Research on the Spatial Attraction Based on the Theory of Improved Fracture Point in Tianshui City, China

Yinxia Tian[a], Tianpeng Wang*

School of Architecture and Urban Planning, Lanzhou Jiaotong University, Lanzhou China

[a]3489229804@qq.com; *wangtp@mail.lzjtu.cn

Abstract. Exploring the interactions between cities and regions, the Tianshui metropolitan area is taken as the research object to carry out the quantitative optimization research of its spatial structure. Based on the improvement of the fracture point theory, the population data and GDP data of eight cities around Tianshui are processed and analyzed in ArcGIS to study the location of the fracture point, so as to determine the scope of attraction of the city of Tianshui, and then analyze the main trend of the spatial structure of Tianshui metropolitan area toward the outside, and propose that the scope of the new Tianshui metropolitan area includes: the whole city of Tianshui, Xihe county, Li county, Cheng county, Hui county, Liangdang county, Zhuanglang county, Jingning county, Tongwei county, Zhang county, Zhang county, and the entire city of Tianshui. Li County, Cheng County, Hui County, Liangdang County, Zhuanglang County, Jingning County, Tongwei County, Zhang County, Longxi County, and part of Dangchang County; and parts of Anding District, Wen County, Wudu District, Kang County, Loyang County, Chencang District, Huating City and Long County.

Keywords: breaking point theory; attractiveness; Tianshui metropolitan area

1 Introduction

Under the guidance of Xi Jinping's Thought on Socialism with Chinese Characteristics for a New Era, it will adhere to the new urbanization strategy that focuses on human beings, continue to push forward the democratization of the rural population, actively promote the integrated development of urban and rural areas, and modernize the construction and governance of cities and towns, so as to lay a solid foundation for the comprehensive completion of socialist modernization.[1] . Taking urban agglomeration as the main form, the urban spatial layout of "one core and two centers" with Lanzhou-Baiyin metropolitan area as the core and Tianshui-Jiuquan-Jiayuguan as the secondary centers, the city agglomeration and metropolitan area will be promoted to be organically linked, and the coordinated development of large, medium-sized and small cities as well as small towns will be promoted. Actively promote the construction of Longdongnan town belt and vigorously develop Tianshui metropolitan area.[1] The city of Tianshui will be developed vigorously. With Qingshui, Zhangjiachuan, Wushan, Xihe,

Li County, Cheng County, Hui County, Liangdang and other 18 counties as the axis, there are more than 170 organized towns, forming a sub-town system.

Therefore, in order to improve the practical operability of the definition of the scope of attractiveness of the Tianshui metropolitan area, based on the reference of the existing information, we utilize the theory of improving the breaking point to explore the attractiveness of the Tianshui metropolitan area in the preliminary stage, demonstrate the current status of its development at the present stage, and put forward some practical and feasible suggestions for the development of the Tianshui metropolitan area.

2   Study Area and Research Methodology

2.1   Study Area

Tianshui metropolitan area is located in the eastern region of Gansu, with a special geographic location, Tianshui city is the sub-center city of Gansu province, and also the sub-core city of Guanzhong Plain City Cluster[2] Tianshui is the deputy center of Gansu Province and the sub-core city of Guanzhong Plain City Cluster. The Tianshui metropolitan area plays an important role in driving the development of the entire south-east Longdong region, with a radiated area including 18 counties and cities such as Qingshui and Zhangjiachuan, and more than 170 towns and villages.[3]. According to the "Gansu Provincial Township System Plan (2013-2030)" adopted in April 2015[4] (2013-2030) (hereinafter referred to as the "Plan"), Tianshui metropolitan area, Tianshui city center, Sanyangchuan, Gangu, Qin'an as the core of the construction, vigorously constructed to become a high degree of integration of urban and rural metropolitan area structure (as shown in Figure 1), but also strengthened between the region, the interconnection between the cities to promote common development, the construction of a modern metropolis, Tianshui is also the core of the cooperation of Gansu-Shaanxi, is the Silk Road Economic Belt on the core of the city, is the Silk Road Economic Belt on the Silk Road Economic Belt. Tianshui is also the core city of Gansu-Shaanxi cooperation and an important place for trade and exchange on the Silk Road Economic Belt.[5] The establishment of the Tianshui metropolitan area The establishment of Tianshui metropolitan area not only plays a role in the development of its own spatial structure, but also for the development of the surrounding 18 counties and cities have a radiating effect, therefore, the construction of Tianshui metropolitan area is of great significance, not only for its own spatial structure of the optimization of the development of the region, but also for Gansu Province and its Tianshui City surrounding the region has a great impact on the economic development of Tianshui City, Tianshui city, the construction of the metropolitan area, a powerful enhancement of the organic links between the region, which is of great significance. The construction of Tianshui metropolitan area is of great significance, not only for the optimization of its own spatial structure, but also for the economic development of Gansu Province and its surrounding areas.
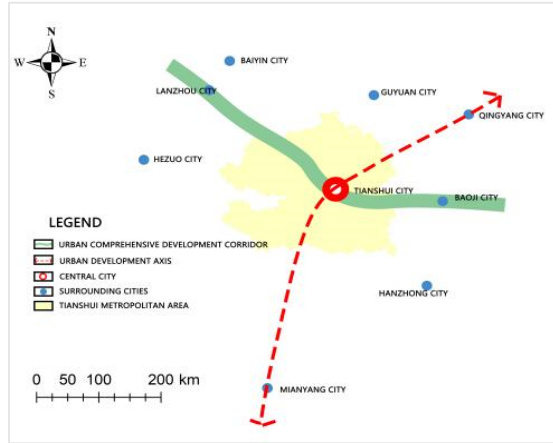
Fig. 1. Tianshui Metropolitan Area Development Guideline Map

