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Spatial Distribution Pattern of the Catering Industry in A Tourist City: Taking Lhasa City as A Case

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Abstract: Affected by factors such as the city's functional orientation and tourism consumption, the spatial layout of the catering industry in a tourism city has its own distinctive characteristics. The spatial distribution characteristics of the catering industry and the factors impacting it (from the perspectives of transportation, tourism resources and population) in the main city area of Lhasa, Tibet were analysed through point of interest data mining, average nearest neighbour analysis, a standard deviational ellipse, kernel density estimation, and buffer analysis in ArcGIS software. As a result, the spatial distribution pattern showed catering providers are mainly aggregated in the vicinity of areas with either developed transportation or rich tourism resources. The resident population has an important but inconclusive influence on the distribution, while the distribution of its concentration is highly consistent with that of the instant population. Considering the spatial structure, functional orientation, and tourism development of the area, measures are proposed for optimizing the spatial layout of the catering industry in this tourism-heavy plateau city.

Key words: catering industry; spatial distribution; tourism city; POI; Lhasa

1 Introduction

Catering consumption is a basic consumer demand that is very close to people's livelihoods (Dong, 2008). With the improvement of residents' living standards and the expansion of China's floating population, catering consumption has gradually increased as a popular lifestyle for China's residents; and, as a result, the catering industry has become one of the fastest growing industries in the country since the opening up of China (Yu, 2019). Even in the industry's deep adjustment period, the national catering turnover in 2017 still reached 531.28 billion Yuan (National Bureau of Statistics, 2017). Particularly in tourism-heavy cities, in which the overarching tourism industry plays a leading role in urban development, the catering industry is a dominant part of the urban industrial structure (Yang, 2008). The tourism industry's catalytic effects not only drive the development of related industries but also influence the directional development, as well as the functional orientation of the city (Yang, 2008). Notably, the distinctiveness of a tourism city's function and its industrial structure determines the development of the catering industry. The spatial layout of tourism cities is significantly different than that of non-tourism cities: and the spatial layout of the catering industry in a tourism city not only affects the lifestyle of the local residents, but also impacts the tour routes and organization of tourism activities. Additionally, factors such as resident gatherings, and the occurrence of tourism activities, in turn, impact the spa-

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tial layout of the catering industry. Therefore, the quantitative analysis of the catering industry's layout characteristics and the factors influencing the catering industry in tourism-heavy cities not only contribute to the healthy development of the catering industry itself, but they also integrally impact the optimization of the city's spatial function.

The geospatial organization of economic activities is a core element of economic geography research (Liu, 2006). As an integral economic aspect of a city, the spatial layout and optimized organization of the catering industry has recently become a primary research topic of economic geography (Fang, 2014; Yang et al., 2016; Li et al., 2018; Xia et al., 2018). As early as the 1980s, international scholars have studied the spatial layout of the catering industry from the perspective of tourism (Wall et al., 1985; Ritter, 1986). At first, research objects were primarily concentrated in urban hotels. For example, Wall et al. (1985) analysed the spatial distribution of accommodations in Toronto by point pattern analysis. Urtasun and Gutierrez (2006) studied the location, price, size and services of 240 hotels in the tourism cities of Madrid from 1936 to 1998 by establishing a geographic and location model. Schiff (2015) measured urban diversity with a set of data involving more than 127000 restaurants from 726 cities in the United States, and explored the impacts of population size and population density on urban catering diversity.

However, related investigations in China have only begun more recently. Research content mainly focuses on the spatial distribution characteristics of the catering industry and the factors which influence its spatial layout. Studies on spatial distribution characteristics primarily consider the spatial pattern of the catering industry in a single geographical unit and the spatial distribution of a single catering business (Zhang, 2016). There are both national and urban scales on which spatial distribution characteristics can be considered (Liu, 2014; Zhang, 2016; Xia et al., 2018), including macro-scale (e.g. economic culture), meso-scale (e.g. traffic and road), and micro-scale (e.g. consumer) (Qin et al., 2019) perspectives. Notably, for research on spatial distribution characteristics on an urban scale, first-tier cities such as Beijing, Shanghai, Nanjing, Changsha, Xi'an, Chengdu, Guangzhou, Wuhan, and Xiamen are areas of particular research interest (Liang, 2007; Shu et al., 2012; Fang, 2014; Qin et al., 2014; Tan et al., 2016; Wu, 2016; Xu,2016; Cheng, 2017; Zeng et al., 2018; Qin et al., 2019; Zhang and Li, 2019). Regarding the spatial distribution of individual catering businesses, not only are the distribution patterns of Chinese old-fashioned catering brands, snack bars, and Chinese traditional restaurants to be considered, but also the distribution characteristics of foreign catering institutions, such as KFC and McDonald's (Tao et al., 2011; Wang,2013; Fang, 2014; Zhou et al., 2015; Lei, 2016; Jin et al., 2018).

Studies have shown that the spatial layout of the catering industry is affected by macro-factors (e.g. regional policy systems, economy, and culture), meso-factors (e.g. traffic convenience and distribution of tourism resources), and micro-factors (e.g. population density and distribution and consumer behaviour), among others (Hu and Zhang, 2002; Liang, 2007; Zhou et al., 2008; Zheng, 2009; Yang et al., 2012; Guo et al., 2014; Zhang, 2014; Tao et al., 2015; Tan et al., 2016; Xu, 2016). First, roads are essential to all urban development, facilitating the flow of people, logistics, and traffic in the city. Studies have indicated that the road network is an important factor affecting the layout of the hotel industry, with a certain shaping effect on city-specific functional space (Hu and Zhang, 2002; Tao et al., 2015). Second, the spatial distribution of tourism resources has an important impact on the spatial layout of the catering industry. Yang et al. (2012) found, according to an ordered logit model, that the impact of high-quality tourism attractions on the location of hotels is significant in Beijing. Hu and Zhang (2002) found that hotels in Nanjing are moderately concentrated in famous scenic spots. Additionally, the catering industry has a strong dependence on population density. In theory, densely populated areas are places with a large number of catering providers; thus, the resident population is also an important factor affecting the layout of the catering industry (Xu, 2016).

Analytical methods commonly used for investigating the spatial layout of the catering industry include several spatial analysis methods, such as kernel density analysis, the standard deviational ellipse, and buffer analysis (Qin et al., 2014; Tao et al., 2015; Tang et al., 2017; Xia et al., 2018; Zhang and Li, 2019). Research on impact factor analysis of spatial layout has used methods such as correlation analysis, regression analysis, comparative analysis, and comprehensive evaluations (Liang, 2007; Tan et al., 2016; Xia et al., 2018; Zeng et al., 2018). For example, by using the evaluation data of catering providers in Nanjing (Nanjing Station) from Dianping.com, Qin et al. (2014) calculated comprehensive word-of-mouth scores and rankings of various catering providers by establishing a word-of-mouth evaluation index system; while kernel density analysis and a comprehensive evaluation of the spatial distribution pattern of the urban catering industry were also conducted. The data used to study the spatial layout of the catering industry includes both macro-statistics and micro-investigation data (Liang, 2007; Tao et al., 2011; Fang, 2014). For example, Ren (2012) studied the spatial layout of dining districts in China via a field-survey. Based on the behaviourist perspective, Fang (2014) systematically analysed the commercial space layout characteristics and aggregation mechanism of the Korean catering industry in the Wudaokou area of Beijing through field interviews with Korean restaurants, Korean food operators, and Korean food consumers. However, such data have the disadvantages of high acquisition costs and small sample sizes.

