Accessibility Analysis and Site Selection Suggestions for Cultural Complexes in Nanjing

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Abstract. In recent years, with the increase of urban cultural consumption demand, cultural complexes, the role of cultural complexes, notably bookstores, have become increasingly significant. In this study, we took the 11th district of Nanjing as the research object and selected the cultural complex represented by bookstores in Nanjing to study and analyze their distribution and accessibility. First, the study collected data on the location, transportation network, and population density of bookstores in Nanjing. Then, a comprehensive evaluation system was constructed to evaluate the impact of different modes of transportation on the accessibility of bookstores. By using the spatial analysis method, this study quantitatively evaluated the spatial distribution pattern, service scope and service equity of Nanjing bookstores. The results show that the distribution of bookstores in Nanjing shows a similar imbalance with the distribution of population density, in which the accessibility of the central area of the city is relatively high, while the peripheral area is low. In particular, the issue of accessibility equity for children is particularly prominent. Based on the above findings, this paper proposes targeted suggestions and improvement strategies for bookstore site selection, aiming to provide a scientific basis and practical guidance for government decision-makers, urban planners and bookstore operators.

Keywords: Nanjing, Cultural Complexes, Accessibility Analysis, Spatial Distribution, Service Equity.

1. Introduction

The cultural complex is a comprehensive cultural venue. It is based on cultural production, characterized by cultural experience, focusing on cultural leisure and commerce, extending to creative industries, and integrating functions such as exhibitions and business services. It combines the pan-cultural industry and provides a multi-functional cultural space for the public. The concept of Chinese cultural complexes is mainly inclined to design, such as the comprehensive design strategy of Chang'an Academy in 2023 [1] and the green space landscape design of Beijing Fengtai Lize Sports and Cultural Complex in 2021 [2]. These also reflect the cultural and leisure attributes of the cultural complex. As a part of urban hard brand, cultural complex is the synthesis of physical economy and symbolic economy of urban consumption space. At present, China has introduced policies to promote the participation of physical bookstores in public cultural services, and bookstores, as typical representatives of cultural complexes, are both universal and special. The accessibility analysis of cultural complexes represented by bookstores can not only help residents better choose leisure and entertainment spaces and help site selection, but also provide stronger support for urban planning. Domestic and international studies have focused more on its design or its role in urban development and cultural policy, and less on the analysis of accessibility [3, 4].

Therefore, this study was carried out in 11 municipal districts under the jurisdiction of Nanjing, and the cultural complex represented by bookstores was selected. The accessibility of bookstores was analyzed using QGIS, ArcGIS software, and the site selection scheme was proposed. This study will fill the gap in the research on the accessibility of cultural complexes in China, so as to promote the construction of public cultural service system and enrich the spiritual and cultural life of the masses.

2. Background of Study Area

Nanjing, as the capital of Jiangsu Province, is not only the ancient capital of the Six Dynasties in Chinese history, but also a modern city with profound cultural accumulation (Figure 1). Its rich historical and cultural heritage and modern cultural innovation have jointly shaped Nanjing's unique urban cultural identity. Nanjing has been recognized as the "World Book Capital" by UNESCO and has also been awarded the reputation of "Bookstore Capital", which not only highlights its outstanding achievements in books and reading culture, but also provides new opportunities for the city's cultural development and international exchanges.

With the rapid development of Internet technology and the increasingly obvious trend of multi-industry integration, Nanjing's cultural complexes, especially physical bookstores, face new challenges in transformation and upgrading. Creating a stronger cultural atmosphere and providing a better reading experience in the digital wave has become a key issue in Nanjing's cultural development. In order to address these challenges, since 2021, the Nanjing Municipal Government has successively issued policy documents such as the "Implementation Opinions on Promoting the Development of Physical Bookstores in Nanjing", aiming to promote the innovation and development of the physical bookstore industry through policy guidance and support.

In this context, this study selects bookstores in Nanjing as the research object, aiming to provide a scientific basis for the planning and development of cultural complex in Nanjing by analyzing the spatial distribution characteristics, accessibility and service equity of bookstores. The study uses geographic information system (GIS) and spatial analysis methods, combined with field research and data analysis, to explore the relationship between the distribution of bookstores and the spatial structure of the city, as well as the equity of bookstore services among different social groups.

