

Research on Tobacco Retail Point Layout in Guanshanhu District, Guizhou Province Based on Transportation Accessibility

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Abstract. Guizhou tobacco planting has a long history, thanks to Guizhou's superior climate, soil and other ecological conditions and rich planting experience, laid an important position of Guizhou tobacco in China's tobacco industry, tobacco industry is Guizhou's traditional advantageous industry, but also an important pillar industry, in the economic and social development of Guizhou Province plays an irreplaceable important role, Guanshanhu District is the key work area of Guizhou Tobacco Company to arrange tobacco sales related service configuration, so for the existing tobacco network layout system in Guanshanhu District. Through the spatial layout, traffic accessibility analysis under the conditions of surrounding basic transportation facilities, and the construction of traffic time isochronous circles, the following optimization suggestions are given for the traffic layout: 1. Adjust the density of outlets to improve the efficiency of services; 2 Considering a variety of factors to help increase tobacco sales; 3. Regularly evaluate and adjust the layout; 4 Consider regional characteristics.

Keywords: tobacco planting; inverse distance weighting; accessibility analysis.

1. Introduction

Tobacco cultivation in Guizhou has a long history and has benefited from favorable ecological conditions such as the climate, soil, and rich cultivation experience. This has established the important position of Guizhou tobacco in the tobacco industry in China. According to the "China Statistical Yearbook 2021," Guizhou ranks second in national tobacco leaf production, second only to Yunnan Province, accounting for approximately 10.54% of the total national tobacco leaf production. The tobacco industry is not only a traditional advantage but also a crucial pillar industry in the economic and social development of Guizhou Province [1].

Approved by the State Council in November 2012, Guanshanhu District covers a total area of 307 square kilometers, with a built-up area of 64.5 square kilometers. It has an urbanization rate of 87.8% and is divided into three towns, seven street offices, and 141 village committees. With a permanent population of over 650,000, it serves as the new urban district, central district, window district, ecological, and experimental zone of Guiyang City. It is a key area where Guizhou Tobacco Corporation arranges tobacco sales and related services. Therefore, focusing on the existing tobacco outlet layout system in Guanshanhu District, this study aims to provide data support for the decision-making of the tobacco company in the district through spatial layout and conducting an analysis of transportation accessibility considering the surrounding basic transportation infrastructure. By constructing isochrones of travel time and other methods, it seeks to offer reference analysis and data support for optimizing the outlet layout and further enhancing the level of regional services.

2. Methods and Data Sources

2.1 Research Methods

The inverse distance weighting (IDW) method is based on the similarity of sample points within the interpolation area. It calculates the weighted average of the sample points' values in the neighboring areas to estimate the value of each cell and interpolate a surface. The IDW method is implemented in the ArcGIS platform, where point data is loaded and interpolated using spatial analysis tools. It assumes that each measurement point has a local influence that decreases with increasing distance. This method transforms scattered data into a continuous surface through interpolation. Accessibility usually refers to the degree to which individuals or groups can reach or use a geographic area or specific destination within a certain time and cost range. Accessibility is an important indicator for evaluating transportation systems and spatial distribution. It quantifies the extent to which people can reach designated locations or activities using diverse transportation modes [3]. Accessibility analysis helps us understand the activities and mobility patterns of people in different geographic areas [4], providing important reference for transportation planning and policy-making. In accessibility analysis, indicators such as time and cost are commonly used to measure the differences in distance and accessibility between different geographic areas.

