The Conceptualization, Spatial Patterns, and Influencing Factors of Dietary Geographical Belts: A Case Study of Guangdong Province, China

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Abstract. This study introduces the innovative concept of "Dietary Geographic Belts" for the first time, integrating it within the socio-cultural-economic framework for a novel geographical delineation of dietary patterns. Focusing on Guangdong Province's diverse culinary landscape, the research employs Moran's I, clustering analysis, and Geographically Weighted Regression (GWR) models to analyze the spatial differentiation and structure of culinary cultures in the province, in conjunction with both natural and cultural factors. Key findings include: (1) The development of the social economy significantly alters the landscape of dietary geographic belts, as evidenced by disparities between traditional perceptions and data from Meituan's Points of Interest (POI); (2) Teochew, Guangzhou, and Hakka cuisines, as primary sub-cuisines of the region, exhibit a distinctive "One Province, Three Cuisines" pattern with significant clustering; (3) These sub-cuisines demonstrate structural characteristics of spatial differentiation, exhibiting single, dual, and triple structures; (4) Six identified influencing factors exert differentiated impacts on these sub-cuisines, among which the size of the permanent population plays a crucial positive role, while raw material output has a negative effect. This study not only delves into the geographic characteristics and influencing factors of dietary culture but also offers a novel perspective and toolset for regional culinary culture research.

Keywords: dietary culture, dietary geographical belt, sub-cuisines of Cantonese cuisine, geographically weighted regression, Guangdong Province

1   Introduction

Dietary health emerges as a pivotal driver in realizing the ambitious "Healthy China 2030" initiative, intricately intertwined with the populace's fundamental well-being. In the backdrop of China's accelerating high-quality economic advancement, a notable shift has been observed in per capita disposable income, leading to an evolution in both levels and traditional paradigms of consumption. This shift has ushered in heightened attention towards dietary culture, with an increasing emphasis on the provenance of culinary offerings. These dynamics have catalyzed the rapid evolution of China's dietary culture. Emblematic of this trend was the pioneering "Cantonese Cuisine Master" project, initiated by the People's Government of Guangdong Province in 2018, aimed at bolstering the province's culinary heritage.

The concept of "Dietary Geographical Belts", a novel construct rooted in the socio-cultural-economic fabric, offers a tangible manifestation of regional dietary culture and landscape. This concept not only encapsulates the cultural geography dynamics but also holds substantial relevance in advancing geoscientific understanding. The recent strategic directives from the CPC Central Committee and the State Council regarding carbon peak and carbon neutrality have further accentuated the importance of sustainable practices across various sectors, including the catering industry. The United Nations Environment Program highlights that dietary choices account for approximately 27% of global carbon emissions, underlining the significance of this sector in the ecological context. Hence, understanding the dynamics of dietary geographical belts becomes crucial in shaping theories around human-land relationships and the low carbonization trajectory of the food industry.

Prior literature has extensively explored regional dietary cultures. Neal's categorization of cities based on restaurant types and quantities [1], Schiff's exploration of urban catering diversity in relation to population metrics [2], and Dock et al.'s application of gravity models to assess restaurant competitiveness and spatial interactions [3], collectively lay a foundational framework for understanding dietary cultural divisions. Contributions from seminal works like Chen's "The Culture of Chinese Diet: Regional Differentiation and Developing Trends" [4], Cai and Situ's "Study on the Formation and Development Mechanisms of Dietary Culture in Guangdong" [5], and Zhu's "A Brief Status Analysis of Lingnan Dietary Culture" [6] have enriched this discourse. However, there remains a gap in the spatial pattern analysis of specific dietary geographical belts.

Addressing this lacuna, the current study leverages intelligent data analysis, employing Meituan's point of interest (POI) data to dissect the spatial patterns of three sub-cuisines of Cantonese cuisine in Guangdong Province. By conducting clustering analysis based on their quantitative ratios, this research not only offers an incisive look into the spatial dynamics of the province's dietary cultures but also extends theoretical and practical implications for the "Cantonese Cuisine Master" strategy. This study stands at the forefront of regional dietary geographical belt research, providing novel insights into the spatial distribution of dietary cultures and contributing to the scholarly discourse on sustainable culinary practices in the context of China's broader economic and environmental objectives.

2   Overview of Study Area

2.1   Overview of natural geography

Located along the coast of the South China Sea, Guangdong Province borders Fujian Province in the northeast, Jiangxi Province and Hunan Province in the north, and Guangxi Zhuang Autonomous Region in the west. It is separated by the Qiongzhou Strait from Hainan Province in the south, which is close to Hong Kong and Macao Special Administrative Regions. Being the southern gate of the Chinese Mainland, Guangdong enjoys a predominant geological location that belongs to the East Asian monsoon region, which spans the subtropics. The Tropic of Cancer traverses the middle of the province from west to east. From north to south, the province has a middle subtropical climate, south subtropical climate, and tropical climate in succession. Having a moderate climate, Guangdong remains green throughout the year and is rich in light, heat, water, and animal and plant resources. The summers are long, and the winters are short. The plants are predominantly of subtropical species, which are more complex than those growing in the temperate and frigid zones of China. All these factors combine to provide an important raw material basis for the development of the dietary culture in Guangdong Province, which is known for its complex and diverse terrain types, such as mountains, hills, terraces, and plains. Mountains and hills account for about 60% of the total area of the province, which is also one of the birthplaces of agricultural civilization in China. The major river systems are the Xijiang, Dongjiang, Beijiang, Pearl, and Hanjiang.