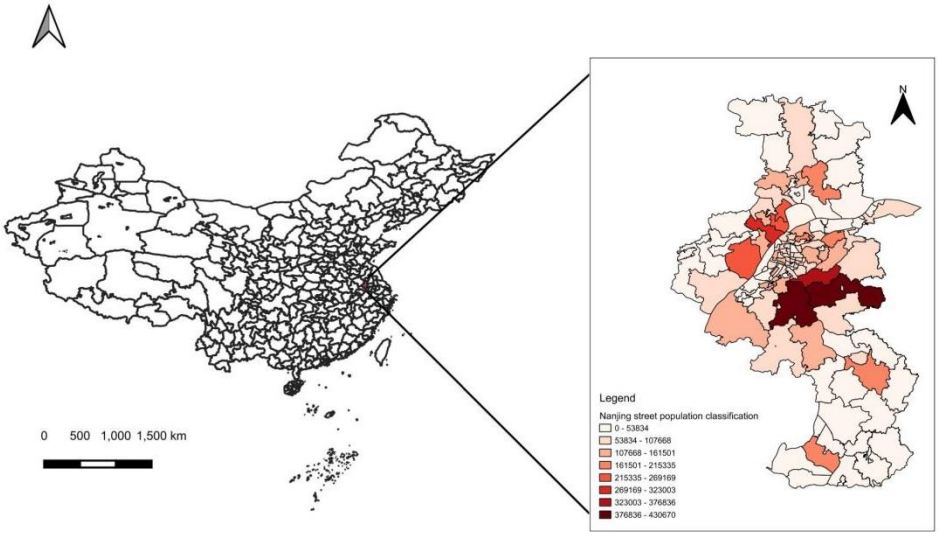

Figure 1. Thumbnail of Nanjing's position in the country (Original figure)

3. Data and Methods

3.1. Data Sources

The basic data used in this study for the cultural complex is the Point of Interest (POI), an important part of geospatial data analysis and widely used in urban research. This article mainly uses Gaode Map as the data source. Through its official open API, a total of 2,915 POI data entries in Nanjing were obtained. After data cleansing, 1189 valid data entries were finally retained as specific research objects. The source of the population data is the 2020 Population Census data, which is accurate to the streets of Nanjing. The road network information comes from OpenStreetMap, which obtains the road network data and speed limits of sidewalks, motor vehicles and non-motorized lanes in the urban area of Nanjing.

3.2. Methodologies

The main software used in this paper is ArcGIS and QGIS, and the specific methods are as follows:

3.2.1 Standard deviation ellipse

The standard deviation ellipse is a spatial statistical tool that reflects the extent of distribution, center location, and expansion direction of data on a map. It can accurately identify the distribution characteristics and trends of spatial data. The center of the ellipse represents the average position or geographic center of gravity of the dataset. The coverage area (including most data points) reflects the concentration, and the extension direction represents the direction of the spread of the data, indicating which areas are denser and can be used to illustrate trends [5].

3.2.2 Kernel density estimation

Kernel density estimation is a non-parametric statistical method that estimates data density through a central kernel, which can reflect data clustering in space. Hao et al. (2024) shows that the distribution of brick-and-mortar bookstores in Nanjing is uneven. Based on this assumption, the authors hypothesize that the distribution of the cultural complex in Nanjing will also be concentrated in certain areas. In this paper, all the cultural complex data are imported into the administrative map of Nanjing for feature analysis, and then they are subdivided into three categories: traditional, modern, and cross-industry integration for separate kernel density estimation. This analysis could determine if different types of complexes have different distribution characteristics [6].

3.2.3 Two-part mobile

The two-step mobile search method is used to analyze spatial accessibility and service coverage, and is used primarily to evaluate the accessibility of service facilities, medical facilities, or other public facilities. Wang (2021) argued that in 2021 that 2SFCA overcomes the shortcomings of previous approaches and allows people to value access to multiple suppliers, with choices not limited by geopolitical units. The author classified the Nanjing road network according to vehicle speed and the default speed of sidewalks was 5km/h, the default speed of non-motorized lanes was 20km/h, and the default speed of motorized lanes was 30km/h, and each traffic mode was divided into 0.5 hours, 1 hour, and 1.5 hours, and their accessibility was analyzed [7].

