Identification and Spatial Optimization Strategies for Dunhuang's Charming Territorial Space: A Postprint

Authors: Chen Tianhao, Fang Haozhou

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Abstract

Research on charming territorial space under the background of national territorial space planning constitutes an important pathway for constructing and perfecting the territorial space pattern in the new era, and exploring its connotation mechanism and spatial identification pathway holds significant meaning for enhancing regional cultural confidence, enriching social life, and protecting the ecological environment. Taking Dunhuang, a typical city in the northwest desert oasis region, as an example, this study comprehensively identifies Dunhuang's charming territorial space by constructing an identification and evaluation index system for Dunhuang's charming territorial space and employing spatial analysis methods such as the grey correlation model, kernel density analysis, and standard deviation ellipse, and proposes spatial development strategies for the identification results.

The results indicate: (1) Dunhuang's charming territorial space exhibits a spatial distribution pattern of "large dispersion, small concentration," with the charming territorial space presenting a spatial pattern of southeast continuity and northwest dispersion.

(2) Dunhuang's existing charming territorial space demonstrates a close relationship with medium-high density zones of charming territorial space, with historical and cultural value serving as the primary evaluation factor influencing existing charming territorial space. Potential charming territorial space exhibits a positive correlation with low-density zones of charming territorial space, with natural ecological value serving as the primary evaluation factor influencing potential charming territorial space.

(3) Dunhuang's charming territorial space demonstrates an east-west orientation, with Dunhuang's charming space being most significantly influenced by the Gobi desert, oasis water system, and historical culture.

(4) Dunhuang's charming territorial space has overall formed a charming territorial space system structure of "charming cities leading development, charming corridors connecting development, and charming nodes being classified and shaped," with six high-quality charming territorial spaces constituting Dunhuang's high-quality territorial space development pattern.

Full Text

Research on Identification and Spatial Optimization Strategies of Dunhuang's Attractive Territorial Space

CHEN Tianhao[1], FANG Haozhou[2]
(1. School of Architecture and Urban Planning, Suzhou University of Science and Technology, Suzhou 215011, Jiangsu, China;
2. Gansu Guancheng Planning and Design Research Co., Ltd., Lanzhou 730070, Gansu, China)

Abstract

Research on attractive territorial space in the context of national spatial planning is an important pathway for constructing and improving the territorial spatial pattern in the new era. Investigating its connotation mechanism and spatial identification path holds significant meaning for enhancing regional cultural confidence, enriching social life, and protecting the ecological environment. Taking Dunhuang, a typical city in the desert oasis region of northwestern China, as a case study, this paper constructs an evaluation index system for identifying Dunhuang's attractive territorial space, employs spatial analysis methods such as the gray correlation model, kernel density analysis, and standard deviation ellipse to comprehensively identify Dunhuang's attractive territorial space, and proposes spatial development strategies based on the identification results. The findings indicate that: (1) Dunhuang's attractive territorial space exhibits a spatial distribution pattern of "large dispersion, small concentration," characterized by a continuous spatial pattern in the southeast and a dispersed pattern in the northwest. (2) Dunhuang's existing attractive territorial space is closely related to medium-high density areas of attractive territorial space, with historical and humanistic value being the primary evaluation factor influencing existing attractive territorial space. Potential attractive territorial space is positively correlated with low-density areas of attractive territorial space, with natural ecological value being the main evaluation factor affecting potential attractive territorial space. (3) Dunhuang's attractive territorial space is oriented in an east-west direction, with the Gobi Desert, oasis water systems, and historical culture exerting the greatest influence on Dunhuang's attractive space. (4) Dunhuang's attractive territorial space has formed an attractive territorial spatial system structure of "attractive cities leading development, attractive corridors linking development, and attractive nodes shaping through classification," with six high-quality attractive territorial spaces constituting Dunhuang's

high-quality territorial spatial development pattern.

