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Spatial Pattern, Quality Evaluation, and Implications of Preschool Education Facilities in New Urban Areas Using Multi-Source Data: A Case Study from Lingui New District in West China

Xiao Wang [1,2], Jiaying Zhao [1], Yuxi Lu [1] and Xiang Li [3,*]

[1] College of Tourism & Landscape Architecture, Guilin University of Technology, Guilin 541004, China; wangxiaoglut@glut.edu.cn (X.W.); 3192032032211@glut.edu.cn (J.Z.); 3192032032240@glut.edu.cn (Y.L.)
[2] Institute of Guangxi Tourism Industry, Guilin University of Technology, Guilin 541004, China
[3] School of Design and Architecture, Zhejiang University of Technology, Hangzhou 310023, China
* Correspondence: lixiang@zjut.edu.cn

Abstract: Currently, China has entered the development stage of a "low birth rate" demographically. There is a huge contradiction between the unbalanced and inadequate distribution of preschool education facilities (PEFs) and the people's expectations for "full and good education for children". This study took the Lingui New District, a typical new urban area in West China as the research area, and through the introduction of POI big data and GIS analysis methods, supplemented by GeoDA Bivariate Moran index analyses, established a kindergarten spatial database. The study found that preschool education facilities have problems such as insufficient quantity, uneven quality, low service coverage, poor accessibility, etc. Therefore, it is suggested to increase the proportion of public affordable preschool education facilities including kindergartens and nurseries, optimize the spatial distribution of preschool education, and improve the accessibility of preschool services to promote affordable, safe, and high-quality development of preschool education and to provide reference suggestions for the revision of relevant standards and the adjustment of the layout of preschool education in undeveloped regions of China.

Keywords: preschool education facilities; spatial distribution; new urban areas; undeveloped regions; Western China

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1. Introduction

Children are the hope of society and the future of society. In recent years, the Chinese government has attached increasing importance to preschool education and implemented a series of special action plans for preschool education for the past ten consecutive years [1,2]. Preschool education facilities (PEFs), represented by kindergartens and nursery care services, therefore, have developed rapidly [3]. According to the *Statistical Bulletin of National Educational Development in 2021*, there were 294,800 kindergartens nationwide, of which 87.78 percent are affordable kindergartens, the affordable kindergartens are subsidized by the government, the admission fees and sponsorship fees are free of charge to balance the allocation of educational resources and solve the problem of "difficult and expensive access to kindergartens". The gross enrollment rate of preschool education is 88.1%. There were 3.191 million full-time teachers in preschool education. In the report, all indicators showed steady growth except for the declining trend in the number of children attending kindergartens. This indicates that the traditional challenges of difficult and expensive kindergarten enrollment have been somewhat alleviated. The pressing needs of the people have shifted from "ensuring access to education for children" to addressing regional disparities, expanding preschool education coverage, enhancing preschool education quality, and ensuring access to high-quality education for all children [4,5]. Among all types of

urban areas, the New Urban Areas (NUAs) which are newly developed regions in cities, have been widely and quickly constructed across China as a result of fast-growing urbanization since the 2000s. As the NUAs are newly built areas, the physical and non-physical environments are not developed compared with other parts of cities; in addition, the NUA in economically underdeveloped Western China has seldom been discussed before. It has its own uniqueness and is generally plagued by the problems of insufficient and uneven distribution of preschool education facilities. Therefore, in-depth research on the spatial distribution of preschool education facilities in NUAs and countermeasures can not only supplement the weaknesses and promote the fair distribution of preschool education, but also provide reference suggestions for the high-quality development of preschool education in Western China, and other underdeveloped countries worldwide [6].

2. Literature Review

2.1. Previous Research Review

At present, the academic research on the layout of preschool education facilities involves multiple perspectives: (1) From the perspective of pedagogy, it aims to encourage multiple related stakeholders to participate in the construction of democratic decision-making procedures, expand the capacity of affordable preschool education resources, and enhance the supply capacity of preschools [4,7–9]. The concept of child-friendly schools encompasses pedagogical theories and educational practices. Child-friendly schools have been shown to proactively enhance the educational environment and theoretical progress in various studies [10–12]. (2) From the perspective of urban planning, for example, child-friendly cities [13], the aim is to establish a baseline standard system for spatial layout adjustment with school-age population coverage, taking service radius, class, and school size as core indicators [14]. (3) From a child-friendly perspective, children are encouraged to participate in planning child-friendly urban environments. The decisions made in urban planning, with input from children and parents' firsthand knowledge and perceptions of neighborhood child-friendliness, can effectively improve the quality of the built environment and make it more child-friendly [15]. A review paper presents a structured literature review of the concept of child-friendly environments to understand the needs from children's perspectives. Children, as the users of urban built environments, reflect the real needs in socio-physical dimensions from their perspectives. These dimensions include aspects such as urban spaces, accessibility, space safety, space connection, spatial fairness, space recreation, freedom, cleanliness, involvement, and learning [16,17].

Previous research on preschool education facilities focused on kindergartens as a single object, and there has been relatively little research on the spatial distribution and optimization of nursery service facilities [18,19]. Due to China's vast territorial expanse, there is a significant economic development gap between the eastern and western regions. Many studies on preschool education infrastructure are based on the experiences of the developed eastern regions, while there is a lack of research in the less developed western regions [20]. Inspired by the above research, this study, through investigation and multi-source data analysis, takes the Lingui New District of Guilin City in an undeveloped region of West China as an example to reveal the distribution characteristics, existing problems, and causes of preschool education facilities, and puts forward child-friendly and other diversified development paths to provide references for relevant policies, regulations and the adjustment of preschool education layout.

2.2. Spatial Distribution of Preschool Education Facilities

At present, the academic circle mainly studies the spatial layout of preschool education facilities from the aspects of supply and demand, construction standards, spatial layout factors, and so on. In terms of supply and demand, existing studies have determined the spatial difference between supply and demand by comparing the current situation of kindergarten supply and the predicted demand for children. In terms of construction standards, starting from empirical cases, the researchers put forward thoughts and suggestions

on relevant standards and norms such as kindergarten service radius and transportation travel. In terms of influencing factors, existing papers have analyzed the impact of birth policy, population distribution, road traffic, land use layout, kindergarten quality, and other factors on spatial layout and countermeasures. From the existing literature, the research object mainly focuses on kindergartens in preschool education facilities, but the research on nursery service facilities represented by nurseries is relatively insufficient. However, with the change in China's social and family structure, affordable nurseries have become a new development point in recent years [21,22]. Accordingly, the research on the spatial layout of nurseries will become a new research trend; therefore, this research combined nurseries into preschool education facilities, developing a more complete ecosystem of preschool education facilities.