2.2   Overview of natural geography

As the southern gate of the Chinese Mainland and one of the most economically powerful provinces in China, Guangdong Province plays a leading and exemplary role in China's economic ties with the outside world, industrial transformation, and upgrading, scientific and technological innovation, etc. By the end of 2021, Guangdong Province had a total population of 127 million and a gross domestic product of 12.44 trillion yuan, together with an enormous catering market. In addition, Guangdong Province is a famous hometown of overseas Chinese people, which creates tremendous potential for the integration of local and non-local dietary cultures, as well as Chinese and foreign dietary cultures.

  Guangdong Province is an important region of Lingnan culture, with unique styles in language, customs, lifestyle, and historical culture, forming various types of dietary styles. Cantonese cuisine has inherited the concept of "He did not dislike his rice finely cleaned nor his minced meat cut quite small" advocated by Confucius and has characteristics such as "clear, fresh, refreshing, tender, and smooth". Cantonese cuisine mainly comprises three sub-cuisines: Teochew cuisine, Guangzhou cuisine, and Hakka cuisine. Firstly, the term "Guangzhou" in "Guangzhou cuisine" covers various cities, such as Zhaoqing and Zhanjiang, as well as counties in the Pearl River Delta. In ancient times, this area was largely within the territory of the Nanyue clan, who enjoyed mixed and raw food. After the Qin Dynasty, the dietary habits of the Yue

clan were a result of fusion with the Han nationality and were greatly influenced by the culture of the ancient Central Plains. Afterward, they drew upon the strengths of other nationalities to gradually emerge as a major component and representative of Cantonese cuisine. Secondly, the term "Teochew" in "Teochew cuisine" covers cities and counties such as Teochew, Shantou, Chaoyang, Puning, Raoping, Jieyang, and Huilai. The Chaoshan region is a settlement of the Yue people. Before the Qin Dynasty, Teochew belonged to Fujian and its people belonged to the Minyue clan. The language family and customs of the Chaoshan region were the same as those of Fujian but different from those of the Nanyue clan. Hence, Teochew cuisine has a different origin from that of Guangzhou cuisine. After the Chaoshan region was placed under the jurisdiction of Guangdong, Teochew cuisine began to be influenced by Guangzhou cuisine but has always maintained its uniqueness. Finally, according to the record about Hakka cuisine in the Annals of Jiaying Prefecture, "originally from Qi and Jin, the ancestors of the Hakka people were forced to relocate to Henan and Anhui in the Qin Dynasty." After the Jin Dynasty, the Hakka people once again migrated in large numbers to the mountainous areas of eastern Guangdong, gaining the appellation of "Hakka". The language system and dietary habits of the Hakka people did not undergo the "Han–Guangdong fusion" stage but maintained the characteristics of the ancient Central Plains, so Hakka cuisine kept its distinctiveness as well.

3   Data Sources and Research Methods

3.1   Data sources

This paper analyzes the spatial data on dietary geographical belts based on POI data, which are characterized by rich data volume and accurate geographical information. Hence, they can reflect the geospatial distributions of geographical elements [7] and improve the accuracy of describing the spatial distributions of the dietary culture industry in Guangdong Province. The POI data of Meituan in the first half of 2022 were obtained by Web Crawler and subjected to empirical analysis after data screening [8]. Regional environmental, social, and economic data are mainly derived from the Guangdong Statistical Yearbook, Guangzhou Statistical Yearbook, and statistical yearbooks of various prefecture-level cities in Guangdong Province over the years. To ensure their validity and accuracy, some data have been revised and supplemented according to the China Statistical Yearbook, China County Statistical Yearbook, China Rural Statistical Yearbook, China Forestry Statistical Yearbook, and China Fishery Statistical Yearbook.

3.2   Research Methods

Exploratory spatial data analysis (ESDA).
ESDA measures and tests spatial association patterns (heterogeneity or convergence) through global spatial autocorrelation analysis and local spatial autocorrelation analysis. Specifically, global indicators reflect the average association degree of a certain attribute value in the entire study area. Taking Guangdong Province as a case

study, global spatial autocorrelation analysis was adopted to explore the clustering degrees of the three sub-cuisines in Guangdong Province and provide prerequisites for the subsequent type of division of dietary geographical belts. In contrast, local indicators reflect the association degree between a certain attribute value in a regional unit and the same attribute value in an adjacent regional unit and their distribution patterns [9]. Hence, this study took the three sub-cuisines as the research object and performed local spatial autocorrelation analyses to generate local indicators of spatial association clustering maps, thereby identifying the most competitive areas in Guangdong Province.