2.2   Research Methodology

Fracture point theory is a theory of city-region interactions, developed by P.D. Converse in 1949 as a development of W.J. Reilly's "law of retail gravity".[6] The law of retail gravity.

The doctrine is that the attractiveness of a given city to its surroundings is directly proportional to its size and inversely proportional to the square of the distance from it[7] . Therefore, the point at which the attractiveness of two cities in close proximity to each other reaches an equilibrium is the breaking point. The equations for the cut-off point of the area of influence of two cities and the breaking point are shown below:

$$\begin{cases} d_A = D_{AB} / (1 + \sqrt{p_B / p_A}), \\ d_B = D_{AB} / (1 + \sqrt{p_A / p_B}). \end{cases} \tag{1}$$

Where: d_A and d_B are the distances from the rupture point to cities A and B respectively; D_{AB} is the straight-line distance between cities A and B; P_A and P_B are the population sizes of cities A and B respectively.

In equation (1), the comprehensive size of the city is represented by the population size, but nowadays, with the development of the society, the population size can not represent the overall size of a city, therefore, in this study, i.e., to improve the breaking point theory, the population size and the city's gross domestic product (GDP) are utilized to represent the comprehensive size of the city. Here X_1 represents the city's resident population and X_2 represents the city's GDP. In the course of social development, the city's population size and GDP can reflect the level of development of a society, for example, the city with higher GDP has a larger city size, and the city with a larger population size has a faster economic development.[8] Therefore, there exists a

certain rationality in using the population size and the gross economic product to represent the comprehensive size of the city, and we use the calculation method of geometric mean to finally arrive at the Y value of the comprehensive size of the city. The mathematical formula is expressed as:

$$Y = \sqrt{X_1 X_2}$$

(2)

Where: Y refers to a city's composite size indicator, X_1 and X_2 refer to the city's resident population and GDP, respectively.

Fracture point theory is widely used in the field of urban planning, mainly for the calculation of spatial structure attraction between two neighboring cities, based on the fracture point theory and the application of the fracture point formula, scientific calculations, the fracture point between a city and its neighboring cities, and then connect its fracture point, you can judge the spatial attraction range of the center of the city, and thus to judge and validate the scope of the development of the city. Question[9] .

According to the eight cities to Tianshui fracture point, respectively, to determine the distance L and (2) formula obtained by the city of the integrated scale Y two to express the city's radiation intensity[10] Thus, the geometric mean of the two indicators of the eight cities can be obtained separately, and the geometric mean indicates the spatial radiation intensity of the city to Tianshui city, and the formula expression is:

$$R = \sqrt{LY}$$

(3)

Where: R refers to the spatial radiation intensity of a city; L and Y refer to the distance from a city to the breakpoint in the Tianshui direction and the city's comprehensive urban scale, respectively.[11-12] .

3   Calculation and Analysis

3.1   Data Sources and Processing

The core data used in this paper include population data and GDP data from the Seventh Population Census (hereinafter referred to as the "7th Census" data) and the Statistical Yearbook, respectively. The representative location points of each city are taken from the latitude and longitude points of the People's Government of that city in the Gaode map.

3.2   Calculation of the Combined Size of the Neighboring Cities of TSA

According to Equation (2), the comprehensive scale indexes of Tianshui City and eight neighboring cities were calculated respectively, and the detailed calculation results are shown in Table 1 below.