2.3. The New Town Movement and New Urban Areas in China

The concept of New Town can be traced back to Howard's Garden City theory in the late 19th century, which was used to relieve the problem of London's urban population surge after WWII [23]. After World War II, the New Town movement emerged in Western countries, aiming to solve problems such as population surge and housing shortage [24]. In the first half of the 20th century, China began to introduce the concept of New Town from Western countries [25], formulating the "The City Plan of Nanking (1927)" [26] and the "Greater Shanghai Plan (1927)" [27]. After the 1990s, China began a large-scale movement of New Towns, including the national level new districts for economic growth [28]; despite the similar definition, the term "new urban areas" (NUAs) is more frequently recognized in China. Various NUAs built not only learned from the experience of Western countries but also formed the development mode with Chinese characteristics. That is, they not only provided a spatial carrier for urbanization but also were regarded as a "necessary investment" by the government [29]. Regarding the research on China's NUAs, scholars believe that the development of NUAs is influenced by the overall economic and social background and is driven by "government-led, high-speed urbanization and land finance" [30,31]. Most of the major problems facing the construction of NUAs include insufficient development power, insufficient development of urban functions, and homogeneous competition [32,33]. In the new era of urbanization development and transformation, NUAs that only consider the functions of residence and employment will not be enough to meet the higher needs of the people, and new development is needed in basic public services, ecological environments, historical culture, spiritual needs, and other aspects [34].

The existing literature has conducted in-depth research on the spatial layout of preschool education facilities and obtained certain results. However, there are still some deficiencies in relevant research. First, most of the existing studies focus on the spatial layout of kindergartens and pay little attention to the spatial layout of nurseries. Second, most existing studies from specific factors analyze the direct causes of the spatial problems of preschool education facilities, while few studies based on the background of macro-urbanization analyze the deeper causes of the problems of preschool education facilities in new towns or NUAs [35,36]. Third, the existing research focuses on the eastern and central regions of China, and preschool education facility layout planning of the economically underdeveloped regions in the west is relatively lacking [5]. In Guangxi, as a populous province in Western China, improving the quality of preschool education is of great significance to its economic development. Based on the above, this paper takes preschool education facilities in the Lingui New District, a typical NUA of Western China, as the research object, studies the spatial distribution and supply and demand relationship of preschool education facilities by using the multivariate data method, establishes a spatial database, and puts forward suggestions on optimizing the layout of preschool education facilities in order to provide scientific reference suggestions for revision of relevant standards and adjustment of preschool education facility layout in NUAs in underdeveloped regions in China and other countries.

3. Research Design

3.1. Research Area

Lingui New District (hereinafter referred to as "Lingui") of Guilin City, Guangxi Province, China, was selected for this research. It is a typical NUA located in the west of Guilin and only 5 km away from the city center, Lingui could to a large extent represent the development of preschool education in NUAs of underdeveloped regions of West China. It has been 10 years since Lingui was set up as a new district and it is a typical representative of NUAs. It has gradually become the new center of Guilin, carrying the important functions of supplementing the old urban areas of Guilin and expanding the space for urban development. By the end of 2021, Lingui covered a total area of 2190.27 square kilometers, had a population of 557,500, and had jurisdiction over 11 towns and townships. The scope of this study is the built-up area of Lingui. Lingui has a high proportion of residential land, which belongs to the "real estate NUA" driven by high-speed urbanization and land finance. Therefore, the city has a high demand for preschool education facilities, and the contradiction between supply and demand for preschool education is prominent.

3.2. Research Methods

In this study, the population data of the research came from the 2022 Guangxi Provincial Statistical Yearbook, and the spatial data introduced from the POI data was supplemented by the analysis methods of yaanp, GIS, and GeoDA Bivariate Moran index. yaanp (2.7, Metadecsn company, Taiyuan, Shanxi China) was used for AHP analysis, GIS (ArcMap 10.7, Esri, Redlands, CA, USA), and GeoDa Software (1.18.0.0, the University of Chicago, Chicago, IL, USA).

A point of interest (POI) is any location on a map that someone might find interesting. These points can be interesting for various reasons, such as residential or educational purposes. POI data are typically collected in a POI database. Geographic information service platforms like Google Maps or Baidu Maps convert real-world locations into data that can be displayed in apps and other software. This provides developers with access to POI data for research projects.

By obtaining the spatial layout data of preschool education facilities in Lingui, therefore, a spatial database was established, and a correlation analysis of kernel density, spatial distribution of quality, buffer zone, and service radius was carried out with GIS software. According to the National Standard, "*Code of Urban Residential Areas Planning & Design*" (GB50180-2018) (hereafter referred to as "Standard") [37], and other latest standards and norms, this study scientifically analyzes the supply imbalance of preschool education facilities within the study area and puts forward an optimization approach for the overall spatial layout of preschool education facilities in Lingui. Therefore, a methodological research framework is presented to better explain the research methods and processes (Figure 1).

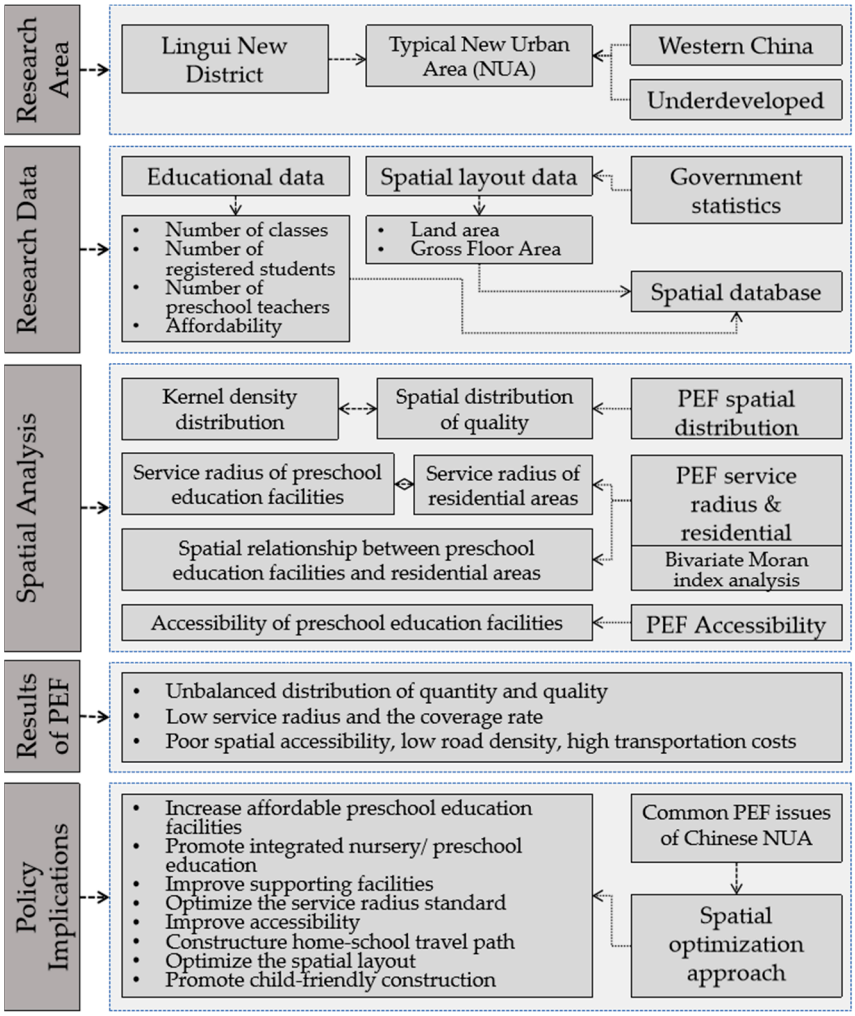


Figure 1. The research framework (Note: The figure contains a single directional arrow that explains the logical relationships).