In general, $Moran's\ I$ is adopted in global spatial autocorrelation analysis by a geographical information system (GIS) [10]:

$$Moran's\ I = \frac{\sum_{i=1}^{n}\sum_{i=1}^{n} W_{ij}(x_i-\bar{x})(x_j-\bar{x})}{S^2 \sum_{i=1}^{n}\sum_{i=1}^{n} W_{ij}} \tag{1}$$

where n denotes the number of restaurants in the study area; x denotes the average value of the three sub-cuisines; S^2 denotes the variance of the three sub-cuisines; x_i and x_j denote the observed values of sub-cuisine proportion characteristic x in spatial units i and j, respectively; W_{ij} denotes a spatial weight matrix. To ensure that each city has adjacent units, this study followed the distance rules in creating the spatial weight matrix. In contrast, local spatial autocorrelation is often expressed by a decomposed $Local\ Moran's\ I$ [11].

Geographically weighted regression (GWR) model.

Traditional regression models estimate parameters based on the least squares method [12], which is equivalent to an "average" or "global" estimation. The GWR, by incorporating the spatial location factor into traditional regression models, effectively addresses the problem of spatial non-stationarity and allows the relations between variables to change with spatial location. The formula is as follows:

$$y\text{i} = \beta_0(u_i, v_i) + \sum_{k=1}^{p}\beta_k(U_i, v_i)x_{ik} + \varepsilon_i \tag{2}$$

where (u_i, v_i) denotes the coordinates of the geographical center of the i spatial unit; $\beta_k(U_i, v_i)$ denotes the regression coefficient of the k variable in the i spatial unit; p denotes the number of variables; εi denotes the error term [13]. ArcGIS 10.2 software was used to construct the GWR model, and the corrected Akaike information criterion (AICc) was adopted to determine the optimal bandwidth of the model.

4 Spatial Patterns of Dietary Geographical Belts in Guangdong Province

4.1 Traditional spatial distribution of Cantonese cuisine based on regional branches of nationality

According to language families and branches of nationality, Guangdong can be divided into three major cultural areas of Cantonese cuisine: Chaoshan Cultural Area, Guangfu Cultural Area, and Hakka Cultural Area. According to the traditional regional administrative divisions, Guangdong is generally divided into four parts: the Pearl River Delta, eastern Guangdong, western Guangdong, and northern Guangdong. The Pearl River Delta is economically developed and enjoys remarkable advantages in terms of politics, economy, culture, and society, whereas eastern Guangdong, western Guangdong, and northern Guangdong are economically underdeveloped. The spatial distribution patterns of cuisines in Guangdong Province can be characterized as "One Province with Three Cuisines" (i.e., Teochew cuisine, Guangzhou cuisine, and Hakka cuisine). Traditionally, the Pearl River Delta and western Guangdong are Guangzhou cuisine-dominant areas, which take up most of the parts of Guangdong Province. Eastern Guangdong (covering Chaoshan and surrounding areas) belongs to the Chaoshan Cultural Area and is dominated by Teochew cuisine. Hakka cuisine prevails over northern Guangdong (see Figure 1).
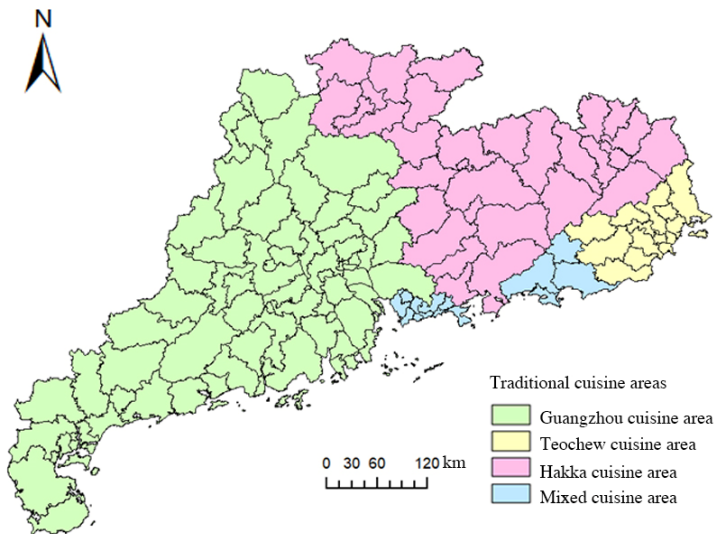

Fig. 1. Traditional spatial patterns of dietary geographical belts in Guangdong Province

4.2   Spatial clustering characteristics of Cantonese cuisine based on POI data

From the statistics on the restaurants of the three sub-cuisines available on Meituan in various counties and districts of Guangdong Province, we collected 153,032 valid data points, of which 34,364 points are for Teochew cuisine, 105,720 points are for Guangzhou cuisine, and 12,948 points are for Hakka cuisine. Quantitatively, Guangzhou cuisine occupies the absolute advantage among the three sub-cuisines in Guangdong Province. The province-wide data of Meituan indicate that the total number of restaurants for each of the sub-cuisines varies greatly across various counties and districts. Guangzhou has the largest total number of restaurants of the three sub-cuisines (53,350 points, of which 9,576 are for Teochew cuisine, 42,165 are for Guangzhou cuisine, and 1,609 are for Hakka cuisine), whereas Yunfu has the smallest (1,007 points). A Moran's I statistical chart was drawn from a global spatial autocorrelation analysis with ArcGIS while the Moran's indices, z-scores, and p-values of Teochew cuisine, Guangzhou cuisine, and Hakka cuisine (Table 1) were calculated. Global spatial autocorrelation analysis has revealed that the three sub-cuisines of Cantonese cuisine have positive spatial autocorrelations at the county or district level and present a convergent tendency, i.e., the three sub-cuisines show a consistent clustering tendency in terms of quantitative distribution, presents a strong global spatial autocorrelation.

