and destination serves as an indicator of this relationship, affecting or hindering access. If the destination is close to the origin—meaning the library is near the target population—accessibility is high. Additionally, the mode of transportation is another crucial factor related to accessibility. Regardless of distance, accessibility improves when target populations have private vehicles, convenient parking, or easy public transport access. The relationship between origin and destination is influenced by users' socioeconomic factors, with some studies identifying internal and external factors. Internal factors refer to library resource and service quality, such as opening hours, collection status, and service programs. External factors are based on the trip-chaining concept, including proximity to other important cultural and social assets, locations, and services.

Trip-chaining describes the practice of visiting multiple destinations during a single journey between origin and destination. For ordinary readers, this might involve borrowing books on the way to work or reading at a nearby library while accompanying children to interest classes. For example, Suzhou Industrial Park Library's children's branch, located in the Youth Activity Center, provides both children's books and materials for parents, enabling them to read and study while waiting for their children. Multiple trip chains form the activity space of potential library users. The library's importance in these chains determines usage frequency. Public libraries are part of urban living space and components of the urban cultural environment. Their convenience must examine connections with other urban spatial elements and study the spatial field from the library's perspective to enhance geospatial accessibility and convenience.

3.2 Public Library Convenience Based on Trip-Chaining

Public library locations and layouts remain relatively stable over time. Placing library network nodes within readers' primary activity fields and living communities transforms them into part of community public service configurations. Community members are both service targets and dynamic actors. Convenient facilities and transportation around libraries convert more potential users into actual readers and increase visit frequency. Static layouts and dynamic routes

jointly promote spatial matching between libraries and readers, increasing the probability of transforming potential information needs into actual library use.

Research indicates that the complexity of community members' trip chains relates to their activities: shopping, socializing, entertainment, commuting, work, and personal business. A study of the Seattle metropolitan area suggests that network distance is appropriate for measuring library access, demonstrating that journeys are often not single-purpose trips from home to library and back, but part of a series of destinations or trips from third locations (like work or school). Library visits can combine with visits to other "daily places" to complete auxiliary tasks such as shopping, medical appointments, schooling, or banking. The transportation infrastructure and urban characteristics in the immediate area around libraries become important, affecting utilization of the entire urban public library network. Trip-chaining theory reveals relationships between urban public transportation and public library network layouts, allowing consideration of library layout rationality from the perspective of the entire public service system. Developed, convenient urban public transportation brings more foot traffic—potential readers and attention—to libraries.

4 Building a Convenient Spatial Network for Public Libraries

4.1 The Library Spatial "Field"

In Bourdieu's sociological theory, "field" is defined as "a network or configuration of objective relations between positions," where various positions form different relational structures based on their resources or capital. This "field" also exists in geospatial terms. For instance, from the perspective of information and service access capacity, public library locations are always adjacent to city center government agencies, public institutions, schools, and important cultural-commercial facilities. Upper-class individuals and their children, as well as students from key schools, often constitute advantaged groups for public libraries. Some important library service brands and operational rules may consciously or unconsciously adapt to this group's needs, potentially displacing resources or programs intended for lower-middle-class groups, the elderly, disabled, migrant workers, or rural left-behind women and children. This illustrates the relationship between spatial "field" and "habitus"—the field, as an objective social structure, shapes actors' habitus through resource distribution, opportunities, and conditions that vary by position, forming dispositions corresponding to objective structures.

The emergence of public library networks avoids the situation where only one library existed per city or region, where only "field"-advantaged groups enjoyed the "habitus" brought by public libraries. Public library network development extends services to community corners, representing an institutional innovation that eliminates spatial "field" differences in public cultural services and creates opportunities for all groups to develop library use "habitus," building a cultural

participation platform for the broadest readership needs.

Many cultural studies reveal attendance and participation rates of different populations through demographic and socioeconomic characteristics, using sociological attributes as primary factors for understanding participation in various cultural and leisure activities. These studies mainly start from "habitus" without considering the interaction between "field" and "habitus." In fact, research suggests that combining geographic variables (accessibility) with sociodemographic variables can accurately predict attendance at cultural venues, as destination accessibility is an important factor in cultural participation. Location and position affect cultural service layout effects and can be assessed by examining public libraries' spatial distribution and its impact on participation levels in specific cultural assets.