4. Current Situation and Analysis of the Spatial Distribution of Preschool Education Facilities

4.1. Spatial Distribution of Preschool Education Facilities

According to the data of the Municipal Education Bureau of Lingui, in 2021, there were 96 registered kindergartens and 16 nurseries in the main urban area of Lingui, with an enrollment of 19,305 children (Figure 2). In China, influenced by Soviet-style planning, the "one thousand people index" is often used as capacity control in urban planning. The one thousand people index refers to the building area and land area of various public service facilities owned by every 1000 people in planning and design, and is taken as the control index of urban public facilities. In the "*Code of Urban Residential Areas Planning & Design*" [37], all kinds of public service facilities of the one thousand people index have been stipulated. Among them, the index of kindergarten students per 1000 people is 34 per 1000 at Lingui, far lower than the standard required by the index of 49 per 1000 in the National Standard. In addition, the number of nurseries per 1000 people is about 1.4, far lower than the provincial average of 2.4 per 1000 and the national average of 1.8 per 1000.

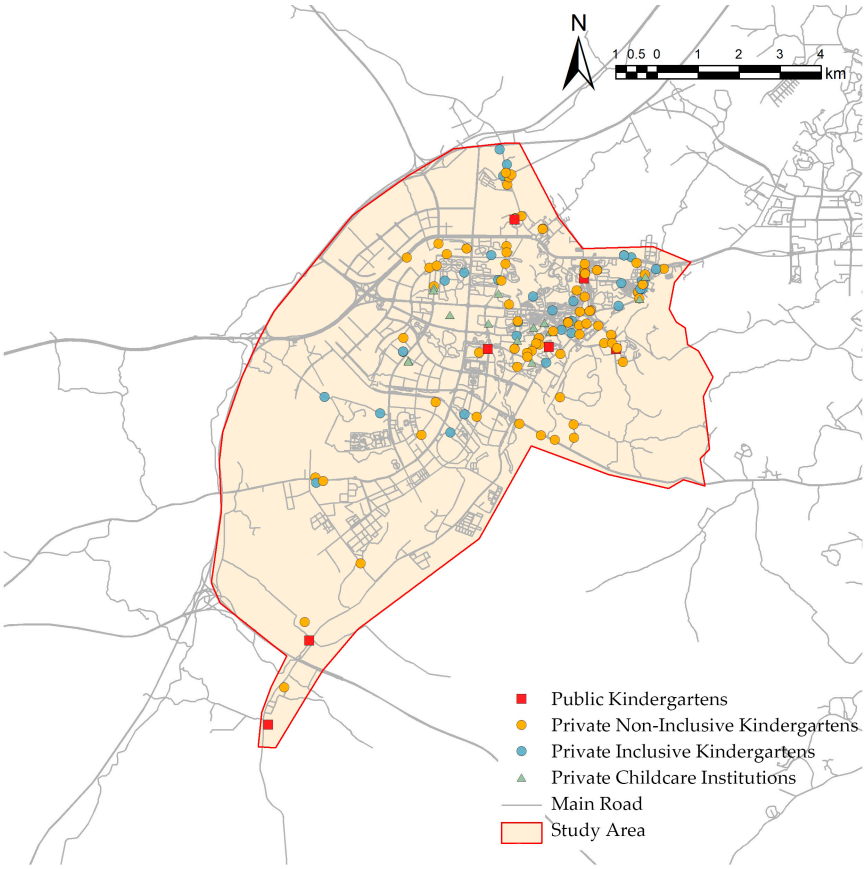


Figure 2. Distribution of preschool education facilities.

In terms of spatial layout, kindergartens are mainly concentrated in the middle and the east and less in the southwest in the Lingui urban area. The nurseries are all distributed in the east and middle, and the coupling degree with kindergartens is low in spatial distribution according to data analysis.

4.1.1. Kernel Density Distribution of Preschool Education Facilities

The spatial density of preschool education facilities in the study area was classified and visually analyzed by using the kernel density analysis method, and its spatial distribution characteristics were revealed. Kernel density can be employed to analyze the relative concentration of spatial point distribution, and its mathematical expression is as in Formula (1),

$$\lambda_h(s) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{s - s_i}{h}\right), \quad (1)$$

where "h" is the threshold value, "n" is the number of points within the threshold range, and "d" is the dimension of data.

In the kernel density analysis method, the pixel size is set as 40 m and the search radius as 1000 m to analyze the distribution data of preschool education. The results are divided into 5 levels according to the natural break, indicating the number of preschool education facilities per square kilometer. In these levels, kernel density level 1 ranges from 0 to 0.58 PEF per km^2, level 2 ranges from 0.59 to 2.3 PEF per km^2, level 3 ranges from 2.4 to 4.7 PEF per km^2, level 4 ranges from 4.8 to 8.3 PEF per km^2, and level 5 ranges from 8.4 to 13 PEF per km^2.

Among them, level 5 kernel density is the highest level, reaching the number of 8.4–13 per square kilometer, and level 1 kernel density is the lowest number. As shown in Figure 2, the density distribution of preschool education facilities within the research scope presents a spatial distribution trend from central agglomeration to southwest decentralization. Level

5 kernel density areas are mainly distributed in the Jinshui community, Hushan community, Jinshan Community, and Guikang community in the central urban area, while Level 1 to Level 2 kernel density areas are mainly concentrated in the southwest, located in suburban areas. In general, the distribution of preschool education facilities in Lingui presents a multi-core circular spatial structure, and the spatial distribution of preschool education facilities presents an unbalanced state; the edge weakening characteristic is significant (Figure 3).

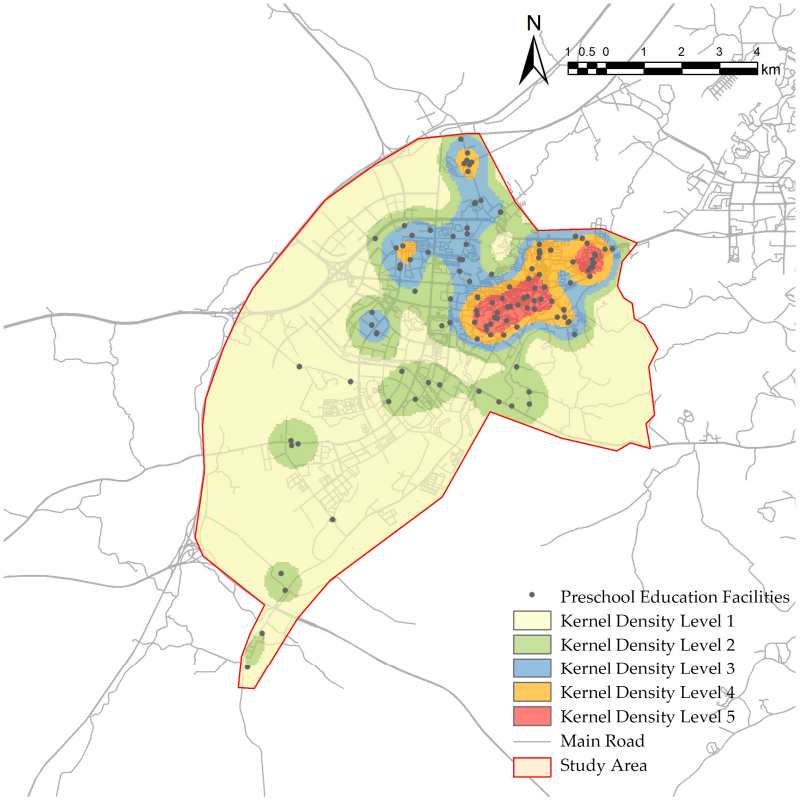


Figure 3. Kernel density analysis of preschool education facilities.