Keywords: attractive territorial space; high quality; existing/potential; spatial identification; spatial optimization strategies; Dunhuang City

1.1 Connotation

The term "charm" originally meant "a power that is extremely attractive"[1]. Contemporary academic circles have explored its connotation from perspectives such as sociology[2], economics[3], and psychology[4]. The charm studied in this paper is primarily materialized through physical resources and expressed via geographical space, namely attractive space. The essence of charm comprises value and attractiveness, which are interdependent and inseparable. In geography, value is typically manifested as tangible and intangible value—where tangible value is carried by physical spaces such as oases and deserts, and intangible value is carried by non-physical spaces such as history and culture. Attractiveness is usually divided into intrinsic emotions (such as feelings, beliefs, etc.) and extrinsic materials (such as scenic spots, cultural heritage sites, etc.), creating appeal through their own characteristics and connotations. As the embodiment of value and the sublimation of attractiveness, charm is represented at the material level through attractive resources, subsequently forming attractive space in geographical space and deriving both existing attractive space and potential attractive space, which together constitute attractive territorial space (Fig. 1). Attractive territorial space refers to that portion of territorial space which, under specific historical stages, regional scopes, cognitive levels, and supply-demand contexts, exists naturally or has been artificially transformed (constructed), provides functional guarantees for biological habitats and human survival and development, and is recognized and perceived by humans as having good value and attractiveness[5]. High-quality attractive territorial space further extracts the elements with the highest value and attractiveness from natural, historical, humanistic, and social dimensions, forming greater recognition and appeal, and exerting a leading and driving role in regional patterns.

1.2 Research Framework

Based on Dunhuang's natural geographical pattern, historical and cultural characteristics, and historical development context, combined with the delineation and shaping of Dunhuang's "production-living-ecological" spaces under the background of territorial spatial planning, this paper classifies Dunhuang's attractive territorial space into three major types: cultural attractive space, productive attractive space, and ecological attractive space. Through a research pathway of "sorting out the background, identifying spaces, shaping patterns, and determining strategies," this study investigates Dunhuang's attractive territorial space, constructing a basic framework for an attractive territorial spatial pattern of "city (point) - corridor (line) - area (plane)," forming three major attractive areas of culture, agriculture, and ecology in Dunhuang, and proposing development strategies according to the characteristics of each type of space (Fig. 2).

2.1 Study Area Overview

Dunhuang is located in the inland desert region of northwestern China, at the junction of Gansu, Qinghai, and Xinjiang provinces. Geologically, it belongs to the western end of the Hexi Corridor depression zone and the southern margin of the Tarim Plateau. Its diverse natural foundation has created a "grand garden" of landforms[6]. Its unique location and geographical pattern have made it a convergence center for multiple cultures, including religious art, Silk Road trade, and frontier military culture[7].

2.2.1 Data Sources

The data involved in this research mainly includes two types: vector spatial data and non-vector data. Vector spatial data primarily consists of resource points, including cultural heritage protection units, natural geographical location data, and other tourist attractions. Non-vector data mainly includes statistical data, resource distribution and characteristic description data, and tourist evaluation data, with sources detailed in Table 1.

2.2.2 Construction of the Attractive Territorial Space Index System

To objectively present the natural, ecological, historical, and humanistic values of Dunhuang's attractive resources, indicator selection follows the principles of scientific rigor, objectivity, authenticity, and accessibility. Building upon previous research[8-10] and combining Dunhuang's actual resource endowments and historical-cultural characteristics, the index system was revised through expert consultation and the Delphi method. Ultimately, 13 sub-indicators were selected from three dimensions—natural ecological value, historical and humanistic value, and resource influence value—to form the evaluation index system for Dunhuang's attractive territorial space. Since all indicators selected in this paper play a positive role in shaping Dunhuang's attractive space, all evaluation indicators are positive indicators. The evaluation index system is presented in Table 2.

This paper takes Dunhuang's municipal area as the research scope and attractive resource points as the basic evaluation units. Based on their value classification and attractiveness type, attractive resources are divided into existing attractive resources and potential attractive resources. Through data collection and web-based big data mining, 67 existing attractive resource points and 143 potential resource points were obtained. Existing attractive resources include national, provincial, and county-level A-grade scenic spots, forest parks, geological parks, exhibition halls, museums, and cultural heritage protection units. Potential attractive resources include mountains, water bodies, forests, and cultural heritage protection units that are ungraded and undeveloped. Using the evaluation index system constructed in this paper, each attractive resource point was graded and classified into three levels, with scores of 1-3 assigned according to the resource type value level, yielding the classification results of attractive resource points (Table 3).