Table 1. Indicators for calculating the combined size of Tianshui City and its neighboring cities

sports event	Tianshui prefecture level city in Gansu	Lanzhou prefecture level city in Zhejiang	Baiyin prefecture level city in Gansu	Guyuan city in Ningxia	Qingyang prefecture level city in Gansu	Baoji prefecture level city in Shaanxi	Hanzhong prefecture level city in Shaanxi	Mianyang prefecture level city in north Sichuan, Sichuan's second city	Cooperative City
Resident population/million	295.44	441.53	150.21	115.19	215.84	326.47	318.00	489.80	11.22
GDP/billion dollars	813.88	3343.50	635.53	409.68	1022.26	2743.10	1905.45	3626.94	69.09
Integrated urban scale	490.36	1215.01	308.97	217.23	469.73	946.33	778.42	1332.84	27.84

3.3　Determination of the Scope of Attractiveness of TSA

The determination of the range of attractiveness between two neighboring cities is generally determined by the spatial straight-line distance between the two cities, in order to more reasonably and effectively represent the most real range of attractiveness of Tianshui City, in the selection of research city objects, the main selection of the eight cities relatively far away from Tianshui City so as to analyze the research, respectively, calculated the spatial straight-line distance between Tianshui City and the selected eight neighboring cities as follows Table 2 Table 2 shows.

Table 2. Spatial straight-line distances between Tianshui City and surrounding cities

surrounding cities	Lanzhou prefecture level city in Zhejiang	Baiyin prefecture level city in Gansu	Guyuan city in Ningxia	Qingyang prefecture level city in Gansu	Baoji prefecture level city in Shaanxi	Hanzhong prefecture level city in Shaanxi	Mianyang prefecture level city in north Sichuan, Sichuan's	Cooperative City

							second city	
Straight line distance/km	240.09	252.44	152.56	222.57	152.85	199.41	328.43	284.55

On the basis of the calculations in Tables 1 and 2, here we use the fracture point theory to determine the fracture points between Tianshui city and eight neighboring cities (Lanzhou city, Baiyin city, Guyuan city, Qingyang city, Baoji city, Hanzhong city, Mianyang city, and Cooperation city).

First, based on the above analysis and results, we replace P_B , P_A , with Y_B , Y_A in Equation (1), and then combine the results of Equation (2) and the data in Table 2, thus calculating, Tianshui to the surrounding, the breakpoints of the eight cities, as shown in Table 3 below.

Table 3. Calculation of fracture points from Tianshui city to neighboring cities

surrounding cities	Integrated urban scale	Straight line distance/km	Distance to fracture point/km
Lanzhou prefecture level city in Zhejiang	1215.01	240.09	146.84
Baiyin prefecture level city in Gansu	308.97	252.44	111.69
Guyuan city in Ningxia	217.23	152.56	60.98
Qingyang prefecture level city in Gansu	469.73	222.57	110.07
Baoji prefecture level city in Shaanxi	946.33	152.85	88.87
Hanzhong prefecture level city in Shaanxi	778.42	199.41	111.15
Mianyang prefecture level city in north Sichuan, Sichuan's second city	1332.84	328.43	204.37
Cooperative City	27.84	284.55	54.75

Secondly, based on the results of the distance to the breakpoints calculated in Table 3, combined with the natural boundaries of the city's spatial structure, transportation boundaries, administrative boundaries, and city boundaries, and other elements to determine the perimeter of the city of Tianshui, and the breakpoints of the cities, in turn, connected, and finally the attractiveness of the city of Tianshui can be derived as shown in Figure 2.
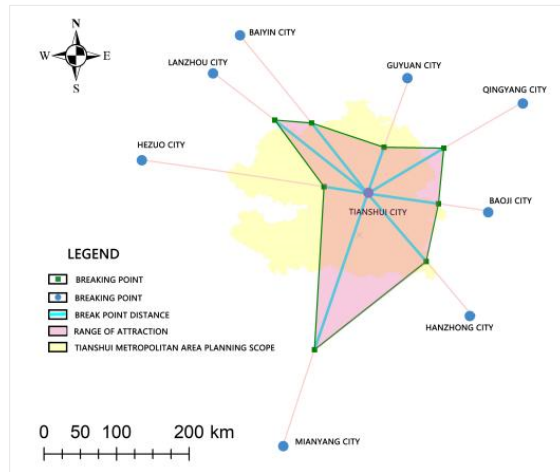
Fig. 2. Schematic diagram of the gravitational range of the Tianshui metropolitan area

Figure 2 shows that the urban attractiveness of Tianshui city is: in addition to the whole territory of Tianshui city in Wushan county, the whole territory of Xihe, Cheng, Hui and Liangdang counties, and the whole territory of Zhuanglang, Jingning, Tong-wei, Longxi, Lixian, Anding, Wen, Wudu, Kang, Liyang, Chencang, and part of Long counties, which is analyzed according to the results of the delineation, and the attrac-tiveness of the city of Tianshui city is not exactly the same as the scope of Tianshui metropolitan area in the "Plan". The scope of Tianshui metropolitan area is more and less than the original metropolitan area, for example, Anding District, Wen County, Wudu District, Kang County, Liuyang County, Chencang District, Huating City and part of Long County are within the scope of the attractiveness of Tianshui; the whole area of Wushan County, Dangchang County, and Zhang County, as well as part of Zhuanglang County, Jingning County, Longxi County, and Lixian County are not within the scope of the attractiveness of Tianshui.