Shi Fei, Zhu Le, and others summarized existing research on accessibility methods and classified them into seven mainstream methods based on model algorithms and research accuracy [2]. These methods include buffer analysis, supply-demand model analysis, network analysis, cost grid method, integration of cost grid and network analysis, analysis based on high-performance graphic database, and analysis based on open map APIs. The buffer analysis method takes into account the service coverage radius of service points and combines it with their spatial location. However, it does not consider spatial barriers present in actual transportation routes, resulting in overly coarse results. The supply-demand model analysis, after further development by Shen Qing, formed the Shen Qing supply-demand model [5], which reflects the accessibility of public transportation to employment but does not consider the actual bus route issues. The network analysis method further addresses this issue, but the generation of the accessibility surface is greatly influenced by data transformation and accuracy limitations, which in turn affects the interpretability. The cost grid method resolves the data transformation issue but is limited by the data types and cannot reflect the actual transportation conditions. To overcome the shortcomings of the network analysis method and the cost grid method, the integration of cost grid and network analysis utilizes topological theory to consider both real transportation conditions and improve computational accuracy. The Public Transport Accessibility Level (PTAL) in London is a relatively simple and mature method for measuring public transportation levels [6]. The high-performance graphic database involves handling and computing a large amount of data, which is difficult to obtain and requires significant computational resources, making it challenging for practical applications. On the other hand, open map APIs provide easy access to up-to-date transportation routes and network data with high data accuracy. However, further processing of a large amount of raw data obtained from the network is required before analysis can be performed.

2.2 Data Sources and Analysis Methods

In this study, we first conducted field surveys to investigate the layout of residential areas and tobacco retail outlets in Guanshanhu District, Guiyang City, Guizhou Province. We combined the data provided by the Tobacco Bureau and conducted on-site visits to most of the retail outlets to understand the convenience of transportation in their vicinity. The survey results showed that Guanshanhu District, influenced by geographical factors, has complex mountainous areas and natural tourist resources such as Baihua Lake in the west. The existing tobacco outlets can roughly meet the scattered residential and tourist needs in the area. In the eastern part, which is the main residential area and has a dense road network, there are problems of incomplete coverage or excessive concentration of tobacco retail outlets around some residential areas and road networks.

Based on the collected data, the tobacco retail outlets and residential areas were selected as the research objects.

The latitude and longitude of the tobacco retail outlets and residential areas were obtained through Baidu Maps, and the ArcGIS software was used for data processing and model construction using the API services provided by Baidu Maps. The city road network data was obtained from the OpenStreetMap open-source website, and a traffic network model with road classification, operating speed, and segment length fields was established based on the city road classification standards. The analysis of the regional differences in transportation accessibility at the sampled points was visualized and analyzed using a combination of qualitative and quantitative methods, and then the tobacco retail outlet transportation planning issue was explored from an accessibility-oriented perspective. The visualization processing is shown in Figure 1 and Figure 2.