3.2.4 Gini coefficient

The Lorentz curve is a tool used to express the degree to which resources are allocated equally. By sorting each region of Nanjing according to population, the service coverage rate of cultural complexes in each region is calculated, and the Lorentz curve is obtained, and then the Gini coefficient is calculated. Coefficients range from 0 to 1, with higher values indicating greater inequality in the distribution of services in the cultural complex. The Gini coefficient is determined by comparing the area between the actual Lorentz curve and the perfectly equal curve (line of 45 degrees).

3.2.5 Shift of center of gravity analysis

The center of gravity migration analysis is mainly used to study the temporal and spatial changes of geographic features. It can be used to reveal changes in the distribution of the center of gravity of specific elements, such as population and economy, over time. In order to study the repositioning of the center of gravity of Nanjing's cultural complex, this paper selects the data of cultural complexes in 2014, 2019 and 2024 for analysis.

3.2.6 Fieldwork

To understand the per capita consumption, daily reception capacity and scale of Nanjing's cultural complexes by conducting an on-site survey, the method involves a sample survey to collect more data and learn more about supply and demand. This approach is designed to draw revealing conclusions.

4. Results

4.1. Demographic Distribution Characteristics

The demographic distribution of Nanjing City exhibits a typical urbanization pattern. The overall trend is towards concentration in the urban center, which forms a clear gradient in population density from the center to the periphery. However, the most densely populated area is not the city center, but slightly south of the center. The population density in districts such as Nanjing's Gulou and Qinhuai is significantly higher than in other areas. In contrast, the population density in Jiangning Distric is lower as Jiangning is near the edge. This pattern is consistent with the general pattern of population flow during urbanization and reflects the attractiveness of the urban center and its central role in social and economic activities.

4.2. Distribution Characteristics of Cultural Complex

The results show that the distribution of cultural complexes is highly consistent with the spatial distribution of population density. There is a general trend towards concentration in the urban center. The study also shows a high degree of concentration in the urban area and a declining trend as the distance from the urban area increases. In addition, the elongation direction of the standard deviation ellipse reveals the dominant trend of cultural complex distribution, showing a northwest-southeast trend (Figure 2).

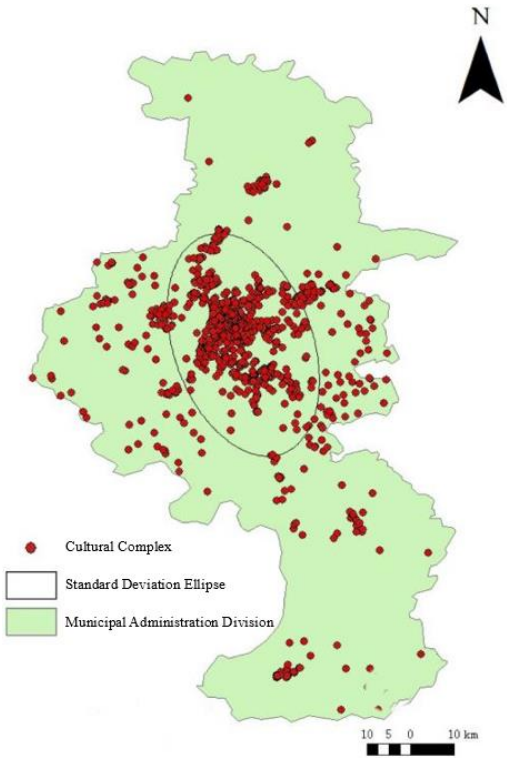

Figure 2. Nanjing Cultural Complex Standard Deviation Ellipse Nanjing Municipal Administration Division (Original figure)

In the kernel density analysis of cultural complexes, the authors set the radius at 15,000 units to present the distribution characteristics of different cultural complexes (Figure 3). The overall kernel density analysis disclosed a clustering phenomenon (Figure 3a). It particularly shows a high-density aggregation in the urban area, featuring three relatively distinct aggregation centers. In the analysis of traditional cultural complexes, there was also an evident high-density region in the urban center (Figure 3b). Although the quantity was larger, it spread towards the periphery. The number of inter-industry cultural complexes was the smallest among the three types. However, the analysis indicated that there was an aggregation in the urban center with a larger range, and there were also small-scale aggregations in the north and south, respectively (Figure 3c). The distribution of new-type cultural

complexes was also most concentrated in the urban center and gradually decreased towards the periphery, but there were two small-scale concentrations in the south as well (Figure 3d).