4.1.2. Spatial Distribution of Preschool Education Quality

Preschool education facilities are an important part of educational public service facilities; their definition determines that the spatial layout should not only ensure balance and fairness in quantity but also pay attention to the spatial distribution of facility quality.

This study comprehensively considers the representativeness and accessibility of data. We employed the Analytic Hierarchy Process (AHP) to design the evaluation system. The indicators and weights are determined. First, 10 experts were invited to determine the preschool education quality evaluation system, which was divided into six indicators of three categories, namely, the number of classes, the total number of students, the school land area, the total building area (gross floor area), the number of preschool teachers, and the cost performance. Then, experts score each indicator to build a judgment matrix. Finally, according to the scoring results of experts, the weight scores of corresponding indicators are calculated in yaanp software based on the entropy model, as shown in Table 1.

Table 1. Indicators and weights of preschool education quality evaluation.

Category	Indicator (*X*)	Unit	Weight (*W*)
Capacity of preschool education	Number of classes (X_1)	Class	0.149758 (W_1)
	Number of registered students (X_2)	Students	0.084238 (W_2)
	Land area (X_3)	m^2	0.218869 (W_3)
	Gross Floor Area (X_4)	m^2	0.222825 (W_4)
Faculty	Number of preschool teachers (X_5)	Teachers	0.200014 (W_5)
Cost performance ratio	Affordability (X_6)	Yuan	0.124296 (W_6)

The formula for calculating the score of preschool education quality is (2),

$$Q_{pe} = X_1W_1 + X_2W_2 + X_3W_3 + X_4W_4 + X_5W_5 + X_6W_6 \quad (2)$$

where Q_{pe} denotes Preschool Education Quality; X represents six indicators selected for representing qualities of preschool education in two categories; W represents indicator weights.

From the spatial distribution map of preschool education quality (Figure 4), we can see that there are high-, medium-, and low-quality preschool education facilities distributed in the northeast of Lingui, among which high-quality preschool education facilities with a score of 80 to 100 are basically public kindergartens. Middle- and high-quality preschool education facilities with a score of 60 to 80 are mostly affordable kindergartens and nurseries. Low-quality preschool education facilities are distributed in the central and eastern parts of the city and are mostly small-scale private preschool institutions. It can be seen that the quality distribution of preschool education facilities in Lingui is better in the northeast than in the southwest, showing uneven characteristics between regions.