With the rapid development of big data technology, new geographic data sources are constantly being explored, such as point of interest (POI) data, mobile phone signalling data,

GPS user behaviour tracking data, and evaluation data on the Internet (e.g. Dianping.com) (Qin et al., 2014; Xia et al., 2018). Based on such data, many researchers have conducted studies on the spatial distribution of urban commercial facilities (Zhou et al., 2014; Wang et al., 2015; Chen et al., 2016; Tan et al., 2016; Hao et al., 2018; Zhang, 2018). For example, Chen et al. (2016) identified the distribution characteristics of different commercial formats in Guangzhou, and explored the commercial space structure based on POI data. Tan et al. (2016) explored the spatial distribution pattern of restaurants in the main city of Beijing with regard to three aspects: spatial distribution, per capita consumption level and internet word-of-mouth. Hao et al. (2018) studied the industrial distribution and agglomeration characteristics of urban commercial spaces through the mining of commercial POI data in the downtown area of Changchun. As an emerging form of big data, POI data has the advantages over statistical data and first-hand survey data of both large available amounts and high precision. However, the current research objectives of studies using POI data largely take aim at business activities, such as focusing on the catering industry in non-highland areas. Research on the spatial distribution pattern of the catering industry in a tourism city on the plateau based on POI data is lacking.

Therefore, this paper uses Lhasa, Tibet to study the spatial layout structure and characteristics of the catering industry in a tourism-heavy city on the plateau. For this analysis, POI data is mined for catering providers and scenic spots. In addition, the interaction mechanisms between the catering industries and the tourism industries, regarding the layout and development of each in this tourism-heavy city, are analysed with regard to three aspects: traffic distribution, tourism resource distribution and population distribution. Ultimately, this study aims to provide a scientific basis to guide and promote the spatial structure optimization of the tourism industry's development, as well as the healthy development of tourism.

2 Materials and methods

2.1 Study area

Lhasa is in an important geographical location that is rich with tourism resources. First, the city is the capital of the Tibet Autonomous Region. The city is located in the hinterland of the Qinghai-Tibet Plateau, in the southeast of the Tibet Autonomous Region, on the northern bank of the Lhasa River, and a tributary of the Yarlung Zangbo River. It has geographical coordinates of 91°06′ E, 29°36′ N, with an average elevation of more than 3650 m. Second, the registered population in Lhasa was 688300 by the end of 2017 (Tibet Autonomous Region Statistics Bureau and Survey Office of the Bureau of Statistics in Tibet Autonomous Region, 2018). The tertiary industry in the area had a total reported production value of 27.23 billion Yuan, accounting for 56.82% of the regional GDP (Tibet Autonomous Region Statistics Bureau and Survey Office of the Bureau of Statistics in Tibet Autonomous Region, 2018).

Finally, Lhasa is an international tourism city with prominent characteristics regarding its religious and uniquely Tibetan customs. Recently, tourism has become one of the leading industries in the area, and Lhasa received more than 19.9 million domestic and foreign tourists in 2018, which was an increase of 24.38% from 2017 (Tibet Daily, 2017; Long, 2018). This activity generated a total annual tourism revenue that reached 28.88 billion Yuan in 2018, accounting for 53.40% of the GDP (54.08 billion Yuan) (Long, 2018; China Daily, 2019). The recent development of the tourism industry has driven the rapid growth of the catering industry: the retail sales of the catering industry in Lhasa reached 2.96 billion Yuan, with a year-on-year increasing rate of 16% in 2016 (Lhasa Municipal People's Government, 2017); and the catering industry's revenue alone, in the first seven months of 2018, was 3.003 billion Yuan, representing an increase of 14.1% from 2017 (Lhasa Municipal People's Government, 2018). Accordingly, the geographical location and recent increases in tourism have contributed to the unique development and layout of the catering industry in Lhasa.

This study focuses on the main city area of Lhasa because most restaurants in Lhasa are concentrated in the main city area where famous scenic spots like Potala Palace and Jokhang Temple are located. This administrative division includes towns or townships in the Chengguan District and part of the Doilungdêqên District, which feature the main streets, scenic spots and catering providers in the main city area of Lhasa (Fig. 1).

2.2 Data sources and classification

Data on the catering providers (e.g. hotels, restaurants, cafes, etc.), scenic spots, roads and resident populations (e.g. resident population and instant population) were included in this study. The data on catering providers was comprised of POI data collected from Gaode Map in February 2019; the road data was from the Gaode Map Road network; the population data was from the National Sixth Census data in China (Population Census Office under the State Council of China and National Bureau of Statistics of China, 2012) and the instant population data was from Baidu map (May 11, 2019, 13:50). Data for 7244 catering providers and 137 scenic spots were obtained after deduplication and correction processing. Further segmentation of scenic spots was then conducted by grouping them into: (i) six quality degrees: A, 2A, 3A, 4A, 5A and NON A (noting that according to attractions" (tourist of quality for rating of "Standard GBT 17775-2003) of China, the quality level of China's tourist attractions is divided into five levels, from high to low, AAAAA, AAAA, AAA, AA, A-level tourist attractions) (National Tourism Bureau, 2003); and (ii) 13 categories by type, based on the information of Gaode Map: temples and

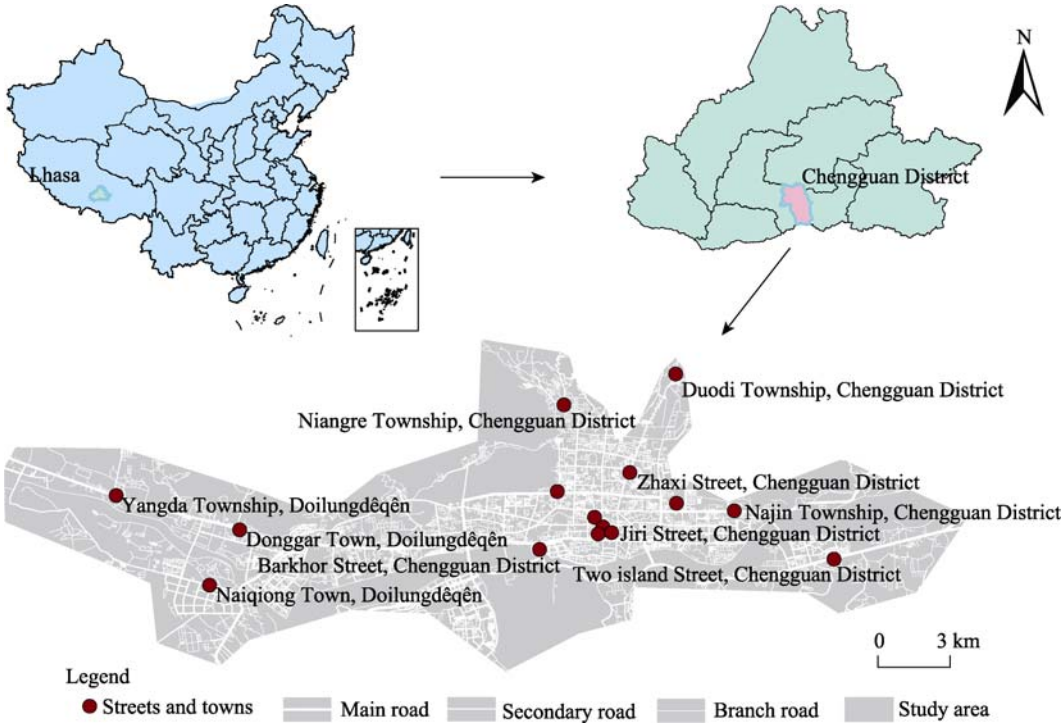

Fig. 1 Location of study area

Taoist temples, gardens, nature reserves, memorial halls, parks, leisure squares, museums, hill-type tourist destinations, local customs and folk etiquette, bridges, medical institutions, shopping venues and industrial parks. Catering providers were classified into 10 categories, also based on the information of Gaode Map: hotels, tea houses, pastry shops (including dessert shops), cafes, Chinese fast food restaurants, Western fast food restaurants, beverage shops (including cold drink shops), snack bars, Chinese restaurants (non-fast food) and Western restaurants (non-fast food). Additionally, all roads were divided into three levels: main roads (35–45 m), secondary roads (30–40 m) and branch roads (15–20 m), based on the "Code for transport planning on urban road (GB 5020-95)" in China (Ministry of Construction National Technical Supervision Bureau, 1995). The locations of all studied catering providers, scenic spots and roads are shown in Fig. 2a.