Figure 1: Road Layout in Guanshanhu District

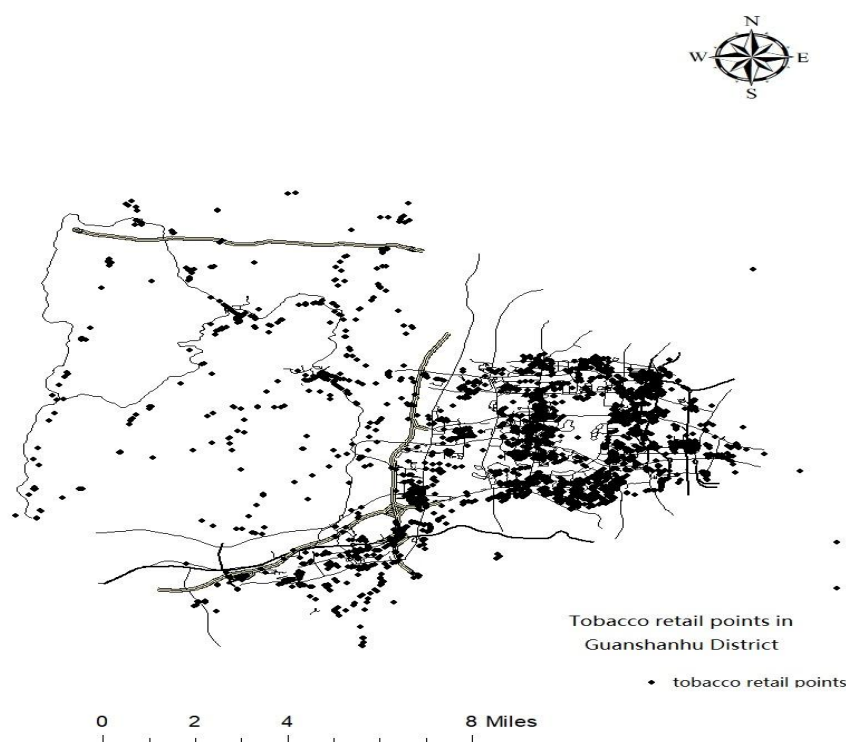


Figure 2: Distribution Map of Tobacco Retail Stores in Guanshanhu District

3. Analysis of Tobacco Retail Outlet Transportation Accessibility

Based on the collected data, the transportation accessibility of the transportation routes to tobacco retail outlets was calculated. The ArcGIS platform was used for inverse distance weighted interpolation and spatial analysis, as shown in Figure 3. In the ideal state, it can be seen that the isochrones within 20 minutes cover most areas. From the road network in Guanshanhu District, the nearest tobacco retail outlets can be reached within 20 minutes. Most tobacco retail outlets are within 1 to 5 minutes of the road network within the 20-minute isochrone. Overall, the areas near Yuntan South Road, Shilin West Road, and Shilin East Road, as well as the areas near Binyang Avenue and Guanqing Road, have relatively poor overall accessibility. The Century City and Bi Hai Garden along Guiyang Metro Line 1 and Line 2 have better accessibility.

Considering the distance between tobacco retail outlets and residential areas, i.e., the distance decay pattern, the initial weight of the facility will systematically decay as the distance from the starting point increases. The basic walkability index of reaching different public facilities within a certain range was calculated for each residential area. There are many patterns of distance decay, and this study adopts a cubic curve for distance decay. According to the distance decay standards on the website [walkscore.com](https://www.walkscore.com/), based on the standard walking speed of 80m/min, the following distance decay patterns were obtained: no decay occurs when the distance is within 400 meters. When the distance is between 400 meters and 1600 meters, the decay is rapid. The formula is as follows, where x is in kilometers and y is in percentage:

$$y = -153.6558x^3 + 419.4604x^2 - 395.9706x + 201.1086$$

When the distance is greater than 1600 meters but less than 2400 meters, the decay is slow, and the decay rate is greater than 1. The formula is as follows:

$$y = -92.8x^3 + 566.6x^2 - 1153.1x + 786.6$$

The spatial distribution characteristics of the walkability index from each residential area in Guanshanhu District to tobacco retail outlets, calculated based on the formulas, are shown in Figure 4. The darker-colored points represent residential areas with higher walkability indexes. The calculations show that the areas near R&F Center and China Resources International Community have significantly higher walkability indexes and denser distribution of tobacco retail outlets. The southwest residential areas have relatively poor walkability to reach tobacco retail outlets. Additionally, in areas with obvious agglomeration effects such as Century City and R&F Center, there are also some residential areas with poor accessibility, where walking times are too long and there is a lack of tobacco retail outlets in the vicinity.