Table 1. Moran's I statistical chart of Teochew cuisine, Guangzhou cuisine, and Hakka cuisine.

Item	Teochew cuisine	Guangzhou cuisine	Hakka cuisine
Moran's I	0.486493	0.569224	0.529568
z-score	8.948323	10.058928	9.491023
p-value[a]	0.000000	0.000000	0.000000

[a] $p < 0.001$, the model passes the significance test.

To show the spatial association characteristics of the three sub-cuisines of Cantonese cuisine in Guangdong Province more intuitively and clearly, we have drawn the LISA clustering maps of Teochew cuisine, Guangzhou cuisine, and Hakka cuisine by analyzing the calculated cluster and outlier values (Anselin Local Moran's I) of each county and district (Figure 2). The three sub-cuisines all show high–high clustering in Guangdong Province. Teochew cuisine is distributed in Guangzhou (Huadu District, Baiyun District, Zengcheng District, and Panyu District), Foshan (Nanhai District, Chancheng District, and Shunde District), Dongguan, and Shenzhen (Bao'an District, Longgang District, Nanshan District, and Luohu District) (Figure 2a). Guangzhou cuisine is distributed in Guangzhou (Huadu District, Baiyun District, Zengcheng District, Huangpu District, Panyu District, and Nansha District), Foshan (Nanhai District and Shunde District), Zhongshan, and Shenzhen (Bao'an District) (Figure 2b). Hakka cuisine is distributed in Dongguan, Shenzhen (Bao'an District, Nanshan District, Longgang District, and Luohu District), Guangzhou (Zengcheng District), and Huizhou (Boluo County, Huicheng District, and Huiyang District) (Figure 2c). Overall, the spatial distribution and clustering of the dietary geographical belts, particularly those of the Teochew and Guangzhou cuisines, in Guangdong Province mainly occur within the core of the Pearl River Delta region. In contrast, Hakka cuisine is mainly

clustered at the eastern edge of the Pearl River Delta and has not yet fully penetrated the core area.
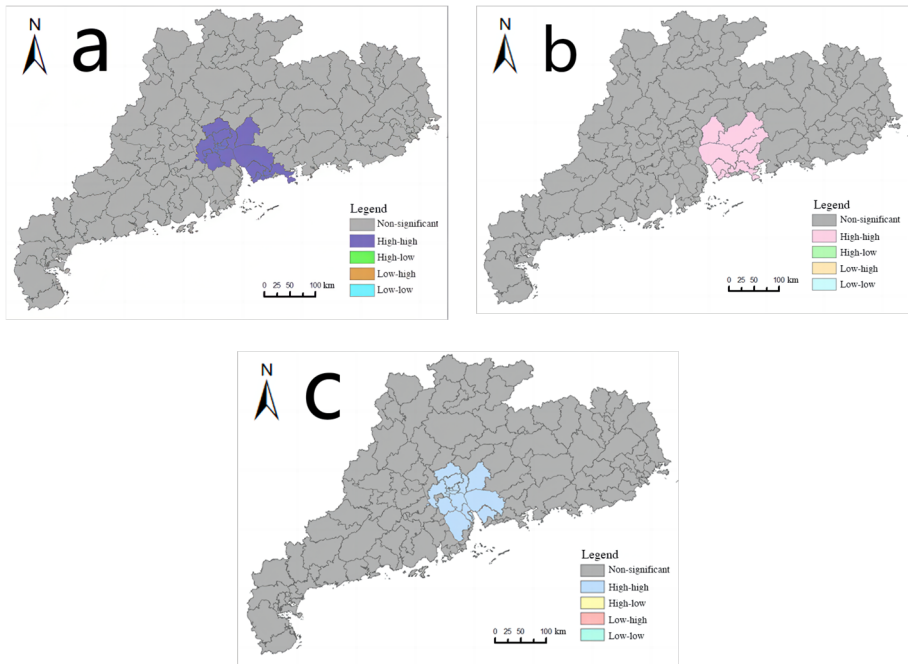

Fig. 2. LISA clustering map of Teochew cuisine, Guangzhou cuisine, and Hakka cuisine

4.3   Overall spatial structural types of dietary geographical belts in Guangdong Province

The quantitative process of the type of division of dietary geographical belts in Guangdong Province regarding different sub-cuisines is realized by converting the numbers of restaurants of different sub-cuisines into proportions through non-dimensionalization, then analyzing and calculating each proportion. Based on the POI data of Meituan, the numbers of restaurants of the three sub-cuisines in 122 cities and 2 special administrative regions were converted into proportions, which were then input into SPSS software for k-means clustering analysis. The results were visualized in combination with GIS. Hierarchical clustering was performed by the between-groups linkage method and taking the proportions of different sub-cuisines as the clustering variable, the 124 research units as the clustering sample, and the sum of squares of Euclidean distance as the spacing [14]. The 124 counties and districts of Guangdong Province are classified into six categories (i.e., three single-structure categories, two dual-structure categories, and one triple-structure category), thereby obtaining the type of system of the dietary geographical belts in Guangdong Province (Table 2).