2.3 Study methods

Based on ArcGIS 10.2 software, this study investigates the overall spatial distribution mode of catering providers in Lhasa through average nearest neighbor analysis (ANNA) and the standard deviational ellipse (SDE). The space agglomeration feature of catering providers is also considered with kernel density estimation (KDE). The main factors affecting the spatial layout structure of the catering industry are also investigated with a buffer analysis with regard to traffic, tourism resources and resident population.

2.3.1 Average Nearest Neighbor Analysis

ANNA is commonly used to analyse the distribution patterns of features in space. The average nearest neighbor ratio (*ANNR*) is an index that reflects the degree of proximity between elements in space (Yang et al., 2012). *ANNR* is calculated as follows:

$$ANNR = \frac{\bar{D}_1}{\bar{D}_2} \tag{1}$$

where $\bar{D}_1$ is the observed mean distance between each feature and its nearest neighbor, and $\bar{D}_2$ is the expected mean distance between specified features in a random mode; and the observed and expected mean distances are calculated by Eq. (2) and Eq. (3), respectively:

$$\bar{D}_1 = \frac{\sum_{i=1}^{n} d_i}{n} \tag{2}$$

$$\bar{D}_2 = \frac{0.5}{\sqrt{n/S}} \tag{3}$$

where, d_i is the distance between the feature and its nearest neighbor, n is the total number of elements and S is the area of the smallest circumscribed rectangle that can include all elements or the specified "area" value.

In addition, the formula for the average nearest neighbor z-score is:

$$z = \frac{\bar{D}_1}{N} - \frac{\bar{D}_2}{N} \tag{4}$$

where N is the overall standard deviation calculated as:

$$N = \frac{0.26136}{\sqrt{n^2 / S}} \tag{5}$$

ANNA was used here to study the distribution pattern of catering providers in Lhasa. When the *ANNR* is equal to 1, the distribution mode is in a random state; when it is less than 1, the distribution mode is in a clustering state; when it is greater than 1, the distribution pattern is considered discrete or competitive.

2.3.2 Standard Deviational Ellipse

SDE is a method commonly used to measure the distribution trend of a set of points or regions. It was proposed by D. Welty Lefever, a sociology professor at the University of Southern California in 1926, and is also called Lefever's "Standard Deviational Ellipse" (Lan et al., 2018). With it, the distribution characteristics of elements and the distribution differences between different categories can be analysed from the elliptical centre, the distribution range and the direction and shape of the ellipse. The distribution centre of elements can be expressed by the centre of the standard deviation ellipse. The azimuth and the standard deviation ratios of the short and long axes reflect the main trend and shape of the distribution of the elements (Xin and Bu, 2018). The formula of the SDE can be expressed as follows (Esri, 2018):

$$SDE_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{X})^2}{n}} \quad \text{and} \quad SDE_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \overline{Y})^2}{n}} \tag{6}$$

where x_i and y_i are the coordinates of element i; $\{\overline{X}, \overline{Y}\}$ denotes the mean centre of the element; and n is the total number of elements. The calculation of the rotation angle is:

$\tan\theta = \frac{A+B}{C}$, where

$$A = \left(\sum_{i=1}^{n}\tilde{x}_i^2 - \sum_{i=1}^{n}\tilde{y}_i^2\right)$$

$$B = \sqrt{\left(\sum_{i=1}^{n}\tilde{x}_i^2 - \sum_{i=1}^{n}\tilde{y}_i^2\right)^2 + 4\left(\sum_{i=1}^{n}\tilde{x}_i\tilde{y}_i\right)^2}$$

$$C = 2\sum_{i=1}^{n}\tilde{x}_i\tilde{y}_i \tag{7}$$

such that $\tilde{x}_i$ and $\tilde{y}_i$ are the deviations of the coordinate of element i from the mean centre.

The standard deviations of the x-axis and y-axis are calculated as follows, respectively:

$$\sigma_x = \sqrt{\frac{2\sum_{i=1}^{n}\left(\tilde{x}_i\cos\theta - \tilde{y}_i\sin\theta\right)^2}{n}} \quad \text{and}$$

$$\sigma_y = \sqrt{\frac{2\sum_{i=1}^{n}\left(\tilde{x}_i\sin\theta + \tilde{y}_i\cos\theta\right)^2}{n}} \tag{8}$$

The long semi-axis of the ellipse represents the direction of the element distribution, and the short semi-axis represents the range of the element distribution. The larger the difference between the long semi-axis and the short semi-axis (i.e. the larger the flattening ratio), the more obvious the directionality of the element. Conversely, if the long semi-axis and the short semi-axis are more similar, then the directionality is less noticeable.

2.3.3 Kernel Density Estimation

KDE is a density function used to estimate unknowns in probability theory. It is one of the nonparametric test methods. KDE is characterized by the absence of a definite functional form, and density calculations through function parameters using known data points for estimation. KDE is an effective way to visualize spatial point information and it is widely used in research on the spatial distributions of natural resources, human resources and infrastructure (Cai et al., 2013; Guo, 2014; Liu et al., 2016; Tang et al., 2017; Chen et al., 2018). The Rosenblatt-Paren kernel estimate is usually used and it is calculated as follows (Cong et al., 2013):

$$K(x) = \frac{1}{nd}\sum_{i=1}^{n} a\left(\frac{x - X_i}{d}\right) \tag{9}$$

where $a\left(\frac{x - X_i}{d}\right)$ is the kernel function; and d is the bandwidth, such that $d > 0$; $(x\text{-}X_i)$ is the distance from the estimated point to the event point X_i. In this study, the KDE was used to analyse the spatial aggregation feature of catering providers, scenic spots and population in Lhasa. Darker colours in the images of the KDE represent more catering providers and scenic spots, and a higher resident population.

2.3.4 Buffer analysis

Buffer analysis refers to automatically creating a buffer polygon layer within a certain width range based on points, lines, and surface entities, and then superimposing that layer with the target layer to obtain the desired result. Buffer analysis is one of the spatial analysis tools used to solve proximity problems. Here, buffer analysis was used to analyse the impacts of traffic and tourism resources on the spatial distributions of catering providers.

To consider the impact of traffic distribution, the buffer radius of main roads, secondary roads and branch roads were set as 150 m, 100 m, and 50 m, respectively. For the impact of tourism resource distribution, the buffer radius of each attraction was set as 500 m and then 1000 m, while the buffer radius of each scenic spot above the 2A-level was set as 1000 m and then 2000 m. After obtaining the buffer range of a road/scenic spot, the catering providers in the area were intersected with the buffer ranges of different grades (Intersect),

generating distribution maps of catering providers within different road/scenic spot buffer zones.

Before performing calculations of the SDE, ANNA, and KDE, and the buffer analysis, all POI data in the study area were projected and coordinated. The projection coordinates were defined as WGS_1984_UTM_Zone_46N to ensure data consistency based on the location of Lhasa. For the population heat map, reclassification (heat value: 1-7) (Wang, 2018) was conducted according to the natural discontinuity method based on the heat values. The greater the heat value, the denser the instant population that gathers, and vice versa.

3 Results

3.1 Spatial distribution characteristics of the catering industry in Lhasa

3.1.1 Overall distribution characteristics

There is a total of 7244 catering providers in the study area. Regarding different cuisine types, more than half of these providers are Chinese restaurants, at 59%, followed by tea houses, at 17%, and then Chinese fast food restaurants, at 8% (Fig. 2b). Local restaurants account for the largest proportion of the catering provider types, at 64%, whereas Sichuan restaurants and Halal restaurants account for 6% and 3%, respectively (Fig. 2c).

3.1.2 Spatial distribution pattern

The distribution of catering providers has a significant aggregation pattern. For all catering providers, the result of ANNA showed that *ANNR*=0.237079 (*ANNR* < 1). For different kinds of catering providers, the agglomeration of Chinese restaurants is the strongest with *ANNR*=0.216627, which is even higher than that of all catering providers, followed by Chinese fast food restaurants (*ANNR*=0.273403) and tea houses (*ANNR*=0.320395). The agglomeration of hotels is the weakest (*ANNR*=0.532431). Among the different cuisines of the catering providers, the local restaurants, Halal restaurants and Sichuan restaurants are all less aggregated than the all catering providers; however, among these three, the relative concentration of local restaurants is more aggregated (*ANNR*=0.239218).