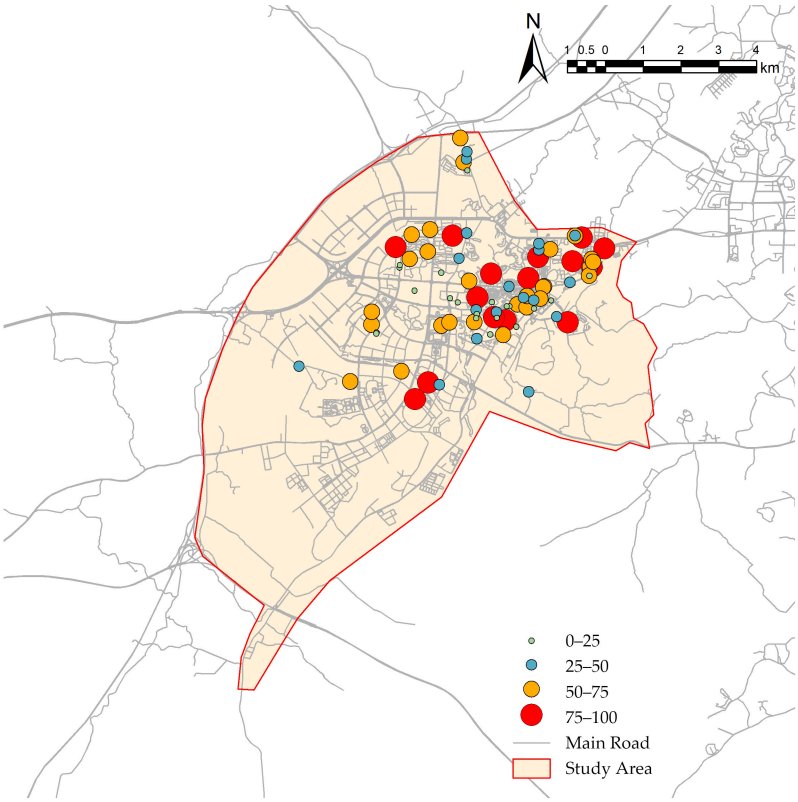


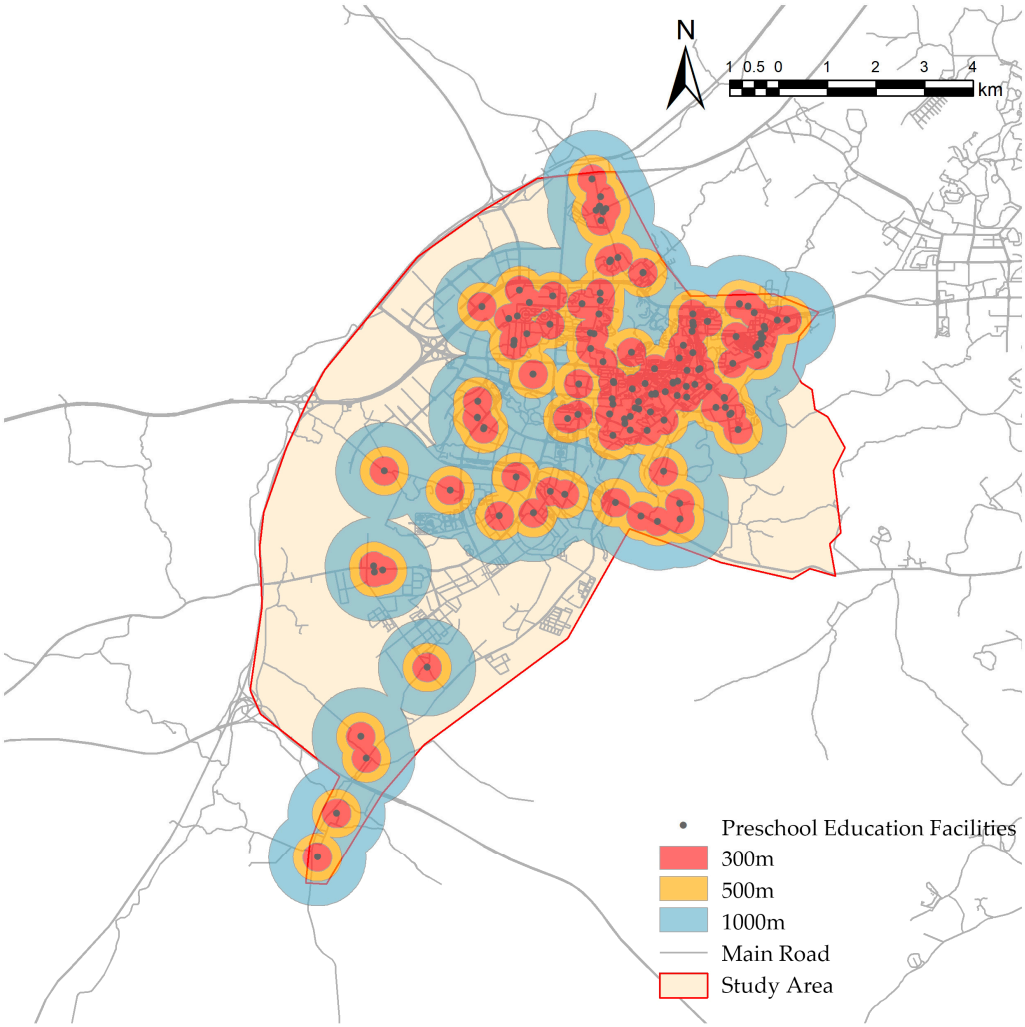
Figure 4. Spatial distribution of preschool education quality of Lingui.

4.2. Service Radius of Preschool Education Facilities and Spatial Distribution of Residential Areas

4.2.1. Analysis of Service Radius of Preschool Education Facilities and Residential Areas

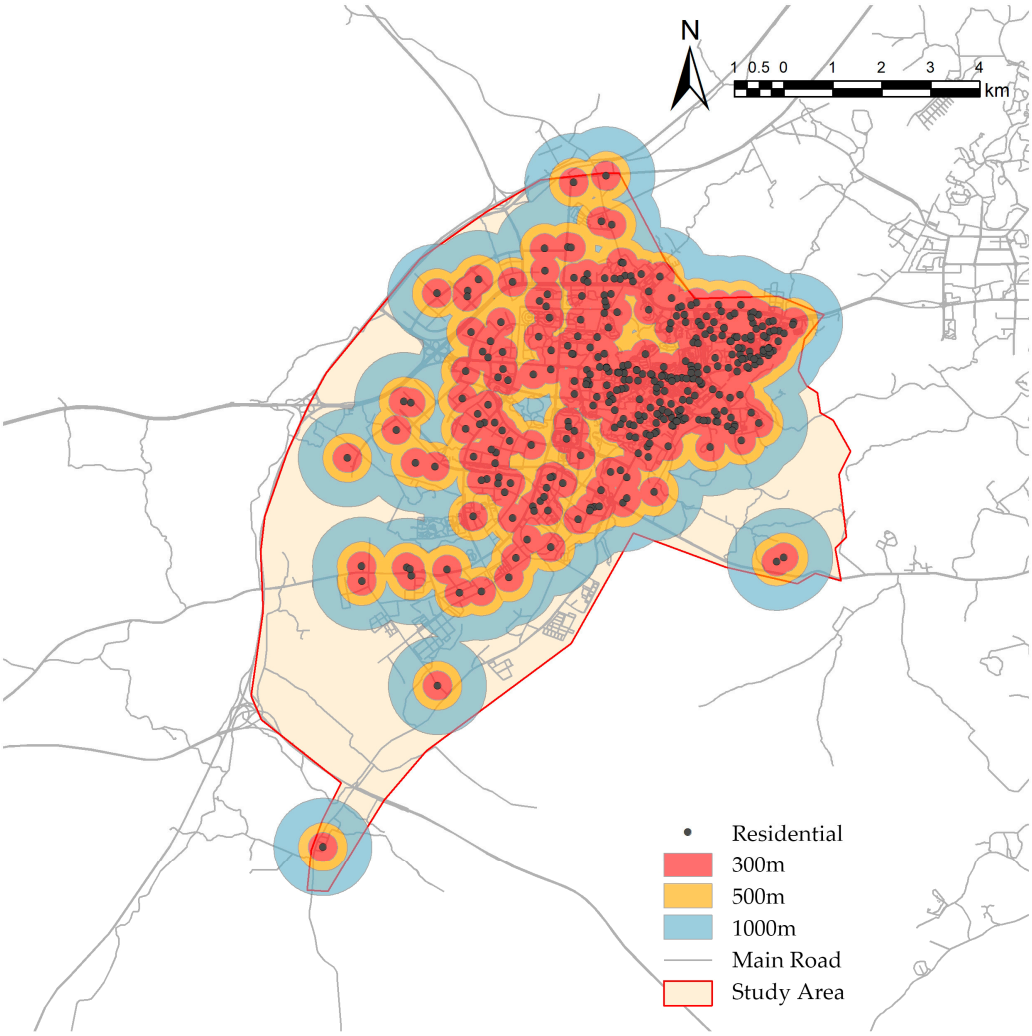
The buffer analysis is based on geographical elements, and the buffer polygon layers are built around geographical elements based on buffer distance to obtain the influence range of geographical elements.

As can be seen from Figure 5a, with preschool education facilities' POIs as the center, when the buffer radius is 300 m, the coverage rate of preschool education facilities is 23.3%, which makes is difficult to fully cover the residential area. After enlarging the buffer radius to 500 m, the coverage rate is 46%. When the radius is 1000 m, 84% of residential land is covered, which could satisfy the functions of preschool education services in Lingui (Figure 5a).



(**a**)

Figure 5. *Cont.*



(**b**)

Figure 5. (**a**) Preschool education facility buffer analysis. (**b**) Residential buffer analysis.

According to the "*Code of Urban Residential Areas Planning & Design*" [37], a four-level residential area service radius for the daily-life circle is referenced; thus, GIS software is used to take residential POIs as the center of the circle, and three buffer radii with different radii of 300 m, 500 m, and 1000 m are selected, respectively, combined with the spatial distribution point information of preschool education facilities, to analyze the configuration within the coverage range of residential point space (Figure 5b).

4.2.2. Analysis of the Spatial Distribution Relationship between Preschool Education Facilities and Residential Areas

Since the students of preschool education facilities mainly come from nearby residential areas, and the construction standards of preschool education facilities are highly correlated with residential areas, it is of practical significance to analyze the spatial relationship between preschool education facilities and residential areas. First, we used the ArcToolbox in ArcMap 10.7, selected the Data Management Tools, clicked Create Fishnet in the Sampling button, and created polygons with a cell size of 50 m × 50 m in the research area. Then, the current service radii of preschool education facilities and residential area kernel density were classified, and the two were separately derived and associated with the corresponding fishnets. Then two datasets were imported into GeoDA software to conduct a spatial coupling analysis of the current service radius of preschool education facilities and the kernel density of residential areas after the fishnet association. Finally, a

Bivariate Local Moran index analysis was carried out, and five spatial distribution coupling relationships between the service radius of preschool education facilities and residential areas were obtained (Figure 6).