Table 2. Type system of dietary geographical belts in Guangdong Province.

Clustering category	Single structure	Dual structure	Triple structure
Clustering category I	Guangzhou cuisine-dominant area		
Clustering category II		Guangzhou–Teochew mixed cuisine area	
Clustering category III			Guangzhou–Teochew–Hakka mixed cuisine area
Clustering category IV	Hakka cuisine-dominant area		
Clustering category V	Teochew cuisine-dominant area		
Clustering category VI		Guangzhou–Hakka mixed cuisine area	

According to Figure 3, western Guangdong is a Guangzhou cuisine-dominant area; eastern Guangdong is a Teochew cuisine-dominant area; northern Guangdong is a Hakka cuisine-dominant area and a Guangzhou–Hakka mixed cuisine area; the Pearl River Delta region in central Guangdong is relatively special, being a Guangzhou–Teochew mixed cuisine area and a Guangzhou–Teochew–Hakka mixed cuisine area. All cuisine areas show a massive, planar distribution. The economically underdeveloped eastern Guangdong, western Guangdong, and northern Guangdong are distributed with Teochew cuisine, Guangzhou cuisine, and Hakka cuisine, respectively, whereas the most economically developed Pearl River Delta region is dominated by Guangzhou cuisine, showing a complementary mixture of Guangzhou–Teochew, Guangzhou–Hakka, and Guangzhou–Teochew–Hakka mixed cuisine areas.
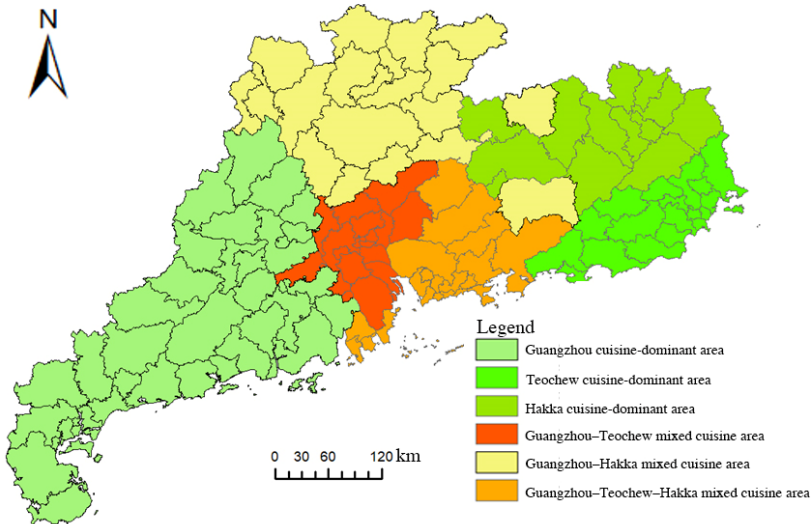

Fig. 3. Spatial distribution map of dietary geographical belts in Guangdong Province

5   Influencing Factors of Dietary Geographical Belts in Guangdong Province

5.1   Selection of causal factors

So far, the causal factors of the distribution patterns of catering spaces in individual cities have been confirmed to include regional economic level [15], population distribution [16], traffic conditions [17], convenience of public service facilities [18], tourism activities [19], urban development pattern [15], land use type [16], and urban cultural traditions [20]. Firstly, we have referred to the findings of previous studies and considered the open economic form of Guangdong Province and the regional characteristic of "One Province with Three Cuisines". In response to the difficulty of collecting data on causal factors, we extended the research on the causal factors of the spatial distribution patterns of the dietary geographical belts in Guangdong Province to a study of causal factors in 21 prefecture-level cities of Guangdong Province. Proceeding from natural and cultural dimensions, we eventually selected six indicators as causal factors: average annual rainfall; total output value of agriculture, forestry, animal husbandry, and fishery in 2020; permanent population in 2020; urbanization rate in 2020; per capita disposable income in 2020; passenger volume in 2020. These causal factors are then used to explain the influencing factors of the spatial patterns of the dietary geographical belts in Guangdong Province. Specific indicators are provided in Table 3. Deviation standardization is performed first to eliminate the influence of dimensionality [13].

Table 3. Descriptions of influencing factors.

Factor name	Unit	Variable description
Rainfall (RF)	mm	Average annual rainfall
Raw material output value	100 million yuan	Total output value of agriculture, forestry, animal husbandry, and fishery
Permanent population (PO)	10,000 persons	Permanent population in 2020
Urbanization rate (UR)	Percentage	Proportion of urban population out of the total population in 2020
Per capita disposable income	Yuan	Per capita disposable income in 2020
Passenger volume (PV)	10,000 persons	Total passenger throughput by sea, land, and air

5.2   GWR model

A GWR model was constructed by ArcGIS 10.2 software and a data analysis were performed. The results are shown in Table 4. Notably, corrected r2 is an extremely important criterion in the test results of the GWR model and a value within the range of 0.0–1.0 indicates a better goodness of fit for the model. This value can be explained as the variance ratio of the dependent variables covered by the model. Generally, a value greater than 0.5 indicates higher validity.