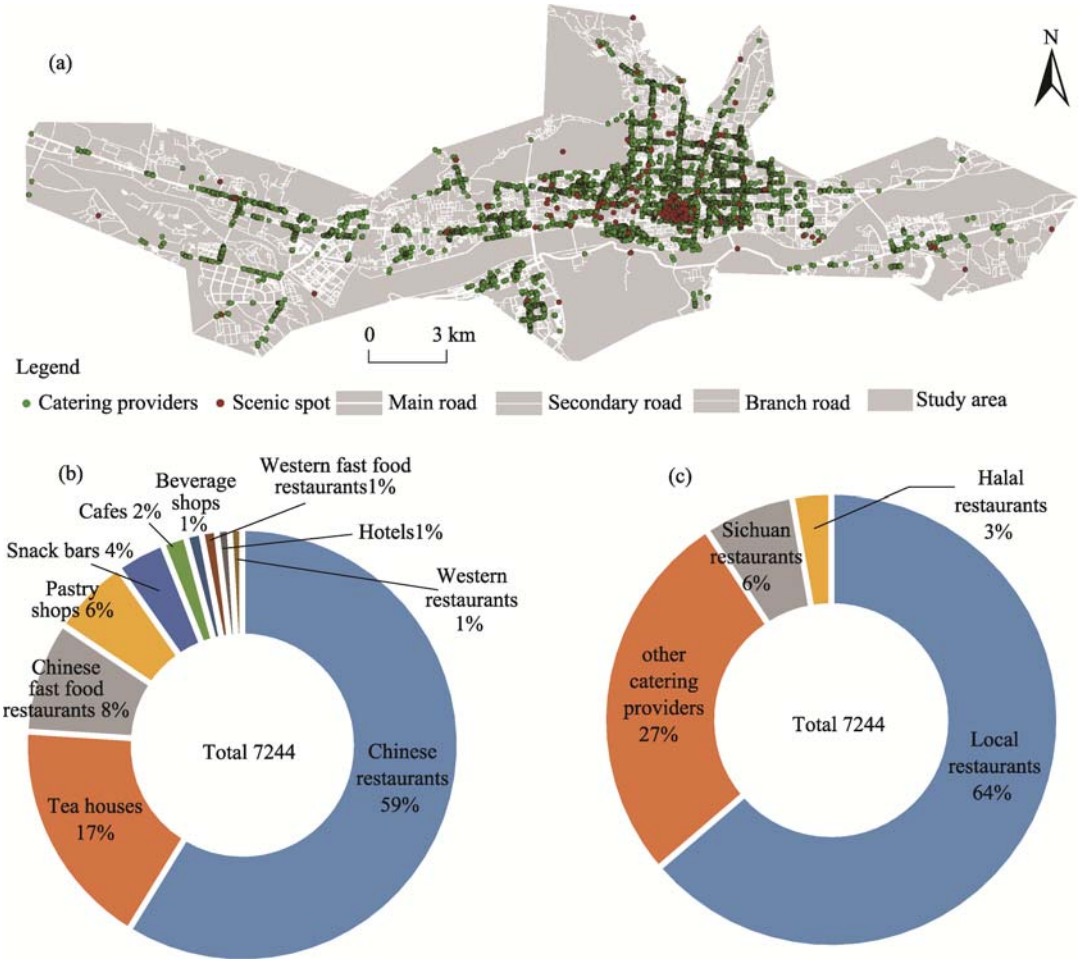

Fig. 2 Distribution of catering providers in the study area

Note: (a) the spatial distribution of catering providers in Lhasa's main city area; (b) the proportions of different kinds of catering providers; and (c) the proportions of the different cuisines of catering providers.

Table 1 Average nearest neighbor analysis results for different kinds of catering providers

	Catering providers	Observed mean distance (m)	Expected mean distance (m)	Nearest neighbour ratio	z-score	*P*-value
	All catering providers	26.8839	113.3963	0.237079	–95.216245	0
Different kinds of catering providers	Chinese restaurant	18.8288	86.9181	0.216627	–127.552406	0
	Chinese fast food restaurant	82.0259	300.0183	0.273403	–34.274909	0
	Tea house	67.0662	209.3236	0.320395	–45.948244	0
	Western restaurant	323.4324	903.7787	0.357867	–10.055262	0
	Pastry shop	139.0467	358.8435	0.387486	–24.156927	0
	Snack bar	186.8654	451.0486	0.414291	–18.377602	0
	Beverage shop	355.9832	802.3984	0.443649	–9.812716	0
	Cafe	293.8510	646.3442	0.454635	–11.941351	0
	Western fast food restaurant	385.0135	816.9446	0.471285	–9.159245	0
	Hotel	467.4488	877.9511	0.532431	–7.537118	0
Different cuisines of catering provides	Local restaurant	26.0471	108.8846	0.239218	–98.883560	0
	Other catering providers	50.1552	167.1834	0.300001	–59.256315	0
	Halal restaurant	213.3069	520.5037	0.409809	–16.047207	0
	Sichuan restaurant	153.8062	341.9610	0.449777	–22.771546	0

The distributions of various catering providers are similar, generally extending in the "east-west" direction (Fig. 3); this is consistent with the distribution direction of the administrative area and the road network, reflecting the impact of the urban road structure on the location of catering providers. The long axis of the standard deviation ellipse for all kinds of catering providers and all cuisine types among catering providers is significantly longer than that of the short axis, suggesting that the distribution direction of the catering providers is obvious. For different kinds of catering providers, the directional tendency pertaining to hotels is most prominent, i.e. its long axis is the longest among the long axes among all the SDEs, followed by pastry shops and then Chinese restaurants (Fig. 3a). For different cuisine types, the directional tendency of Halal restaurants is the most prominent, followed by Sichuan restaurants and then local restaurants (Fig. 3b). The distribution centres of Halal restaurants, Sichuan restaurants, local restaurants and other catering providers are located on the west side of Norbulingka, near the Shangri-La Hotel in Lhasa, and on the west and north sides of Potala Palace, respectively.

3.1.3 Spatial agglomeration feature

The results of the KDE for catering providers indicate that:

(1) Chinese fast food restaurants are mainly concentrated in Chengguan District, in multiple groups (Fig. 4a); they are mainly concentrated in the vicinity of the Jokhang Temple, Sun Island, Tianhai Commercial Circle, Niangjiao Road and the intersection of Dangxi Road and Zaki Temple. Most of

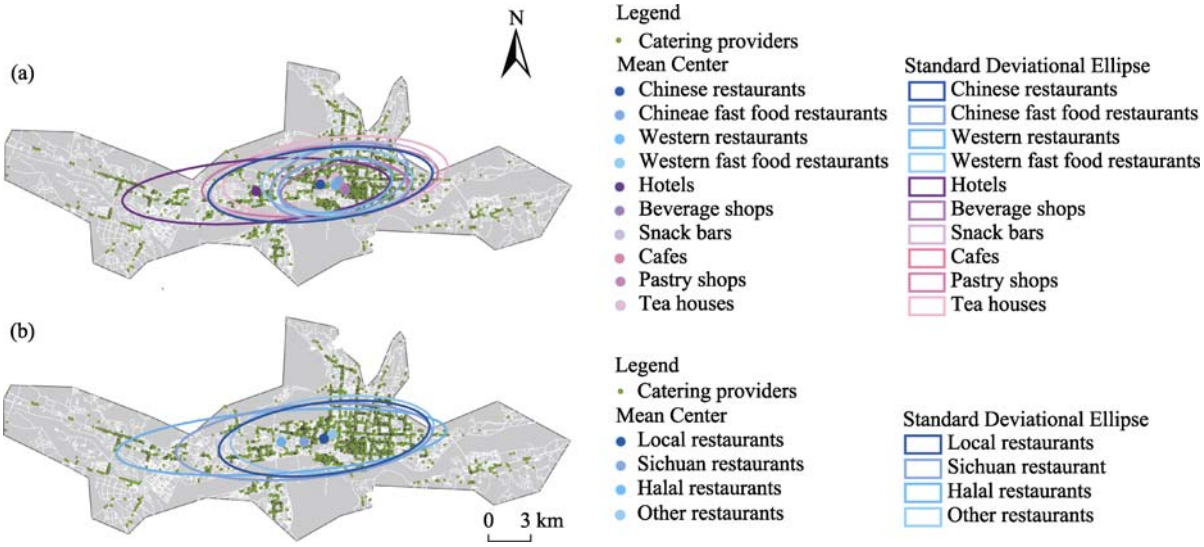

Fig. 3 Standard deviational ellipse of catering providers for (a) different kinds of catering providers and (b) different cuisine types provided by the various kinds of catering providers