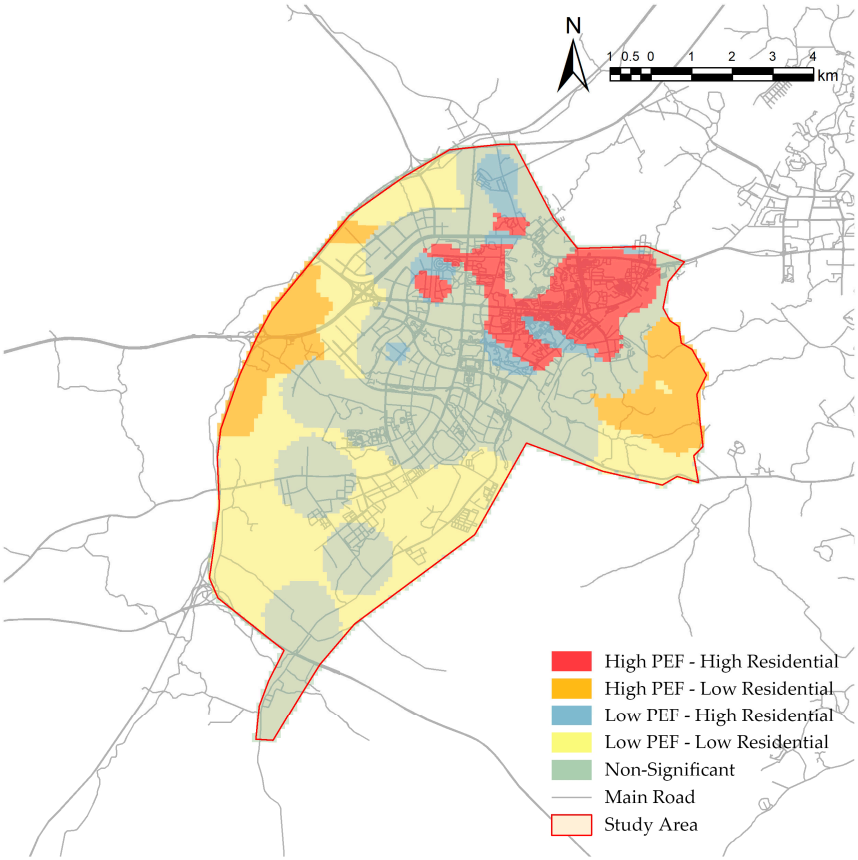


Figure 6. Moran index map of spatial distribution of kindergartens and residential areas.

(1) High-density preschool education facilities and high-density residential areas. These areas are mainly concentrated in the old town of Lingui and the scattered new communities in the southern city. These parts of the settlements fully meet the educational needs of preschool education facilities, with no need to plan new preschool education facilities.
(2) Low-density preschool education facilities and low-density residential areas. These regions are mainly distributed in the suburbs around the city, showing a sporadic distribution state. According to the field survey conducted by the authors in this research, these regions are mainly areas with few residential land items such as bus stations and rural assembly points, so the number of preschool education facilities in these regions meets the actual demand.
(3) Low-density preschool education facilities and high-density residential areas. This area mainly consists of the outskirts of the city, including villages and new communities. The primary demographic is made up of migrant workers and new immigrants in the NUA. The psychological and socio-economic status of these residents differs significantly from those in the old city, as they have lower economic income, weaker social relations, and more delicate social psychology. Therefore, appropriate measures need to be developed.

Firstly, it is important to rationally determine the scale and standards of public service facilities to avoid waste. Inclusive kindergartens and nurseries should be expanded, and the day care hours should be extended to accommodate the busy work schedules and low incomes of the residents.

Furthermore, there is a need to develop long-term plans, making flexible adjustments. In the short and medium term, the goal is to gradually improve the coverage of preschool education in this area, while the long-term plan involves enhancing quality upgrading. Although the region currently has a high population density due to new immigrants, the declining birth rate and reduction in the number of migrant workers, along with the increase in preschool infrastructure, will keep the population of preschool children stable. Therefore, it is crucial to regularly monitor the demographic structure and develop flexible plans accordingly.

Finally, relevant government departments should provide increased financial and policy support. This could include inclusive subsidies, encouraging large enterprises and institutions to establish childcare services, and proposing children's centers in residential communities to provide various care services such as temporary, hourly, half-day, and full-day care.

(4) High-density preschool education facilities and low-density residential areas. Usually, these areas are distributed around the non-significant areas of the city. As the main road of the city or large public areas block urban spaces, in this study area, such areas are mainly distributed in the western area of the city with good traffic conditions. Such areas do not require the planning of new preschool education facilities and the road accessibility should be further improved.

(5) Non-significant areas. These areas are typically found surrounding urban scenic spots, major transportation hubs, public spaces, and rural farmland.

4.3. Accessibility of Preschool Education Facilities

In addition to the spatial distribution of preschool education facilities, accessibility of roads should also be considered in the public service efficiency of preschool education facilities. In this study, the network analyst method in GIS is employed to analyze accessibility. The network analyst is based on the network topological relationship and traffic cost to analyze the accessibility of POIs through vector operation. The accessibility results analyzed could better reflect the actual service radius of preschool education facilities. Based on the spatial information of the road network, road grade, and traffic cost of Lingui, this study establishes the network dataset. Then, it establishes the service scope and loads the geospatial information of preschool education facilities. Three different distance costs of 300 m, 500 m, and 1000 m are selected, respectively, as resistance values for accessibility analysis, and the accessibility analysis diagram of preschool education facilities is finally obtained (Figure 7).

According to the data, the spatial accessibility of preschool education facilities in Lingui is generally low, and the difference between east and west cities is significant. When the traffic distance is 1000 m, the coverage rate of residential areas is 42.1%; there is still a big gap with the service radius of the kindergarten (nursery) stipulated in the "*Code of Urban Residential Areas Planning & Design*" [37], which should not be greater than 300 m. Currently, the areas with high accessibility are mainly located in the urban center, with high road network density and complete supporting facilities. In contrast, the low accessibility is in the southwest and the surrounding urban–rural combination areas, which are mostly college campuses and industrial parks in various scales. In these areas, the construction of residential areas and supporting facilities is relatively slow, and the density of the road network is lower than that of the central urban area. The research results show that the accessibility of preschool education facilities in Lingui is generally low and the service radius is further reduced after road resistance is added to the path accessibility analysis. This highlights the need for further optimization of the road network density in Lingui.