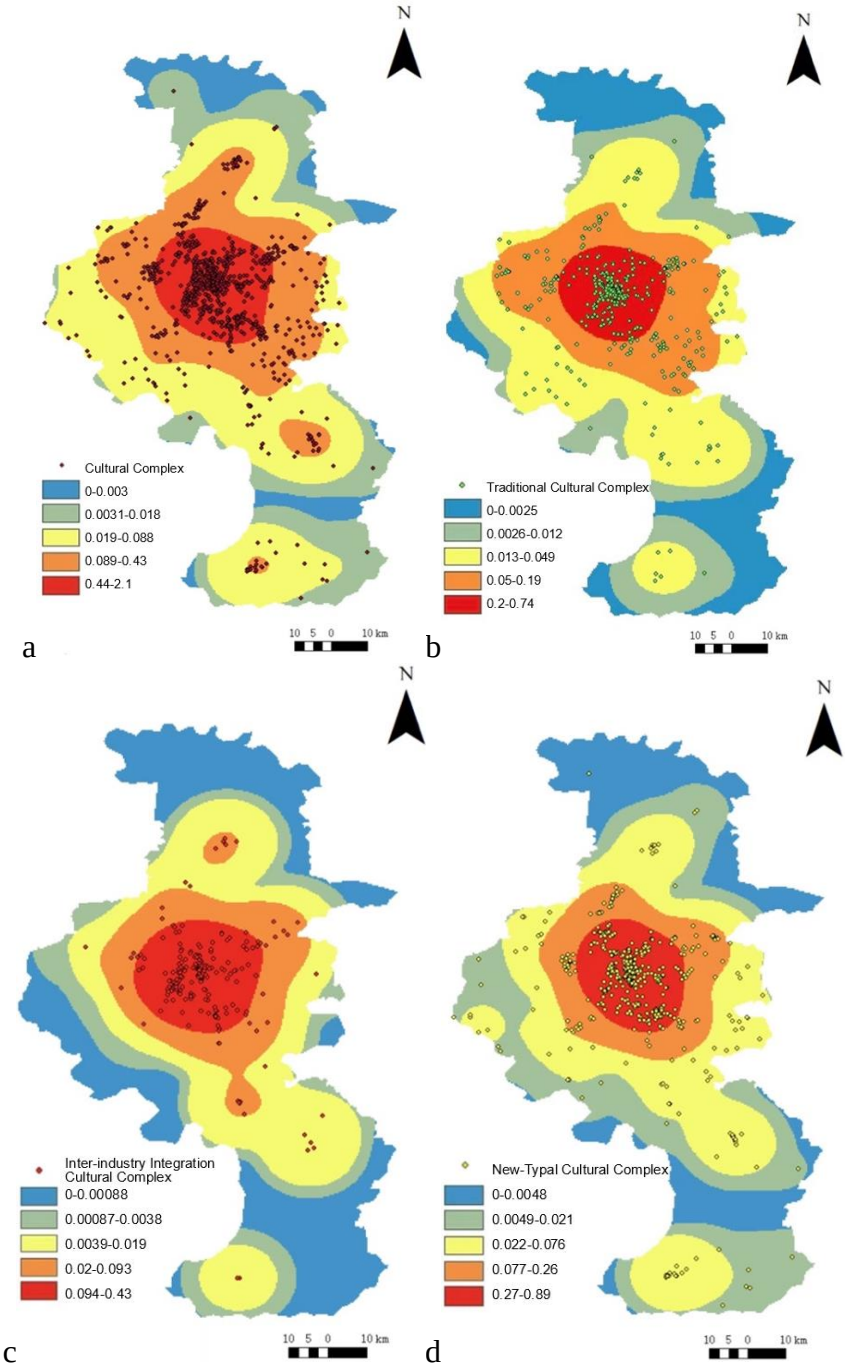

Figure 3. (a) Distribution of Nanjing Cultural Complex; (b) Tradition Cultural Complex; (c) Inter-industry Cultural Complex; (d) New-Type Cultural Complex by Kernel Density Analysis (Original figure)