Figure 3: Isodistance Map of Tobacco Retail Store Accessibility

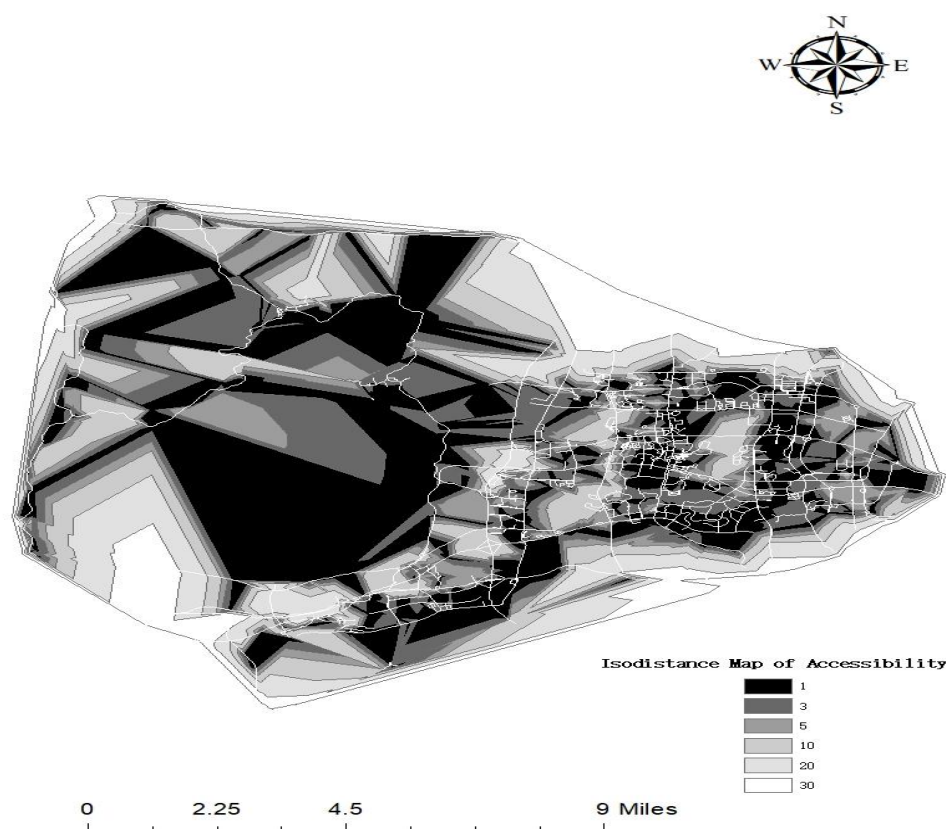


Figure 4: Spatial Distribution Characteristics of Walkability Index in Residential Areas of Guanshanhu District

4. Traffic Layout and Optimization Recommendations

4.1 Adjusting the density of retail outlets

Based on the analysis of transportation accessibility, adjust the density of tobacco retail outlets to an appropriate level. If certain areas have a high density of retail outlets, such as the vicinity of Century City and R&F Center, which show excellent performance in terms of transportation accessibility and residential accessibility, consider closing or merging some outlets in those areas, or temporarily refrain from further increasing outlets to reduce operating costs and avoid intense competition. In areas with lower accessibility, such as the southwest and southeast directions of Guanshanhu District, consider adding tobacco retail outlets to improve service coverage.

4.2 Consider multiple influencing factors

Consider not only densely populated residential areas but also areas with high human flow, such as commercial and office districts. Combine transportation accessibility with the layout of retail outlets around transportation hubs to identify any gaps. Ensure an adequate number of retail outlets in these areas, which are typically areas with high foot traffic, to meet the needs of residents, business customers, and commuters, thereby increasing tobacco sales.

4.3 Regular evaluation and adjustment of layout strategies

Regularly assess the layout of tobacco retail outlets in line with the development and population changes in Guanshanhu District. Adjust outlet expansion or establishment strategies promptly based on demand. Flexibility and timeliness are crucial for optimizing the layout to adapt to changing markets and customer needs. Additionally, understanding the distribution of competitor retail

outlets and market demands is an important factor in optimizing the layout. If competitors have an advantage in certain areas, consider seeking untapped market share in other areas and establishing retail outlets to meet the demand there.

4.4 Consider regional characteristics

Guanshanhu District has unique regional characteristics, such as the Baihua Lake Scenic Area and wetland parks. In the layout optimization, consider placing retail outlets in locations that align with these scenic areas, parks, and cultural clusters. This approach can leverage local features to attract more tourists and local residents to purchase tobacco products.

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