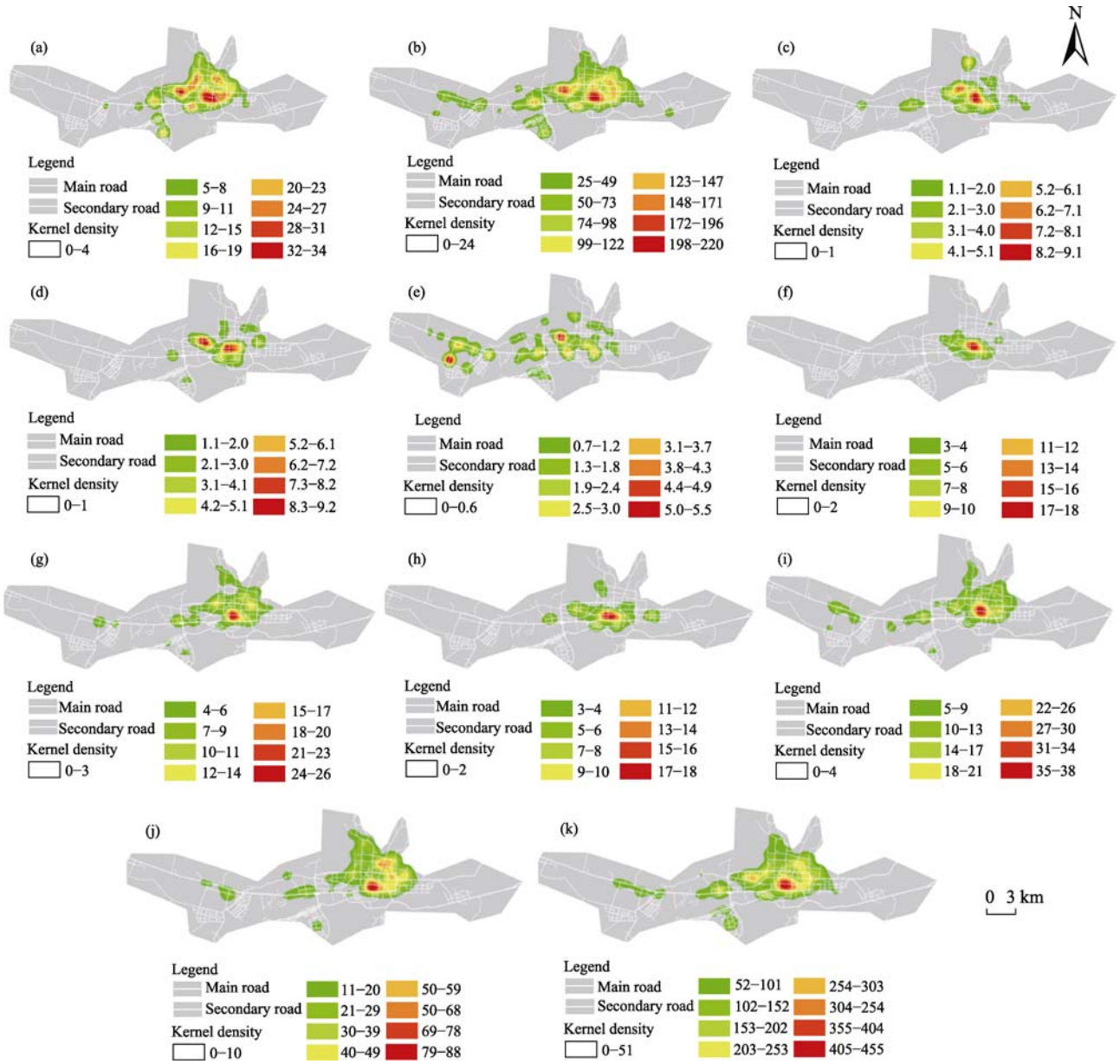

Fig. 4 Kernel density estimation of different kinds of catering providers: (a) Chinese fast food restaurants; (b) Chinese restaurants; (c) Western fast food restaurants; (d) Western restaurants; (e) hotels; (f) beverage shops; (g) snack bars; (h) cafes; (i) pastry shops; (j) tea houses and (k) all catering providers combined.

them are concentrated in the Old City of Lhasa. There is also a central distribution on the edge of the city.

(2) Chinese restaurants have a wider spatial distribution than Chinese fast food restaurants. Furthermore, the Chinese restaurant centre has a higher concentration value than that of any other restaurant types, which is also the highest of all kinds of catering providers (Fig. 4b). However, the concentration centre is not as compact as that of Chinese fast food restaurants. Chinese restaurants in the Jokhang Temple, Sun Island, Tianhai Commercial Circle and Zaki Temple areas have strong agglomeration effects. Notably, along Jinzhu Road, some gathering centres have a beaded distribution with a continuous circle along Jinzhu Road, which is a spatial distribution feature that Chinese fast food restaurants do not have.

(3) Western fast food restaurants and Western restaurants have a smaller spatial distribution and are concentrated in fewer areas (Figs. 4c–4d). For example, Western fast food restaurants are concentrated at Jokhang Temple, at the intersection of Niang Hot Road and Dangxi Road and in the vicinity of Lhasa Teachers College. Western restaurants are concentrated at Jokhang Temple and in the Tianhai Business District. In general, Western fast food restaurants and Western restaurants are far less distributed and less concentrated than either Chinese fast food restaurants or Chinese restaurants.

(4) Hotels are more scattered in their spatial distribution and are mostly distributed outside the core area of Lhasa (Fig. 4e). The spatial characteristics of the bead-like distribution along the main road are more obvious. Beverage shops and cafes are mainly distributed in a single-centre structure, which is mainly concentrated near the Jokhang Temple (Fig. 4f, Fig. 4h). Snack bars, pastry shops and tea houses are still distributed around the Jokhang Temple, but their gathering centres have moved eastward, and the distribution ranges have expanded (Fig. 4g, Fig. 4i, Fig. 4j).

(5) The overall distribution characteristics of all catering providers overlap with the sub-types of catering providers in the spatial agglomeration area (Fig. 4k). The gathering effect of the catering providers in the Jokhang Temple and Tianhai Commercial Circle is the strongest in the urban area. There are also some concentration centres in Chengguan District scattered along roads and intersections.

Regarding cuisine types, the local restaurant cuisine type is the most widely distributed in its spatial distribution. It is concentrated in the centre of the Chengguan District (Jokhang Temple area), wherein the centre has the highest concentration, which is far more than those of the other cuisine types (Fig. 5a). In contrast, the gathering centre of Sichuan restaurants is offset from the centre of local restaurants, does not occupy the core location of the main city area, and has a prominent expansion trend along the road (Jinzhu Road) (Fig. 5b). The Halal restaurant cuisine type is centred at the Jokhang Temple, Dangzhong Road, and the Dulong Deqing District Government. In the area between Chengguan District and Dulong Deqing District, there are a few gathering centres of Halal restaurants at road intersections (Fig. 5c). In general, the concentrations of Halal restaurants and Sichuan restaurants are not as high as that of Local restaurants. Catering provider cuisine types other than local, Sichuan, or Halal formed a singular distribution feature with the Jokhangsi area as the centre (Fig. 5d).