4.3. Accessibility Analysis

Due to the overall low coverage of walking path, this paper adopts another different approach called Service Area to simulate walking accessibility. Figure 4 shows the analysis results, from which it can be seen that although walking accessibility is generally low, the range of accessibility gradually expands with the increase in walking time. The accessibility is highest in urban central areas. The study then looked at the data of elderly people and set a default speed of 3 km/h for the same service

area calculations. It can be observed that older people have a smaller range of accessibility and a lower continuity in this region compared to the general population.

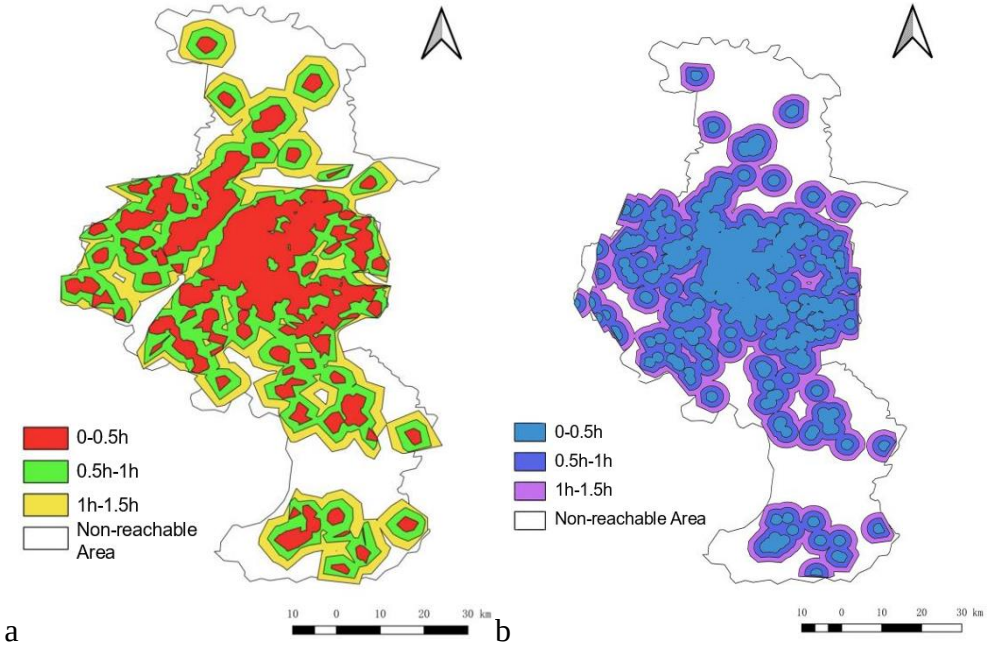

Figure 4. Accessibility of (a) walking at different times, and (b) elderly people walking at different times (Original figure)

Figure 5 shows the accessibility of non-motorized vehicles. Within 0.5 hours, accessibility is relatively low, mainly concentrated in the eastern region of Nanjing. As the time extends to 1 hour, the accessibility improves significantly, particularly in the city's central area. When the time is prolonged to 1.5 hours, the highest accessibility value will be attained, yet the highest accessibility will not be manifested in the city center but in the periphery.