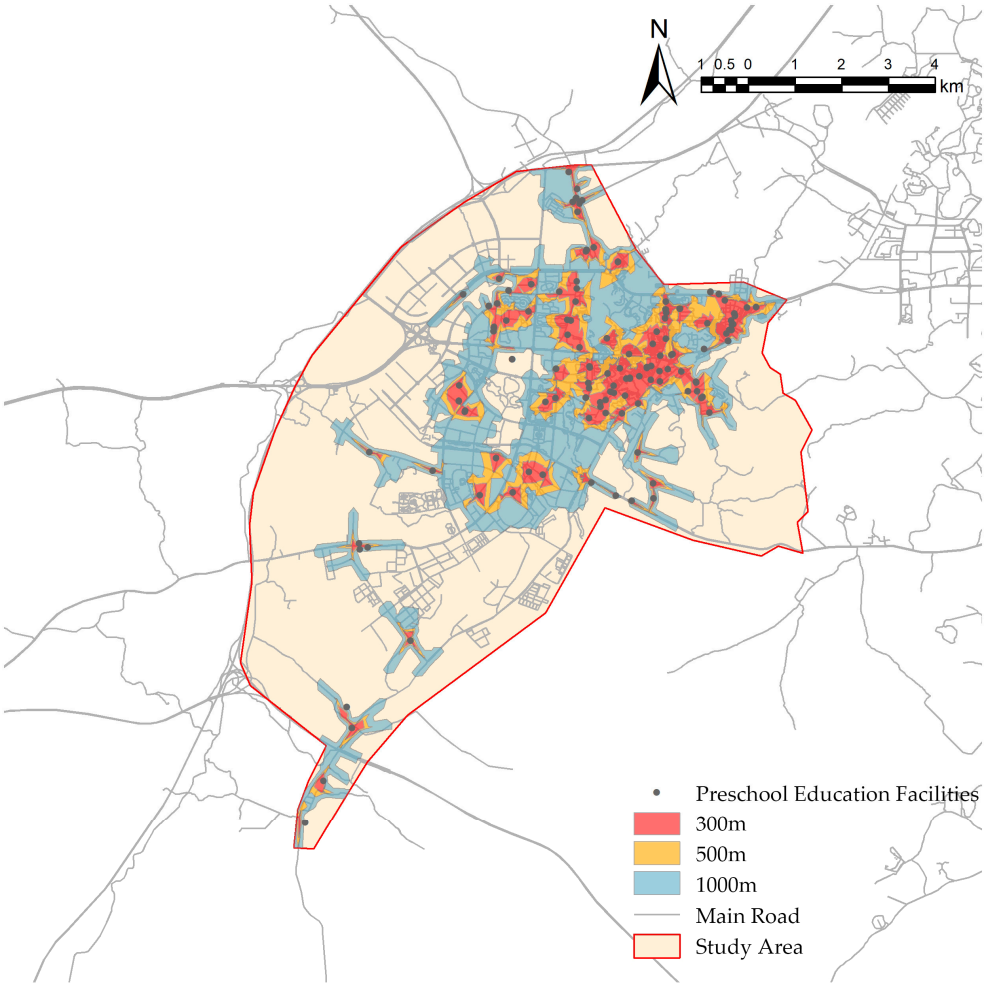


Figure 7. Analysis of accessibility of preschool education facilities.

5. Results and Discussion

5.1. Results

Based on the analysis above, three main issues in the spatial distribution of preschool education facilities in Lingui are evident (Table 2):

(1) There is an imbalance in the quantity and quality of preschool education facilities among regions, with the northeast having better facilities than the southwest. Additionally, there is a shortage of nurseries, and their spatial coupling with kindergartens is low.

(2) The actual service radius of preschool education facilities is 1000 m, resulting in low coverage. There are numerous service blind areas in the southwest as well. Notably, in the southeastern and northeastern parts of the city, there is a shortage of supporting facilities compared to the number of residential areas. This has led to an imbalance between the supply and demand of preschool education.

(3) Poor spatial accessibility, coupled with low road network density, leads to high transportation costs for accessing preschool education facilities.

Table 2. Main issues in the spatial distribution of preschool education facilities in Lingui.

Preschool Education Facilities	Summary of Spatial Distribution	Details of Spatial Problems
Quantity and quality	Imbalance in the quantity and quality of preschool education facilities	1. Northeast having better facilities than the southwest 2. Shortage of nurseries 3. Low spatial coupling between nurseries and kindergartens
Service coverage	Inadequate service coverage of preschool education facilities	1. Numerous service blind areas in the southwest 2. The southeastern and northeastern city have a shortage of supporting facilities compared to the number of residential areas 3. Led to an imbalance between the supply and demand of preschool education
Spatial accessibility	Poor spatial accessibility of preschool education facilities	1. Low road network density 2. Leads to high transportation costs

5.2. Common Problems of Lingui and Other Chinese NUAs

The development of NUAs requires sustainable industrial and population aggregation and distribution. As a supporting system for the industrial and population development of NUAs, basic public service facilities can effectively guide the development of NUAs in a fair, efficient, and sustainable direction. Lingui is the epitome of the NUA development model driven by "government-led, high-speed urbanization and land finance" in China in the 2010s, which has its progressive limits. On the one hand, as an NUA of Guilin, Lingui is close to Guilin Center, which can greatly expand the urban construction land on the basis of its original area, and provide space for high-speed urbanization of Guilin. On the other hand, in the construction process of Lingui, led by the government, too much attention is paid to short-term interests such as investment attraction and land finance, while ignoring public services, industrial chains, and public transportation development in the NUA, resulting in insufficient development of urban functions. As an important basic public service facility, the planning and construction of preschool education facilities are closely related to the spatial functional structure, policy orientation, and transportation planning of the NUA.

(1) Unsustainable land finance driven model. According to statistics, in the course of China's high-speed urbanization, a high proportion of the fiscal revenue of prefecture-level cities and county-level cities comes from land transfer fees and real estate development revenues, accounting for 30–35% and 50–70%, respectively. Lingui is the typical case, the urban development is driven by land finance, and the proportion of residential functions is high with rapid construction processes; nevertheless, the functional development of industry and public services is insufficient, the job opportunities provided are lower than expected, and the population is insufficient, resulting in the actual construction seriously lagging behind the planning, and some of the planned preschool education facilities remain incomplete as per the original planning schemes.

(2) Unbalanced spatial functional structure. The spatial functional structure of Lingui is centered on administrative and commercial finance functions; the city water system and ecological residence are located in the middle and northeast, and the modern

service industry and advanced manufacturing industry are located in the southwest. Influenced by the functional structure of Lingui, the public service facilities conform to Concentric Zone Theory [38] and are characterized by concentric zones. The central and eastern parts of the core zone are dominated by public facilities, developed from the original county and close to the Guilin old city, and preschool education facilities can basically meet the needs. The southeast and northeast adjacent to the enclosure are dominated by production services. However, due to the lack of NUA development, slow population migration, and low occupancy rate of residential areas, the construction of preschool education facilities lags behind the plan and the actual service radius is large. The southwest of the outer circle is dominated by the demand for industrial development, forming an industrial agglomeration area, with insufficient supporting facilities for public services and a large number of blind areas covering preschool education facilities. Therefore, the spatial distribution of preschool education facilities in the northeast is superior to that in the southwest in both quantity and quality.