Table 4. Parameter estimation and test results of Geographically Weighted Regression (GWR) model.

Model parameter	Teochew cuisine	Guangzhou cuisine	Hakka cuisine
Bandwidth	71.387	71.387	71.387
Residual sum of squares	8525866.522	151136038.2	5197441.485
Significand	6.008	6.008	6.008
Sigma value	754.122	3175.095	588.796
AICc	353.427	413.803	343.032
r2	0.935	0.908	0.636
Corrected r2	0.913	0.877	0.515

The GWR coefficients of the causal factors of the three sub-cuisines in Guangdong Province (Figs. 4–6) show how the six factors affect Guangzhou cuisine, Teochew cuisine, and Hakka cuisine to varying degrees. Permanent population (i.e., the objective need for diets) is the most important influencing factor. Analyzed from the natural and cultural dimensions, the natural factors show a negative correlation with the number of restaurants, whereas the cultural factors present a positive correlation.
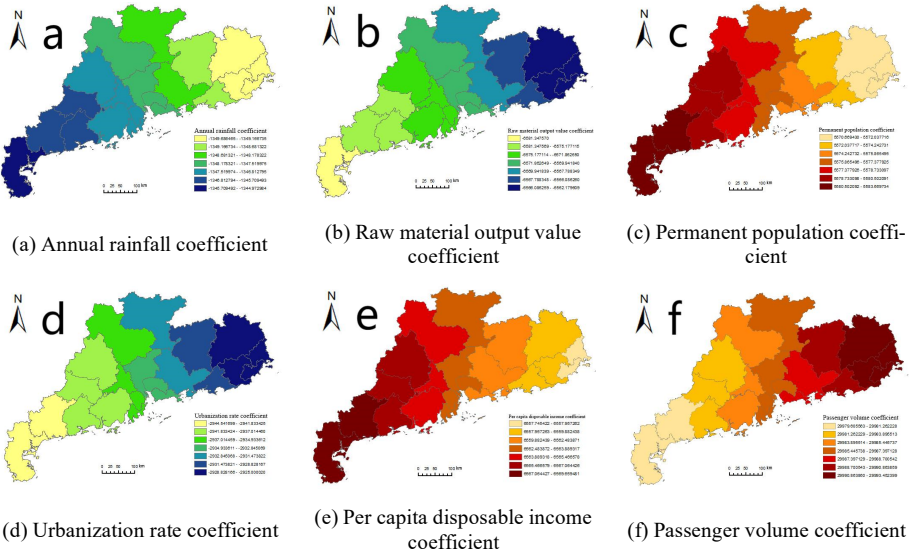

(a) Annual rainfall coefficient

(b) Raw material output value coefficient

(c) Permanent population coefficient

(d) Urbanization rate coefficient

(e) Per capita disposable income coefficient

(f) Passenger volume coefficient

Fig. 4. Spatial distributions of regression coefficients of GWR model for Guangzhou cuisine

The natural influencing factors, such as annual rainfall and raw materials, have little effect on Teochew cuisine and Guangzhou cuisine, suggesting that they had gradually eliminated traditional geographical restrictions while presenting an orderly and stabilizing diffusion trend. For Hakka cuisine, the raw material output value coefficient shows a negative correlation, but the annual rainfall coefficient still presents a positive correlation. These results suggest that Hakka cuisine has made some breakthroughs in the place of origin of raw materials but has yet to cast off traditional geographical restrictions, which are closely related to the cultural geographical environment of Hakka cuisine. Teochew cuisine was first spread by the original inhabitants

of Teochew, then brought back home by external settlers. Guangzhou cuisine, by virtue of the enormous advantages of the Guangfu Cultural Area, is widely known as a typical representative of Cantonese cuisine. Hakka cuisine, however, is barely known outside of China because of the lack of humanistic feelings and regional traffic advantages.
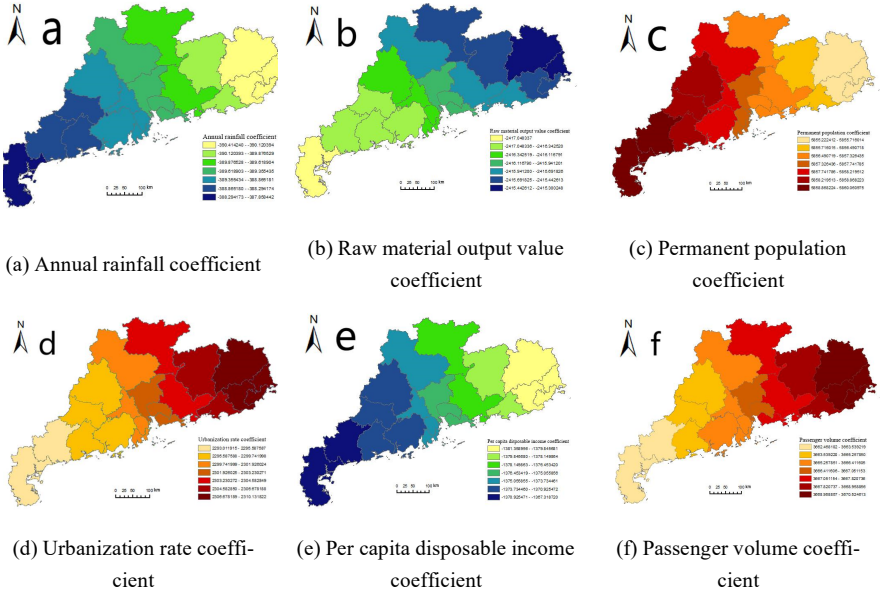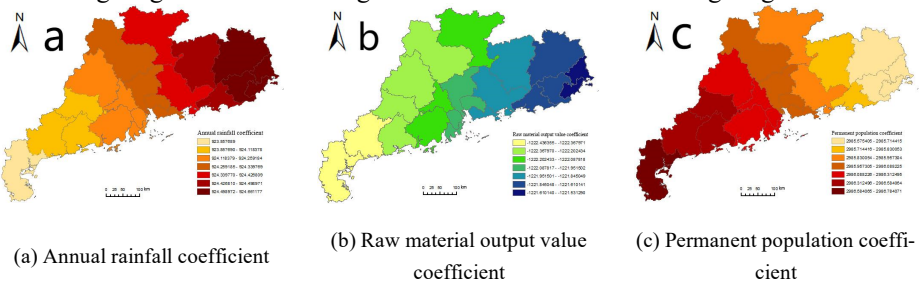