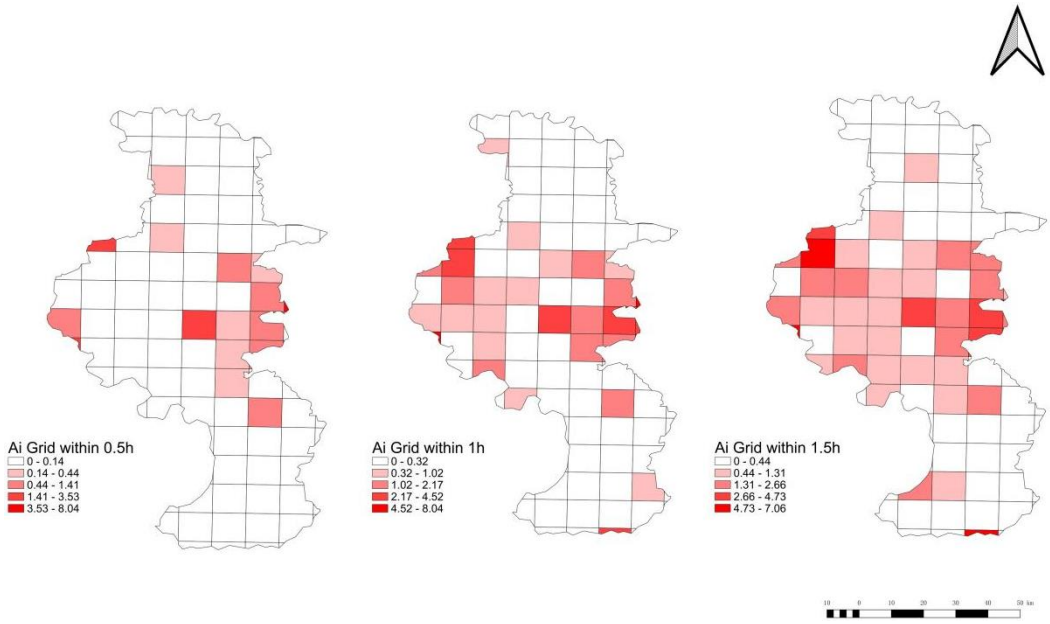

Figure 5. Accessibility of non-motorized vehicles at different times (Original figure)

Compared with walking and non-motorized vehicles, the accessibility of motorized vehicles is generally higher (Figure 6). Within 0.5 hours, the accessibility of motor vehicles is mainly concentrated in the urban center, featuring distinct spatial variations. As time increases, the accessible range expands further after 1 hour. The accessibility at the edges gradually exceeds that at the center. When the time is prolonged to 1.5 hours, the accessible range keeps expanding. The accessibility

advantage in the urban center area diminishes, while the accessibility advantage in the edge area reaches its maximum.

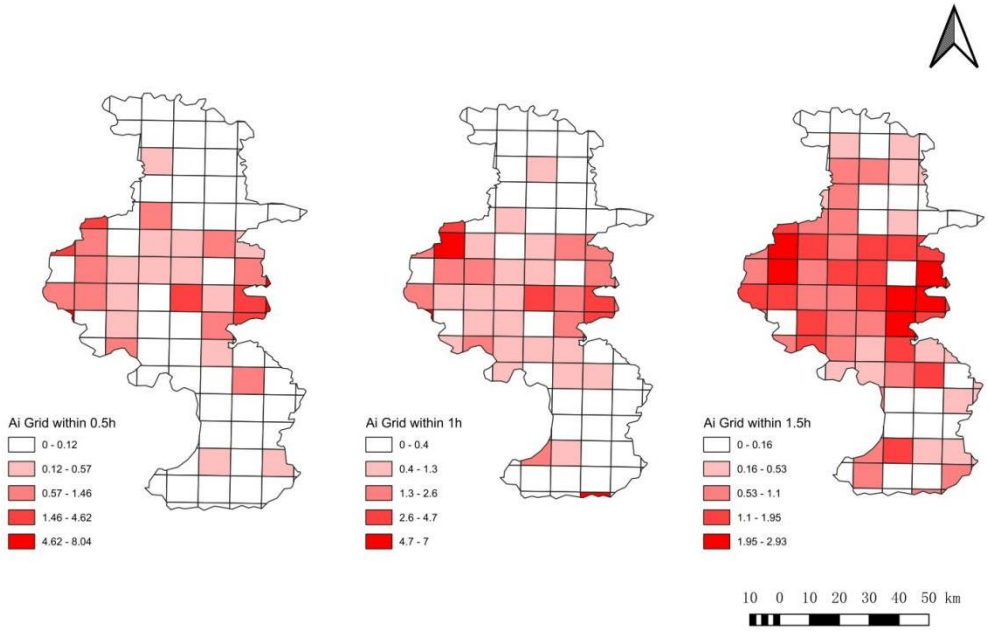

Figure 6. Accessibility of motor vehicles at different times (Original figure)

4.4. Degree of Equity

Figure 7 presents the Gini coefficient, where G represents the degree of inequality in overall cultural services. The author computed the Gini coefficients for different age groups separately, and the results observed from the image demonstrate similarities. In terms of numerical values, rounded to two decimal places, the Gini coefficients are as follows: for the aggregate of all age groups, the result is 0.24; for the age group of 0 - 14, the result is 0.26; for the age group of 15 - 59, the result is 0.25; for the age group of 60 and above, the result is 0.23; for the age group of 65 and above, the result is 0.21. The results indicate that fairness improves with the increase in age.