3.2 Impact factors of the catering industry's spatial distribution

3.2.1 Traffic distribution

The spatial layout of the catering industry in Lhasa is largely influenced by the convenience of transportation. The catering providers are mainly distributed on both sides of the road or at the intersections of roads, reflecting the road network's influence in spatially shaping the catering industry (Fig. 6). The distribution of catering providers within 150 m of the main road reflects the feature of distribution on both sides of the road more clearly: at this distance, the distribution of catering providers is closer to the sides of the road. Secondary roads are more transitive than main roads; the speed of vehicles on secondary roads is slower, and thus, they are more friendly to pedestrians. Secondary roads fill the areas that the main road cannot reach and constitute the most concentrated areas of catering providers. Branch roads are the most dynamic areas, and have a weaker isolation effect on pedestrians and commercial activities, with better passability. On branch roads, consumers are also more random in their process of selecting dining places. Therefore, catering providers within the buffer zones of branch roads are more clustered (showing a closer distance in the space), covering the outside areas that are not affected by main and secondary roads.

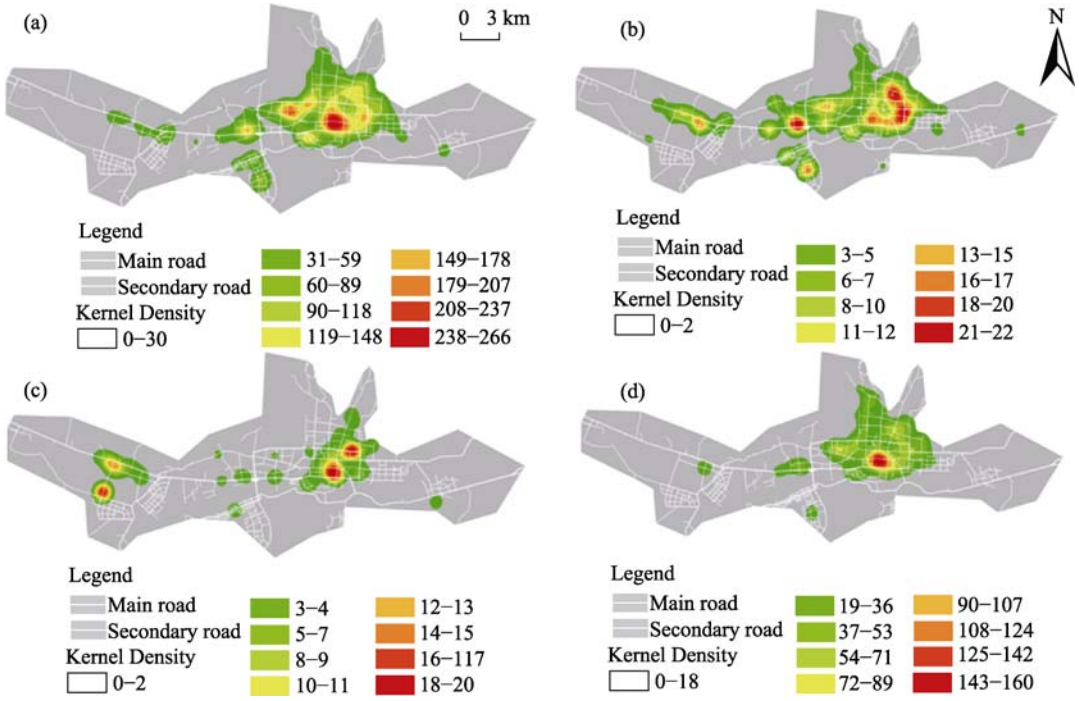

Fig. 5 Kernel density estimation of catering providers' different cuisines types: (a) local; (b) Sichuan; (c) Halal and (d) all others.

In terms of quantity, the number of catering providers within the secondary road buffer is the largest (Table 2). The number of catering providers within the main road buffer, the secondary road buffer and the branch road buffer accounted for 24.41%, 79.20% and 75.12% of all catering providers, respectively.

3.2.2 Tourism resource distribution

The results of the kernel density analysis show that the scenic spots are most concentrated near the Jokhang Temple, followed by Potala Palace (Fig.7a). Among the 13 types of scenic spots, the numbers of temples and Taoist temples combined are the largest, accounting for 37.23% of scenic spots, followed by parks at 18.25% and local customs and folk etiquette at 16.79% (Fig.7b).

Table 2 Catering provider quantities in buffer areas of different levels of roads and their proportions within the total number of catering providers.

Buffer area	Number of catering providers	Proportion (%)
150 m range buffer of main road	1768	24.41
100 m range buffer of secondary road	5737	79.20
50 m range buffer of branch road	5442	75.12

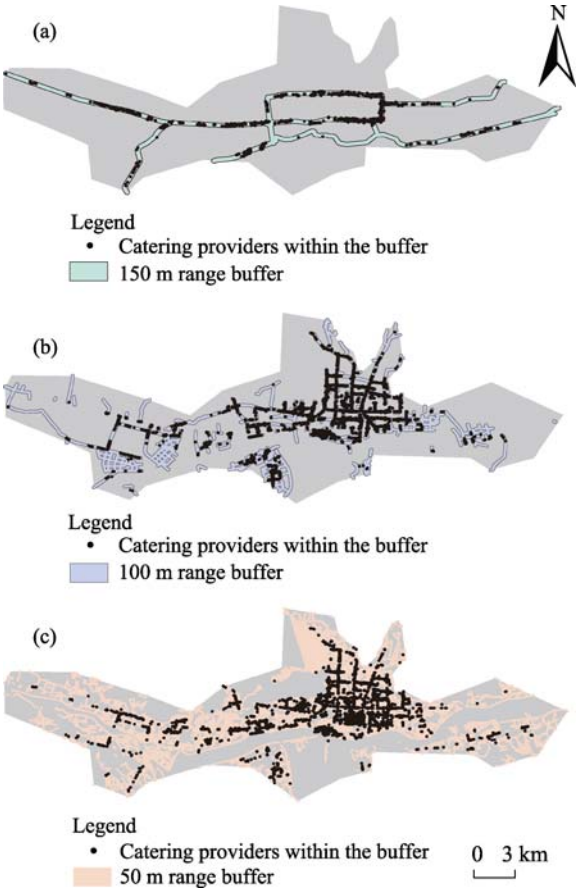

Fig. 6 Buffer analysis for different kinds of roads: (a) main roads; (b) secondary roads and (c) branch roads.

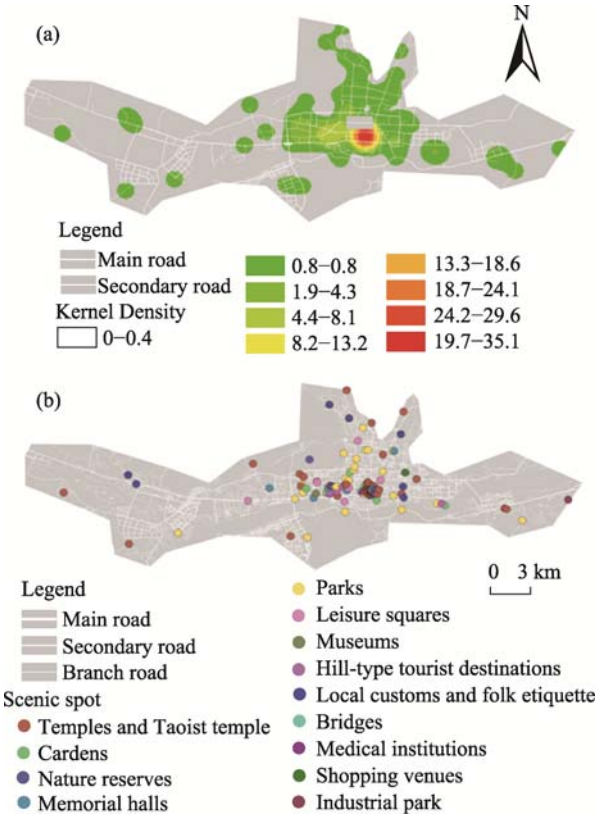

Fig. 7 (a) Kernel density estimation of scenic spots and (b) the spatial distribution of different kinds of scenic spots

The results of the buffer analysis of scenic spots indicate that 54.67% of catering providers are within the 500 m buffer zone of a scenic spot, and 85.59% of catering providers are within the 1000 m buffer zone of a scenic spot, indicating that the spatial layout of the catering industry has a strong dependence on tourism resources. Among catering providers, 20.83% are located within the 1000 m buffer zone of the scenic spots above 2A-level, and 49.12% are within the 2000 m buffer zone, indicating that the high- level scenic spots integrally impact the spatial layout of the catering industry (Table 3, Fig. 8).