(a) Annual rainfall coefficient

(b) Raw material output value coefficient

(c) Permanent population coefficient

(d) Urbanization rate coefficient

(e) Per capita disposable income coefficient

(f) Passenger volume coefficient

Fig. 5. Spatial distributions of regression coefficients of GWR model for Teochew cuisine

Permanent population has a significant effect on all of the three sub-cuisines, with a positive coefficient in each case, thus indicating that the permanent urban population has affected the distributions of the cuisines and an increase in the population would be conducive to their development. The regression coefficient of the permanent population presents a decreasing trend from west to east, suggesting that the population of western Guangdong has played an important role in the development of the three sub-cuisines. Accordingly, eastern Guangdong has the minimum regression coefficient, which suggests that its effect on the development of the cuisines in eastern Guangdong has not been as significant as that in western Guangdong.
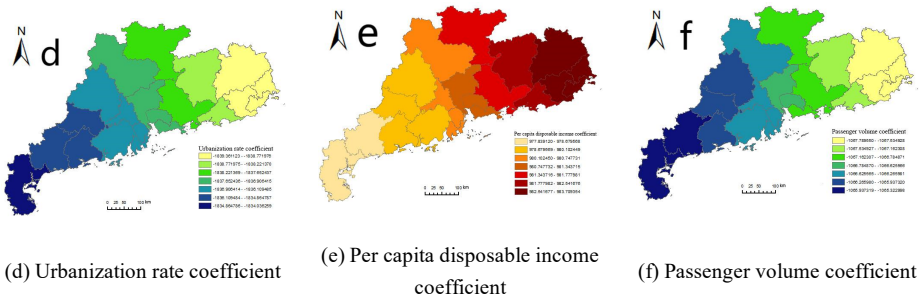

(a) Annual rainfall coefficient

(b) Raw material output value coefficient

(c) Permanent population coefficient

(d) Urbanization rate coefficient

(e) Per capita disposable income coefficient

(f) Passenger volume coefficient

Fig. 6. Spatial distributions of regression coefficients of GWR model for Hakka cuisine

Teochew cuisine has a positive urbanization rate coefficient, whereas Guangzhou cuisine and Hakka cuisine have negative urbanization rate coefficients, thus indicating that Teochew cuisine is more clustered in areas with higher urbanization rates and that a rise in urbanization rate has developed Teochew cuisine. This result is related to the high-end positioning of Teochew cuisine, which has focused on building high-end brands. In contrast, neither Guangzhou cuisine nor Hakka cuisine has presented such a clear trend, which is a significant characteristic that has set Teochew cuisine apart from the other two sub-cuisines.

Per capita disposable income has positively affected both Guangzhou cuisine and Hakka cuisine. Although Teochew cuisine features a high-end positioning, it is still predominant within the scope of traditional diets and has had negligible effect on per capita disposable income. Because of the geographical location of Guangzhou cuisine in the center of Guangdong, passenger volume has had the most significant effect on Guangzhou cuisine, followed by Teochew cuisine, whereas Hakka cuisine presents a contrary trend, which is closely related to the traditional geographical location and scope of Hakka cuisine.

The analysis of the causal factors of the dietary geographical belts of the three sub-cuisines has shown that the influences of various social-cultural-economic factors (such as population mobility, urban development, and improved traffic convenience) have become prominent while traditional natural factors have retired to the background.