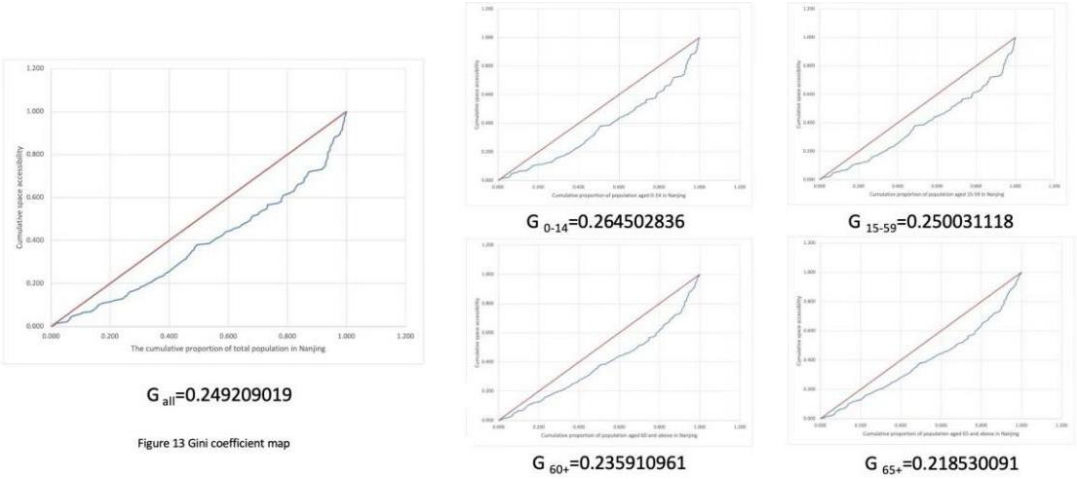

Figure 7. Gini coefficients (Original figure)

5. Discussion

5.1. Distribution Characteristics and Influencing Factors of Cultural Complexes

Population plays an important role in influencing the distribution of cultural complexes. This study has observed the agglomeration of cultural complexes in Nanjing, particularly in the central urban

area, where the density demonstrates a decreasing trend as it extends towards the urban fringes. The formation can be attributed to the higher population density and frequent population mobility in the central area. These factors jointly give rise to an urgent demand for cultural facilities. Additionally, the optimization of transportation infrastructure in the central area has also positively affected the accessibility of cultural complexes.

Although the distribution of cultural complexes and population density exhibit consistency at the macroscopic level, an in-depth analysis of the population data at the street level reveals that the most densely populated areas are not entirely concentrated in the city center [8]. The area with the highest population density shows a southward shift. The main driving force behind this phenomenon lies in the central area of Nanjing, especially in the vicinity of renowned scenic spots such as Confucius Temple and Laomen Dong. In these areas, a large number of floating populations mainly gather, while the resident population is relatively small. These floating populations may also develop an interest in the surrounding cultural complexes, such as physical bookstores, while visiting the scenic spots, thereby maintaining a high degree of agglomeration of cultural complexes in the central area of the city.

Moreover, the rise in population density in the southern region of Nanjing is closely associated with the corresponding increase in the quantity of cultural complexes. This trend is connected with the "small store plan" policy implemented by the Jiangning District government. It aims to enrich and enhance the quality of local cultural life through activities such as physical bookstores and cultural fairs. With the emergence of new types of cultural complexes, their spatial distribution has expanded to the urban fringes. This reflects the policy orientation for the improvement of public cultural services. It also indicates that urban cultural service facilities are gradually covering broader areas to meet the cultural demands of residents in different regions.

The spatial distribution of cultural complexes in Nanjing is significantly affected by population factors. There are disparities in the accessibility and coverage of cultural service facilities between the central urban area and the urban fringes. Future research can further explore how to optimize the spatial layout of cultural complexes through urban planning and policy guidance to achieve equity and efficiency in cultural services [9].