3.2.3 Population distribution

The distributions of permanent residents and the catering industry are somewhat related (Fig. 9). For example, in the Jokhang Temple-Barkhor Street area (Bajiao Street), Niangjiao Township, Gongdelin Street and Karma Gonsu Street area, the more permanent residents there are, the more

Table 3 Catering provider distribution within varying buffer ranges of the scenic spots.

Buffer range	Number of catering providers	Proportion (%)
500 m	3960	54.67
1000 m	6196	85.59
Above 2A-level 1000 m	1509	20.83
Above 2A-level 2000 m	3558	49.12

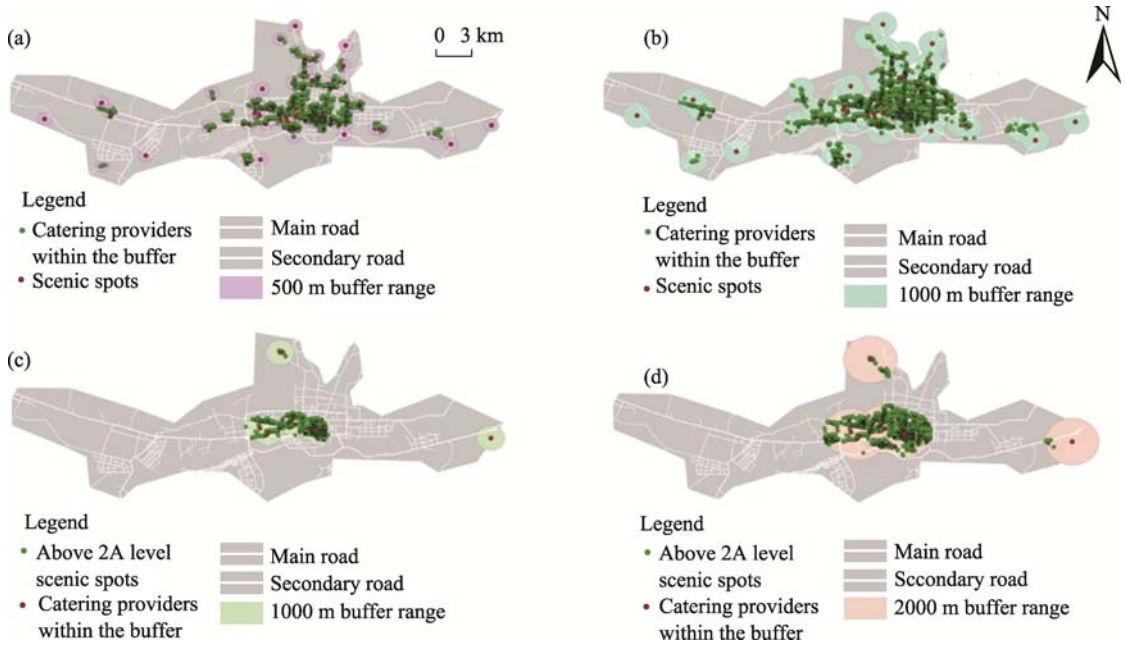

Fig. 8 Buffer analysis of (a) all scenic spots within the 500 m buffer range, (b) all scenic spots within the 1000 m buffer range, (c) 2A level and above scenic spots in the 1000 m buffer range and (d) 2A level and above scenic spots in the 2000 m buffer range.

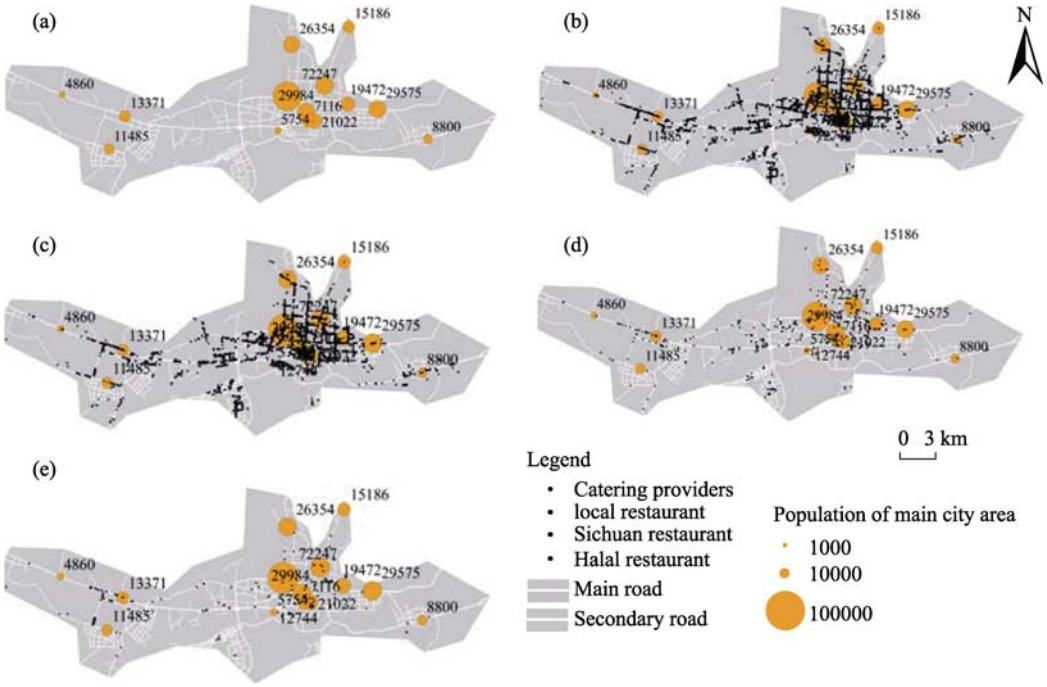

Fig. 9 Spatial distribution of (a) population in the main city area of Lhasa, and the distribution of population overlaid with (b) all catering providers, (c) local restaurants, (d) Sichuan restaurants and (e) Halal restaurants.

catering providers there are. However, the resident population does not completely determine the distribution of the catering industry concentration; i.e., the places with large resident populations are not always the catering industry's most concentrated places, and conversely, some places with a small resident population may have become densely distributed areas of the catering industry. For example, the number of permanent residents in the Jokhang Temple-Barkhor Street area is not the largest, but it is indeed the place with the densest distribution of catering providers. Similarly, the two island streets in the Sun Island area, have a small resident population, but are one of the two main

dining gathering centres; and the Sun Island area is a high-end business hotel, catering and leisure resort in Lhasa, where many tourists gather. Thus, it can be inferred that the main consumers of the Jokhang Temple - Barkhor Street area are not local residents, but rather members of a floating population, such as tourists.

However, the population heat map shows the distribution of the concentration of catering providers is highly consistent with that of the instant population (Fig. 10). Jokhang Temple-Barkhor Street Area, Tianhai Commercial Circle, and Jinzhu Road Area are the most highly concentrated areas.

4 Discussion and conclusions

This study considers the catering network of Lhasa, Tibet as the research object. By mining POI data from the Gaode map, the spatial distribution pattern of catering providers and its influencing factors in the main city area of Lhasa were analysed. The findings could provide a scientific basis and guidance for promoting the spatial structural optimization of the catering industry in this tourism-heavy city on the plateau, as well as the healthy development of tourism in other areas.