Therefore, we can find that the urban attractiveness of Tianshui city has a close relationship with the development of the surrounding cities, and the development changes of the eight cities around Tianshui city in the study have a practical connection with Tianshui city, which is of great significance for the direction of the development of the spatial structure of Tianshui metropolitan area and the optimization of its con-struction.

4   Conclusion

As a must pass through the Eurasian continental line, the eastern gate of Gansu, adjacent to the northwest developed Shaanxi, close to the north of Sichuan, this study of Tianshui metropolitan area spatial structure optimization of the new scope of the quantitative measurement of the definition of the development of the development of the direction of the depth of the study in almost every direction, scientific and rational to improve

the city of Tianshui, the radiation capacity of external economic development, linkage with the joint development of its surrounding cities and regions, but also on its own economic and social development is an integral step. Steps, the optimization of the theory of research for regional development provides innovative ideas and methods.

This study, based on the quantitative study of the fracture point theory, found that the Tianshui metropolitan area can be delineated with new boundaries, breaking the limitations of the traditional administrative divisions, and that the new Tianshui metropolitan area includes the entire city of Tianshui, Xihe County, Li County, Cheng County, Hui County, Liandang County, Zhuanglang County, Jingning County, Tongwei County, Zhang County, Longxi County, and part of the county boundaries of Dangchang County; and part of the city boundaries in the following districts: Anding District, Wenshen District, Wudu District, Kang County, Loyang County, Chencang District, Huating City, and Long County. , Chencang District, Huating City and part of Long County.

References

1. Gansu Province New Urbanization Plan (2021-2035). https://www.3gcj.com/z-220657.html,2021-12-10.
2. Bai Yongping. Adhere to the spirit of the 20th CPC National Congress as a guide to speed up the construction of socialist modernization, happiness and good new Tianshui[N]. Gansu Daily,2022-11-24(002).
3. Jing Chunyan. Tianshui City Investment: "Reform Thinking" Releases Endogenous Power[N]. Tianshui Daily, 2022-11-21(001).
4. XU Tai, E Chongyi, JIANG Xingbo, ZHANG Zhuo, ZHU Xiulan, ZHANG Jufeng, LI Yanju, YANG Fengfeng. Development status and comprehensive management measures of cluster geologic hazards in Beishan, Qinzhou District, Tianshui City[J]. Science, Technology and Engineering,2021,21(32):13614-13627.
5. Gansu Provincial Department of Housing and Urban-Rural Development. Gansu urban system planning (2013 ~ 2030)[R]. Lanzhou: Gansu Provincial Department of Housing and Urban-Rural Development, 2015.
6. Pan Juan. Research on spatial linkage pattern and synergistic development based on improved gravity model--Taking Nanjing metropolitan area and Suzhou-Wuxi Chang metropolitan area as examples[J]. Modern Business Industry,2022,43(22):40-42.
7. LUAN QIAOLIN,ZHANG YONGLEI,WU JIWAN,XIONG CHANGSHENG,PENG YUCHEN. Spatial correlation analysis of towns and cities based on network modeling and spatial gravity model[J]. Shanghai Land Resources,2022,43(03):69-75.
8. CUI Junhui, LONG Limin, ZHAO Tongyao. Research on the development pattern and spatial scope of metropolitan area in Hebei Province[J]. Journal of Hebei Academy of Sciences,2023,40(01):58-66.
9. WANG Jieyu. Study on the change of spatial influence range of central cities based on the fracture point theory[J]. Journal of Hebei Academy of Sciences,2010,27(01):56-59.
10. JIE Manbin, CHAI Qi, ZHANG Wendu. Gansu Tianshui blows the "rallying cry" for five-chain integration of science and technology innovation[N]. Science and Technology Daily, 2024-02-02(007).DOI:10.28502/n.cnki.nkjrb.2024.000673.

11. JIE Manbin, CHAI Qi, ZHANG Wendu. Gansu Tianshui blows five chain integration science and technology innovation "rallying cry"[N]. Science and Technology Daily, 2024-02-02(007).DOI:10.28502/n.cnki.nkjrb.2024.000673.

12. TANG Xianglong,YANG Qian. Optimization of spatial structure of Lanzhou metropolitan area based on fracture point theory[J]. Journal of Lanzhou Jiaotong University,2019,38(03):1-6+20.