5.2. Existing Issues in Bookstore Distribution

An analysis of the distribution map of bookstores in Nanjing reveals a marked imbalance in their spatial distribution. It is predominantly manifested by the high concentration of bookstores in the city center. This clustering phenomenon leads to a non-perfect overlap between the concentrated areas of cultural complexes and the city center. As a result, it adversely affects the residents in the peripheral areas of the city. Specifically, residents in the urban fringes not only encounter a scarcity of cultural complex resources in their vicinity, but also encounter certain difficulties in accessing the cultural complexes in the city center due to lower accessibility. This phenomenon is reflected in the accessibility analysis where bookstores in the city center do not demonstrate the anticipated high accessibility advantage.

Subsequently, through the calculation and analysis of the Gini coefficient, this study uncovers the fairness issue of cultural complexes in spatial distribution for the children's group. The Gini coefficient reveals in this study that the accessibility of cultural complexes for children is relatively low. This outcome is associated with the limited capacity of children to visit distant or large-scale cultural complexes on their own. It also shows the shortage of cultural complexes to fully consider the needs of children in their design and functionality. Some cultural complexes lack specialized activity areas or contents targeted at children. So it reduces children's interest in visiting cultural complexes and subsequently influences their accessibility.

To enhance the fairness and accessibility of cultural complexes, future urban planning and design should give greater consideration to the needs of different age groups, especially children. An equitable allocation and efficient utilization of cultural resources can be achieved by providing more diversified and targeted services and optimising transportation and spatial layout.

5.3. Suggestions on Bookstore Location Selection and Operation

When choosing a bookstore location, the first factor to consider is the volume of human traffic. Existing bookstores meet the criteria of being located in areas with high human traffic [10]. Given the current situation where cultural complex centers are concentrated in the core areas and scarce in the peripheral regions, it is recommended that bookstore locations be extended towards the outskirts. Besides increasing the overall coverage, this can also benefit residents in the peripheral areas. This can allow them to access cultural resources without spending excessive time or travelling long distances, thereby enhancing the efficiency of cultural complexes.

In terms of accessibility analysis, the center shows fewer advantages. However, the highest accessibility for both motorized and non-motorized vehicles occurs in the eastern part. To further enhance operational efficiency, bookstores in the East can adopt a classification method. Clearly define the target audience of the bookstore and categorize different age groups and transportation modes. For instance, more parking spaces can be provided for motor vehicles in areas with higher road network coverage. Alternatively, within bookstores located in densely populated areas, corresponding reading areas and service types can be established based on the age groups of the population.

Additionally, the accessibility of motor vehicles is significantly higher than that of non-motorized vehicles and pedestrians. It is mainly due to the faster speed of motor vehicles and their wider range of road choices. Nevertheless, the accessibility of pedestrians and non-motorized vehicles is restricted by the coverage and completeness of transportation facilities such as sidewalks and bicycle lanes. To improve the accessibility of cultural complexes in peripheral areas, it is suggested that infrastructure construction be strengthened. For example, increasing roads and public transportation facilities, and rationally allocating transportation resources to meet the transportation demands of different regions. Future development strategies should consider how to promote the balanced distribution of cultural resources by optimizing the transportation network and upgrading infrastructure. Simultaneously, sustained actions should be taken to drive the innovative development of cultural complexes to adapt to social progress and the escalating cultural consumption demands of the people.

6. Conclusion

This research has conducted an in-depth analysis of the distribution and accessibility of cultural complexes represented by bookstores in Nanjing. Through integrating the distribution of bookstores, transportation, and population density data in Nanjing, a bookstore accessibility evaluation system was established. Spatial analysis methods were employed to quantify the distribution characteristics, service scope, and fairness of bookstores. The results indicate that the distribution of bookstores in Nanjing is similar to the population distribution, featuring an imbalance. The accessibility of bookstores is better in the central area but poorer in the peripheral areas. The fairness of services for children is inadequate. Based on these findings, this paper presents targeted bookstore location suggestions and operational improvement strategies and proposes feasible approaches for the development of surrounding transportation. These all aim to provide decision-making references for the government, urban planners, and bookstore operators.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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