More than half of catering providers within the study area are Chinese restaurants, followed by tea houses (17%) and Chinese fast food restaurants (8%). As a unique symbol of food culture in Tibetan areas, Tibetan tea is an important part of residents' lives in Lhasa. Therefore, in Lhasa's catering industry, the number of tea house is second only to Chinese restaurants. Among the different cuisine types among catering providers, the local restaurant type is the most prevalent (64%). Sichuan is a neighbouring province of Tibet. Many Sichuanese individuals and companies operate in the catering industry in Lhasa as a result of the rapid development of tourism in the area, and this area is renowned for its Sichuan cuisine. For example, the migration data released by Baidu in 2014 showed that Chengdu and Chongqing are both popular areas for moving in and out of Tibet, indicating that Sichuan and Chongqing people constituted a significant portion of the migrant population in Tibet (People.cn, 2014). Accordingly, it is reasonable that Sichuan cuisine restaurants occupy a considerable proportion (6%) of the total catering providers according to this study.

The catering industry in the study area shows a two main, two secondary and multi-centre spatial distribution patterns. Catering providers are centrally located in the Old City of Lhasa. Overlaps exist among the different kinds of gathering centres for catering providers. Chinese fast food restaurants and Chinese restaurants are the most widely distributed restaurants among all types of catering providers. Other than the single-centre distributions of beverage shops, snack bars, cafes and pastry shops, the distributions of the rest of the catering providers are all multi-centred. In addition to forming a gathering centre around the scenic spots of the Old City, different kinds of catering providers are also distributed in a beaded manner in the space affected by the distribution of the main roads. For the spatial distribution patterns of the different cuisines of catering providers, local restaurants have the dominant position with both the highest concentration and the widest distribution, and the gathering centre of the local restaurants is at the Jokhang Temple area. In comparison, the concentrations of Sichuan restaurants and Halal restaurants are lower, relatively, and their concentration centres are shifted to either side of the Old City, forming a gathering centre in an area where local restaurants are not dominant.

The spatial layout of the catering industry in Lhasa is largely influenced by the convenience of transportation, the distribution of scenic spots and the distribution of the instant population. Catering providers are primarily distributed on either side of roads or at the intersections of roads, reflecting the influence of the road network on spatially shaping

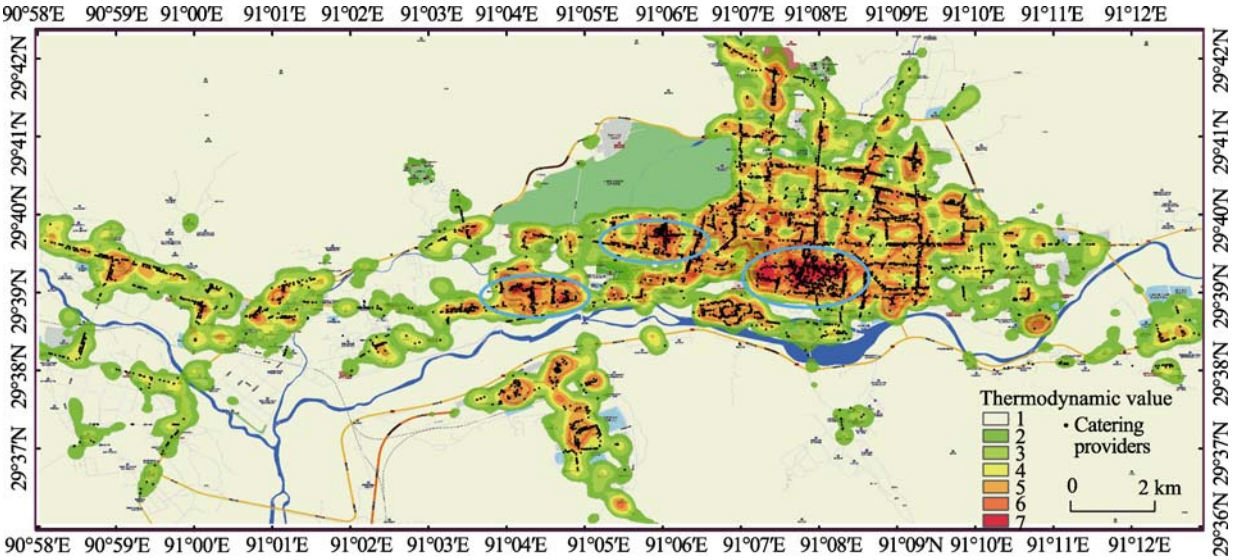

Fig. 10 Population heat map in the Main City Area of Lhasa.

the distribution of catering providers. Roads with lower grades and slower speeds, i.e. branch roads, are more attractive to catering businesses and pedestrians. Particularly in areas with dense branch roads, where the road traffic environment is typically more friendly to pedestrians, catering providers are more clustered. Accordingly, roads integrally affect the layout of the catering industry.

The gathering centres of the catering industry and scenic spots are basically coincident, both have gathering centres in the Jokhang Temple area, indicating a strong correlation between the spatial distributions of the catering industry and scenic spots. Further exploration of the impact of high-level tourism resources (i.e., above 2A level scenic spots) on the distribution of the catering industry found that nearly half of all catering providers are concentrated within 2 km of these scenic spots. This suggests that the spatial layout of the catering industry has a strong dependence on high-level tourism resources, such as the scenic spots above the 2A level. Dependence on high-level tourism resources is also a major feature of the spatial layout of the tourism facilities in a tourism-rich city. The distributions of permanent residents and the catering industry are only somewhat related, as the population of permanent residents does not entirely coincide with the concentration or distribution of the catering industry. However, the concentration distribution of catering providers is highly consistent with the concentration distribution of the instant population.

The catering industry has become an important aspect of Lhasa's function as a tourism city, and the rational layout of the catering industry determines whether the urban economy can operate smoothly. Therefore, in future urban planning processes for Lhasa, the development of the catering industry must be carefully guided and catering facilities must be well-planned. In forming a reasonable spatial layout of the catering industry, it should be considered as a key guiding factor in the future development direction of the city. While maintaining the original transportation convenience of the Old City in road traffic planning, it is also necessary to improve the accessibility of new roads by pedestrians. In activity organization, tourism resources and catering industry facilities should be coordinated and organized around tourism routes. Additionally, tour times of scenic spots, catering consumption and the distribution of accommodation businesses should be fully integrated with urban public transportation. This would enhance the ability to disperse and evacuate people when needed, thus avoiding the urban congestion that can be caused by consumption agglomeration.

One advantage of the POI data used in this study is that they are numerous while also reflecting dynamic changes. To a certain extent, these features overcome the limitations of non-comprehensiveness and time-effectiveness of past field survey data, as well as improve the accuracy of the research results. However, with the continuous development of the city, the catering industry continues to develop rapidly, with the number and types of catering providers constantly changing. Therefore, in future research, an analysis of the changing trends of the quantity, categories and grades of catering facilities in different time series (e.g. different years and seasons) should be considered. Because of the difficulty in obtaining long-term sequence data based on a given study scale and data acquisition technology level in the current space-time pattern evolution of the catering industry, future long-term sequence research should pay more attention to the impact of technical acquisition means (e.g. the level of detail of map features) on the spatial pattern evolution. Additionally, an acquisition and excavation analysis of network evaluation data of relevant websites (e.g. the public comment networks) should be conducted. This analysis could synthesize user preferences and behaviours with data regarding development of the catering industry, and thus further aim to comprehensively and accurately simulate the spatial layout structure and evolutionary trends of the catering industry in tourism cities. Ultimately, this analysis could provide a useful reference for urban and rural planning, tourism development and commercial investment.

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旅游城市餐饮业空间布局特征——以拉萨市为例

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摘　要：受城市功能定位、旅游消费驱动等因素影响，旅游城市餐饮产业空间布局具有其自身特征。通过对互联网电子地图 POI 数据的挖掘，并结合 ArcGIS 最近邻分析、标准差椭圆、核密度分析和缓冲区分析工具，本文分析了高原旅游城市拉萨市主城区餐饮业空间分布格局特征及其影响因素(基于道路交通、旅游资源和人口视角)。研究发现拉萨市主城区餐饮业空间分布总体呈现集聚特征，主要集中在交通发达和旅游资源密集区周边地区；常住人口集聚区域餐饮点同样集中布局，餐饮点密集区与实时人口密集区高度重叠。针对拉萨市城市空间结构、功能定位和旅游发展，文章进一步提出拉萨市餐饮业空间布局优化措施。

关键词：餐饮产业；空间布局；旅游城市；POI；拉萨市