2.3.1 Improved Gray Correlation Model

In this study of attractive territorial space, to ensure the objectivity and authenticity of identification results while maintaining public recognition and acceptance, an improved gray correlation model is employed to assign weights.

The gray correlation model is a method that overcomes traditional subjective weighting by determining weights based on mathematical models. However, the traditional gray correlation model has obvious shortcomings, such as excessive randomness in indicator weight determination and uncertainty in weights. The improved gray correlation model for solving indicator weights can overcome the influence of decision-maker subjectivity, making the weight results for attractive territorial space evaluation indicators more scientific and objective. The specific improved algorithm steps are as follows[11]:

First, construct and standardize the original matrix and data. Second, calculate the distance between each indicator sequence X_i and the optimal vector, using Formula (1):

$$D_i = \sum_{k=1}^{m} |X_i(k) - W(k)|$$

Third, calculate the weight of each indicator, using Formula (2):

$$w_i = 1/D_i$$

Finally, calculate the normalized weight of each indicator, using Formula (3):

$$w_i^* = w_i / \sum_{i=1}^{n} w_i$$

2.3.2 Kernel Density Analysis Method

Kernel density is a measure that reflects the clustering characteristics of spatial point elements. Based on Dunhuang's attractive resource points, this paper estimates the clustering and influence degree of adjacent or surrounding attractive resource points. The ArcGIS kernel density analysis tool is used to conduct kernel density analysis on different types of attractive resource points separately. Indicators are classified using the standard deviation stretching method, with the n value set to 1000m. The identification results of attractive territorial space are graded and classified using the natural breaks method. The calculation formula for kernel density analysis of attractive resource points is as follows[12]:

$$f_n(x) = 1/(nh^2) \sum_{i=1}^{n} k((x - X_i)/h)$$

Where: f_n(x) is the estimated kernel density value at point x on the plane; k is the kernel function; n is the number of attractive resource points; h is

the bandwidth, determined based on the distance between attractive resource points; x is the distance from a certain attractive resource point x to other attractive resource points X_i.

2.3.3 Standard Deviation Ellipse

The standard deviation ellipse is a spatial statistical method that represents the spatial variation and distribution characteristics of attractive resource points. This paper uses it to reflect the centroid distribution and movement trends of attractive resources. The ellipse centroid reflects the main clustering location of attractive resources, the ellipse rotation angle reflects the primary trend direction of spatial distribution, and the long and short axes reflect the degree of dispersion of attractive resources in different directions. The calculation formulas are as follows[13]:

$$SDE_x = \sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2/n}$$

$$SDE_y = \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2/n}$$

$$\theta = \arctan((\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y}))/(\sum_{i=1}^{n}(x_i - \bar{x})^2 - \sum_{i=1}^{n}(y_i - \bar{y})^2))$$

Where: x_i, y_i are the coordinates of each attractive resource point; $\bar{x}$, $\bar{y}$ are the coordinates of the mean center resource point; SDE_x, SDE_y are the deviation distances in the x and y directions from the mean center resource point; is the ellipse rotation angle.

3.1.1 Distribution Characteristics of Existing Attractive Territorial Space

Existing attractive territorial space is obtained by superimposing three types of spaces: existing natural ecology, historical humanities, and resource influence (Fig. 4). From the perspective of existing natural ecological value (Fig. 4a), high-density areas are distributed in four natural ecological regions: the Mingsha Mountain-Yueya Spring scenic area near Dunhuang's central urban district, the Yangguan National Nature Reserve to the southwest, and the Xihu National Nature Reserve and Yadan National Geopark to the northwest. Among these, the natural landscape value factor has the highest influence, with a maximum kernel density of 0.0021. From the perspective of existing historical and humanistic value (Fig. 4b), high-density areas are relatively dispersed, mainly comprising existing historical and cultural regions represented by the Mogao Grottoes, Xuanquanzhi, and Yumen Pass, as well as cultural heritage protection units from various periods in Dunhuang, reflecting Dunhuang's existing historical and humanistic value. The historical and cultural value factor has the highest influence, with a maximum kernel density of 0.0018. From the perspective of existing resource influence value (Fig. 4c), Dunhuang's 5A-level scenic