4.2 Push and Pull Factors in Public Library Space

The UK launched the "Understanding Everyday Participation—Articulating Cultural Value" project (2012-2017), where "location" of cultural participation was a key aspect. The project selected six regions in England and Scotland, marking cultural and community asset locations on sociodemographic maps, involving various other public facilities and services like shops, banks, hospitals, etc. It analyzed relationships between library use and specific geographic locations, quantifying both library service scope (internal factors) and surrounding area characteristics (external factors). Internal factors include: library user groups; total weekly opening hours. External factors involve: number of daily assets within 400 square meters (e.g., shops, medical facilities, post offices, banks, cafes); presence of supermarkets within 400 square meters; number of educational facilities within 400 meters; presence of parks and playgrounds within 400 meters; number of dedicated bus routes within 400 meters; presence of railway/subway stations within 400 meters.

Calculations and evaluations identified push and pull factors in public library space. Push factors include social class, while pull factors identify attractive library elements: long opening hours, established regular user groups, proximity to many other "daily" venues including supermarkets, playgrounds, and parks, average bus routes within 400 meters, and surrounding primary and secondary schools. These pull factors integrate public libraries as part of community life, embedding them into people's "habitus."

5 Layout and Analysis of Public Libraries in Urban Spatial Fields: A Suzhou Case Study

This section analyzes Suzhou's public library network layout and its geographic relationship with urban transportation and living facilities, examining spatial interactions.

5.1 Public Library Network Layout Along Subway Lines

Mapping Suzhou's operational Lines 1, 2, and 4, we created 400-meter and 1000-meter buffer zones along subway lines and identified libraries within these zones. Eighteen library nodes fall within 400 meters, and thirty-six within 1000 meters (see [Figure 1: see original paper]), accounting for 39% of all Suzhou public library main-branch nodes. This shows Suzhou's library network generally considers dense population distribution along subway lines, effectively leveraging subway corridor field advantages. Many Chinese cities like Beijing, Shanghai, and Wuhan actively explore subway library layouts, capitalizing on high foot traffic and convenient borrowing/returning at subway stations. However, we also observe that Line 1 has relatively uniform library distribution with complete coverage, while the terminal areas of Lines 2 and 4 lack library nodes. These terminal areas have large potential population flows or serve as diversion points, suggesting libraries should prioritize these remote, high-traffic regions, especially where subway and surrounding facilities are well-developed, to meet future needs.

Libraries can also cluster near subway lines to form their own field. For example, the newly operational Suzhou Second Library is located at Xiangcheng District's Huolidao Station, like the main Suzhou Library, both situated on Line 4 stations. This effectively connects libraries, providing transportation convenience while aggregating and linking reader resources.

5.2 Public Transportation Facilities and Layout of Main-Branch Libraries

Library service radius indicators depend on how readers reach libraries. Surveys show over 95% of readers arrive by bicycle, public transport, or walking. Larger cities have more public transport users, but acceptable time and distance remain limited. Therefore, library nodes should provide convenient bus stops and bicycle rental points to maximize accessibility.

This study selected two different branch libraries, marking surrounding bus stops and public bicycle rental points (see [Figure 2: see original paper] and [Figure 3: see original paper]). Jingcheng Branch, located in a bustling area, has denser and more convenient bus services. Within 400-meter and 1000-meter ranges, public bicycle rental points are available. In contrast, the relatively sparsely populated Weiting area has abundant bicycle rental points and parking but fewer bus stops. This indicates differences around various branches require more detailed planning based on reader travel patterns. The transportation convenience of each node in the public library network needs careful interpretation and research.