6   Discussion and Conclusions

Dietary geographical belts, as a micro-symbol of a regional natural-social-economic system, constitute an essential component of regional socio-economic development. Taking various counties and districts of Guangdong Province as the research area, this study explored the spatial patterns of dietary geographical belts in Guangdong Province and their influencing factors. The main conclusions are as follows. (1) The spatial distributions of cuisines in Guangdong Province present an obvious pattern of "One Province with Three Cuisines" and the distribution ranges of the dietary geographical belts delineated by the restaurant categories are significantly different from

those of the traditional cuisines. (2) The geographical distributions of the three sub-cuisines show high–high clustering with the Pearl River Delta region as the center, thus presenting a patchwork type of distribution. (3) The three sub-cuisines of Cantonese cuisine show a structural characteristic of spatial differentiation and exhibit single, dual, and triple structures. Overall, Guangzhou cuisine has dominated Guangdong Province, whereas Teochew cuisine and Hakka cuisine have played complementary roles. (4) The spatial distributions of the three sub-cuisines in Guangdong Province are a result of the combined action of multiple causal factors. Test results suggest that cultural factors (such as economy and traffic) have stronger effects on Teochew cuisine and Guangzhou cuisine, whereas Hakka cuisine is more significantly affected by natural factors.

Varying degrees of spatial differences and effects of the six causal factors are present among the three sub-cuisines in different cities. Some of these factors even exert serious negative impacts. Economic differences and population mobility serve as important conditions for the emergence and development of cuisines. The formation of the factors influencing the spatial patterns of dietary culture in Guangdong is both complex and diverse. The intricate interplay between the natural geographical surroundings of Guangdong Province, the amalgamation and juxtaposition of indigenous and non-indigenous dietary traditions, as well as the advent of market-driven economies and policies for liberalization and economic reforms, collectively assume pivotal roles in shaping the formation and evolution of dietary culture in Guangdong. However, it is pertinent to note that the establishment and progression of this culinary culture in Guangdong emanate from a synergy of the ecological milieu, cultural ambience, and an array of comprehensive determinants.

Since the POI data of Meituan, the spatial pattern of dietary geographical belts in Guangdong Province has been quantitatively and the multiple factors influencing the formation of the "One Province with Three Cuisines" pattern, as well as its natural and cultural dimensions, have been analyzed by a geographically weighted regression (GWR) model, which has facilitated our understanding of the spatial patterns of dietary geographical belts in Guangdong Province. However, this study has focused on the spatial clustering characteristics and influencing factors of the three sub-cuisines without having explored other sub-cuisines in other counties and districts. Therefore, future studies should pay more attention to the spatial distributions of other sub-cuisines in Guangdong Province while considering their temporal and spatial changes for a more in-depth and realistic examination of the spatial patterns of the dietary geographical belts in Guangdong Province.

This research represents a novel foray into the realm of dietary geography, pioneering the integration of intelligent data analysis within the study of culinary cultural behaviors. By introducing the concept of "dietary geographic belts" and employing advanced analytical techniques such as geographically weighted regression (GWR) and clustering analysis, the study has unveiled intricate spatial patterns and influential factors within Guangdong Province's culinary landscape. This approach has not only illuminated the dynamic interplay between regional culinary practices and geographical factors but also underscored the significant role of socio-cultural-economic systems in shaping these patterns. The incorporation of human geography into this re-

search has deepened our understanding of how regional dietary practices reflect, and influenced by, the surrounding environment and cultural context. This multidisciplinary approach, leveraging the prowess of intelligent data analysis, has enabled a more nuanced and comprehensive exploration of dietary culture than previously possible.

6.1   Theoretical Implications

This study contributes significantly to the field of dietary geography by establishing a novel framework for understanding regional cuisine patterns through intelligent data analysis. Theoretically, it expands the domain of human geography by incorporating the concept of "dietary geographical belts", thus offering a new lens to examine the interplay between regional culinary practices and their socio-economic and natural environments. The use of advanced analytical methods, such as geographically weighted regression (GWR), to dissect the spatial patterns of cuisines within Guangdong Province, underscores the potential of integrating spatial analysis with cultural studies. This approach enables a more nuanced understanding of the cultural geography of food, highlighting the spatial differentiation and clustering characteristics of regional cuisines. Moreover, the study's findings contribute to the discourse on cultural and economic geography by illustrating how regional culinary preferences are shaped by a synergy of ecological, cultural, and economic factors. This research thereby enriches theoretical perspectives on the complex and dynamic nature of human-environment interactions within the context of dietary practices.

6.2   Practical Implications

From a practical standpoint, this research has several implications for regional development, cultural preservation, and policymaking. The identification of distinct culinary patterns within Guangdong Province can guide regional development strategies, particularly in promoting culinary tourism and preserving cultural heritage. The study's insights into the influence of economic and population factors on regional cuisines can aid policymakers in understanding the potential impacts of urbanization and economic development on local food cultures. Furthermore, the delineation of dietary geographical belts provides a valuable tool for local governments and cultural organizations to identify and promote unique culinary traditions, enhancing the cultural identity of different regions. The application of intelligent data analysis in this context demonstrates the potential of data-driven approaches in informing sustainable and culturally sensitive development policies. Additionally, the findings can be instrumental for stakeholders in the food and beverage industry, providing them with a deeper understanding of regional consumer preferences and enabling them to tailor their offerings accordingly. Overall, this study not only provides a foundation for future research in dietary geography but also offers practical insights for cultural preservation and regional development in the face of rapid socio-economic changes.

   In conclusion, this study not only marks a significant advancement in the field of dietary geography but also opens up new horizons for the interdisciplinary study of food, culture, and geography. It underscores the potential of intelligent data analysis

in unraveling the complex tapestry of culinary culture and sets the stage for future research that bridges the gap between human geography and dietary studies.

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