(3) Changing policies. The insufficient childcare institutions are closely attributed to the former one-child policy. Before 2016, China still implemented the one-child policy and did not develop universal childcare. After 2016, several birth policies such as the "two-children" and "three-children policy" were introduced successively, and related childcare services have been increasingly valued as fertility support [39]. In July 2022, 17 departments including the National Health Commission jointly issued the "Guiding Opinions on Further Improving and Implementing Positive Fertility Support Measures", proposing the development of a universal childcare service system. It can be predicted that under the direct influence of the policy in the short term, Lingui will build and rebuild more childcare facilities, and the distribution will still appear more in the northeast than in the southwest [40].

(4) Outdated transportation planning. Transportation planning and design commonly share the same problems with other Chinese cities, that is, over-reliance on cars and lack of large-capacity public transportation when planning NUAs. The government pays too much attention to the grand road network structure but neglects improving the road network density, and also emphasizes motor vehicle orientation, whilst neglecting pedestrian and non-motor vehicle traffic planning. The pursuit of large-scale and fast-paced construction eventually led to spatial imbalance in Lingui, such as low road density and poor road accessibility, which further reduced the accessibility of preschool education facilities.

5.3. Countermeasures

5.3.1. Increase the Supply of Affordable Preschool Education Facilities and Promote the Development of "Integrated Nursery and Preschool Education"

"Child participation right" is one of the four basic rights granted to children in the Convention on the Rights of the Child. After the 1970s, with the development of the children's liberation movement, the view that "children can participate in social and political life as independent individuals" gradually became mainstream. The concept of children's participation has been paid increasing attention in the fields of children's education, urban healthy environment, and social governance. The United Nations International Children's Emergency Fund (UNICEF) proposed "child-friendly cities" in 1996 [13], aiming to prioritize the interests of children and form a governance system of cities and communities committed to the realization of children's rights. China has also made "persisting in encouraging children's participation" one of the basic principles in the Program for the Development of Chinese Children (2021–2030) [41]. "Child participation" is not only one of the core methods of child-friendly city construction but also an important part of child-friendly community construction. On the one hand, as the main space of children's daily activities, it is of great significance to strengthen children's participation in planning and decision-making in community construction. On the other hand, due to children's

vulnerability, age, ability, and other factors, children's right to participate has not really changed from a "legal right" to an "actual right". Therefore, it is feasible and necessary to take a child-friendly community as the carrier to realize children's real participation in community planning and other public affairs.

In view of the current shortage of preschool education facilities in Lingui and the lack of policy benefits, the Municipal Education Bureau and relevant government departments should strengthen the financial investment and policy support for the development of nursery service institutions. For example, according to the working hours and income status of the family, various types of childcare services such as day care, hourly childcare, half-day childcare, and full-day childcare should be provided. In addition, the construction of an "integrated nursery and preschool education" system should be promoted, and kindergartens with good conditions should be encouraged to set up affordable nursery classes, so as to alleviate the current short supply of nursery care for infants [21,22].

5.3.2. Improve Supporting Facilities and Optimize the Standard of Kindergarten Service Radius

With the continuous improvement of urban transportation service facilities, the travel mode of residents has also changed with urbanization development. The current "Standard", such as the "Kindergarten Construction Standard" (Construction Standard 175-2016) [42], jointly issued by the Ministry of Education and the Ministry of Housing and Urban-Rural Development of China, indicates 300~500 m as the service radius of kindergartens. However, in China's rapid urban development, this figure is slightly outdated. Therefore, through quantitative analysis in this study, it is suggested that the service radius of kindergartens should be appropriately extended to about 1000 m to adapt to the latest urban development in this area of China.

5.3.3. Improve the Accessibility of Kindergartens and Build a Continuous and Safe Home-School Travel Path

The accessibility of kindergartens is affected by many factors such as the family location, transportation conditions, and economic status of residents. Through this study, it is suggested to properly open urban community roads, weaken the internal closure and/or physical blocks, and therefore improve the urban traffic-carrying capacity and road accessibility. In addition, in terms of the construction of a home-school travel paths, a road traffic system suitable for children's travel and commuting should be designed and constructed, and a safe and continuous home-school travel path should be constructed to provide a safe slow space for children. At the same time, special and interesting home-school travel path guiding signs are installed to promote the building of various public spaces and facilities along the home-school travel path to form child-friendly open spaces.

5.3.4. Optimize the Spatial Layout of Preschool Education and Promote Child-Friendly Construction

The government should strengthen the connection between preschool education and residential areas and balance the allocation of preschool education resources between regions [35,43]. At the same time, the site selection of preschool education should also emphasize the participation of children; introduce the "children impact assessment mechanism" in the entire process of site selection, planning, construction implementation, environmental assessment, regulation, teaching quality feedback, and other aspects; carry out regular surveys of children and their families' perception of the friendliness of preschool education construction and their needs; collect opinions of children and their families; and constantly improve the construction of child-friendly spaces and improve the quality of preschool education.

6. Conclusions

Children's participation is one of the core working methods of building a hild-friendly city, and its mechanism can help to promote public participation and protect children's

rights and interests. This research takes the Lingui New District of Guilin City, an NUA, as the research object, and analyzes the spatial layout of preschool education facilities within the urban area by using the spatial data employed from POI data, supplemented by the analysis methods of yaanp, GIS, and GeoDA Bivariate Moran index, and other multi-source data; the research concludes that the spatial distribution of preschool education facilities in Lingui fails to meet the needs of residents for preschool education facilities, and the problems of "difficult and expensive access to kindergartens" are reflected. Admittedly, there are many factors affecting the spatial layout of preschool education facilities, including population, economy, environment, and other aspects. In future studies, more diversified optimization approaches can be proposed for the optimization of the layout of preschool education facilities by further combining traffic planning, urban economic level, and cultural environment factors.

Preschool education is the starting point of lifelong learning. At present, the contradiction between supply and demand of preschool education facilities is more prominent in NUAs than in old towns. From the perspective of NUA development, this paper takes Lingui in West China as the research case study, and employs multiple data source analysis methods to deeply study the spatial distribution characteristics of preschool education facilities, and finds that there are problems such as uneven distribution of quantity and quality between regions, low service coverage and poor accessibility of preschool education facilities. The reasons are concluded to be closely related to the industry-driven model, spatial functional structure, policy orientation, and transportation planning under the background of NUA development. Therefore, it is suggested to promote the efficiency and fairness of preschool education by following the nature of urban development, formulating flexible plans, increasing the diversified supply of childcare services, and improving the accessibility of roads, in order to provide references for the adjustment of preschool education facilities and sustainable development of NUAs. In-depth research on the spatial distribution of preschool education facilities in NUAs and countermeasures can provide a reference for high-quality development of preschool education in similar new urban areas of Western China, and other developing countries worldwide.

There are some limitations in this study indeed, such as insufficient sample size and narrow geographical focus. However, with the recent decline in birth rates in China [40], there is increased uncertainty in spatial planning for preschool education facilities. Future research should focus on strengthening the sustainable planning and management of preschool education facilities on a broader geographical scale.

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