5.3 Layout of Living Convenience Facilities

Examining the distribution of hospitals, schools, and other facilities around two library branches in Suzhou Industrial Park reveals differences in convenience

(see [Figure 2: see original paper] and [Figure 3: see original paper]). Jingcheng Branch can connect more trip chains for readers, while the less densely populated Weiting area should focus on attracting nearby readers by providing various transportation conveniences. In non-central areas, library nodes need to leverage convenient living service fields and accessible transportation to maximize demand aggregation. Meanwhile, analyzing utilization and convenience associations can reveal service details—for example, a delivery point in an Industrial Park plaza with high foot traffic and convenience has extremely low utilization because it's located in a corner of a shopping mall's basement, making it difficult for users to find and use. This demonstrates that in actual library layout, not only overall living facility convenience matters, but also specific location. As a public service facility, libraries in commercially convenient areas require more coordination and support to obtain priority planning, prominent locations, and adequate space.

5.4 Calculating Public Library Convenience

From a regional perspective, we can calculate the percentage of library nodes distributed near subways. Specifically, we measure the percentage of libraries within 200, 500, and 1000 meters of subway lines or stations. The calculation formula is:

$$P_{d\in\{200,500,1000\}} = \frac{m_d}{M}$$

Where: - P_d = percentage of libraries within d meters of subway - m_d = number of libraries within d meters of subway - M = total number of libraries in the region

This ratio reveals the distribution proportion of library nodes along subway lines, reflecting the interactive convenience relationship between public library layout and urban rail transit.

Further, taking public library nodes as centers, we evaluate surrounding commercial circles by assigning values to facilities like shopping malls, supermarkets, schools, parks, and bus stops based on their distance from the library. These values are weighted by distance and summed to calculate overall convenience for a library node:

$$C = \sum_{i=1}^{n} F_i \times K_i$$

Where: - C = convenience level - F_i = evaluation score of other public facilities based on distance from library - K_i = evaluation score of other public facilities' attractiveness to library

6 Strategies for Improving Public Library Layout Convenience

Public libraries are vital components of urban public services and have become standard community features in many cities. Convenience-based layout must consider not only positional relationships with other public services but also residents' daily lives and travel convenience, planning libraries from a holistic urban service function perspective.

6.1 Coordinated Layout of Public Libraries and Urban Public Transportation

Urban transportation enables more convenient library access, reducing visit costs and influencing usage frequency and efficiency. Many cities locate major libraries at key subway stations, creating cultural landmarks—Beijing, Shanghai, Nanjing, Guangzhou, and Suzhou all exemplify this, with some subway stations even named after libraries. Some public libraries have established subway libraries, leveraging extensive rail networks to increase reader contact and improve resource utilization efficiency. As public library networks become more dense and extensive, the synergy between public service networks and urban public transportation will strengthen.

6.2 Penetration and Access to Library External Spaces

On one hand, dense library layouts extend services into readers' living spaces, making library access ubiquitous and better meeting immediate needs. The development and popularization of self-service libraries in recent years enable more flexible placement in compact urban spaces, creating "chain convenience stores" for information resources. However, since increasing layout nodes is limited, implanting library services in non-library spaces represents an important breakthrough. Integrating partial library service functions into external spaces establishes a ubiquitous, diverse library access network that merges library services with other living spaces.

6.3 Integrating and Extending Public Library Services into Readers' Lives

Reader information behavior has long been a key concern in library and information science, but few studies link it with other socioeconomic behaviors. Trip-chaining and field theory frame library use as part of readers' daily work and life, making it necessary to examine how living habits and activity trajectories affect information behavior. For instance, urban population flows at different times and rural population social relationships and community layouts all impact library use. Therefore, in providing information, education, and cultural resources, libraries need not be confined to specific physical spaces but should integrate soft services into readers' lives, effectively connecting and associating with their other needs. Based on public library network layouts, we

must continuously expand the service network's extension, build ubiquitous library services, and activate reader demand to improve conversion from potential need to actual use. This presents new challenges for public libraries' precision services.

Future research can further correlate public library convenience with utilization, using data and models to reveal relationships between convenience measurements and usage rates, more effectively supporting scientific library planning and layout to enhance overall network effectiveness.

References

[1] Li Guoxin. Modern public cultural service system construction and public library development—Analysis of *Opinions on Accelerating the Construction of a Modern Public Cultural Service System*[J]. *Journal of Library Science in China*, 2015, 41(3): 4-12.

[2] Wu Zhinan, Feng Jia. Public libraries in the modern public cultural service system[J]. *Journal of Library Science in China*, 2015, 41(3): 34-41.

[3] Bhaduri A, de Hoornweg D. The global city indicators program: A more credible voice for cities[J/OL]. *Directions in Urban Development*, 2009(6): 1-4. [2019-01-30]. http://www.bvsde.paho.org/texcom/cd045364/globalcity.pdf.

[4] Department of Science and Education, Bureau of Library Affairs, Ministry of Culture. *World Library Industry Data Compilation*[M]. Beijing: Bibliographic Literature Publishing House, 1990.

[5] Liu Xuan. Overview and implications of American public library standards: Taking *Wisconsin Public Library Standards* as an example[J]. *Library Development*, 2009(7): 72-76.

[6] Shen Xiaojuan. *Research on the Development of China's Grassroots Library Industry from a Standardization Perspective*[M]. Beijing: National Library Press, 2015: 128-129.

[7] Gill P. *The Public Library Service: IFLA/UNESCO Guidelines for Development*[M]. Zoetermeer: NBDBiblion Publishers, 2001.

[8] Parks SJ. Measuring public library accessibility: A case study using GIS[J]. *Library & Information Science Research*, 2012, 34(1): 13-21.

[9] Gu Xin. Discussion on public libraries' public welfare, basic nature, equality, convenience, and socialized services[J]. *Guizhou Library Quarterly*, 2012(2): 63-64.

[10] Cheng Yanan. Interpretation of basic principles in public library construction and service[J]. *Library Theory and Practice*, 2011(5): 1-6.

[11] Chen Yijin, Cao Shujin. Research on urban public library users' information behavior and influencing factors[J]. *Library Tribune*, 2016, 36(3): 56-64.

[12] Li Guoxin, Feng Shouren, Lu Qin. *Analysis of Public Library Planning and Construction Standards*[M]. Beijing: National Library Press, 2009.

[13] Comber A, Brunsdon C, Phillips M. The varying impact of geographic distance as a predictor of dissatisfaction over facility access[J]. *Applied Spatial Analysis and Policy*, 2012, 5(4): 333-350.

[14] Delrieu V, Gibson L. Libraries and the geography of use: How does geography and asset "attractiveness" influence the local dimensions of cultural participation?[J]. *Cultural Trends*, 2017, 26(1): 18-33.

[15] Bertolini L, Le Clercq F, Kapoen L. Sustainable accessibility: A conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward[J]. *Transport Policy*, 2005, 12(3): 207-220.

[16] Primerano F, Taylor MAP, Pitaksringkarn L, et al. Defining and understanding trip-chaining behaviour[J]. *Transportation*, 2008, 35(1): 55-72.

[17] JaePark S. Measuring travel time and distance in library use[J]. *Library Hi Tech*, 2012, 30(1): 151-169.

[18] Yu Liangzhi. *Public Libraries in the Information Society*[M]. Beijing: National Library Press, 2015: 63.

[19] Chan TW, Goldthorpe JH. The social stratification of theatre, dance and cinema attendance[J]. *Cultural Trends*, 2005, 14(3): 193-212.

[20] Brook O. Reframing models of arts attendance: Understanding the role of access to venue—The case of opera in London[J]. *Cultural Trends*, 2013, 22(2): 97-107.

[21] Miles A, Gibson L. Everyday participation and cultural value[J]. *Cultural Trends*, 2016, 25(3): 151-157.

[22] Li Ya, Zhou Junye. Comparative study on service effectiveness of domestic subway libraries[J]. *Library Work and Research*, 2016(11): 90-93.

Author Contributions: Xu Wei: Topic selection, structural design, and paper writing; Li Zhuozhuo: Data processing and paper revision; Qiu Zhen: Paper revision.

Note: Figure translations are in progress. See original paper for figures.