spots are the main sources of resource influence both domestically and internationally, with the crowd perception factor having the highest influence and a maximum kernel density of 0.0016. Dunhuang's existing attractive territorial space is closely related to medium-high density areas of attractive territorial space, with historical and humanistic value being the primary evaluation factor influencing existing attractive territorial space, indicating that Dunhuang's attractive pattern mainly relies on developed and utilized territorial space, and its distribution is closely linked to human activities and socio-economic evolution.

Dunhuang's existing attractive territorial space exhibits concentrated distribution characteristics. The attractive space formed by existing attractive resource points is mainly distributed in Dunhuang's central urban district, Yangguan Town, and along the Dang River, forming a tourism belt, with a small portion distributed along the Shule River. Existing attractive territorial space demonstrates two spatial distribution features: first, existing attractive space distributed along the Dang River and Shule River in the western desert oasis of Dunhuang, indicating that existing attractive space is closely related to water resource distribution and human behavioral activities; second, historical attractive space dominated by human activities such as Dunhuang's 5A-level scenic spots, cultural heritage protection units, and various historical sites, showing that over time, Dunhuang's existing attractive space has changed with the prosperity and decline of Dunhuang's socio-economy.

3.1.2 Distribution Characteristics of Potential Attractive Territorial Space

Potential attractive territorial space is obtained by superimposing potential natural ecological value, potential historical and humanistic value, and potential resource influence value (Fig. 5). From the perspective of potential natural ecological value (Fig. 5a), the Shule River and Dang River corridors are the main ecological corridors, with abundant natural ecological elements in the surrounding areas. Shazhou urban district relies on the advantages of oasis resources, with a large number of potentially undeveloped and unutilized natural ecological elements surrounding it. The natural landscape value factor has the highest influence, with a maximum kernel density of 0.0013. From the perspective of potential historical and humanistic value (Fig. 5b), Dunhuang's potential historical and humanistic value areas are mainly distributed in the central urban district, around Yangguan Town, and along the Shule River, with a relatively wide spatial distribution. The main types are unpublished cultural heritage protection units and ancient buildings and tombs with long histories. The historical and cultural value factor has the highest influence, with a maximum kernel density of 0.0012. From the perspective of potential resource influence value (Fig. 5c), Dunhuang's potential resource influence value areas are concentrated in the central urban district, Yangguan Town, and along the Dang River corridor. The geological parks and nature reserves in the northwest are also potential resource influence distribution areas. The crowd perception factor has the highest influence, with a maximum kernel density of 0.0011. Potential attractive territorial space is positively correlated with low-density areas of attractive territorial

space, with natural ecological value being the main evaluation factor influencing potential attractive territorial space, indicating that the desert natural ecological landscapes formed by Dunhuang's special geography and climate still have considerable potential.

Overall, Dunhuang's potential attractive territorial space is relatively dispersed and widely distributed, indicating that Dunhuang's potential attractive space has high development potential, and most of the attractive space that can be recognized and familiarized by humans has not yet been explored. The attractive space formed by potential attractive resource points is mainly distributed in the southeastern part of the central urban district, along the Shule River, and in Yangguan Town.

3.1.3 Dunhuang's Attractive Territorial Space Pattern

Based on the evaluation results of existing and potential attractive spaces, Dunhuang's attractive territorial space evaluation results were obtained through comprehensive overlay analysis (Fig. 6). The kernel density analysis results were reclassified into five levels using the natural breaks method, yielding the identification results of Dunhuang's attractive territorial space (Fig. 6). Overall, Dunhuang's attractive territorial space exhibits a spatial distribution pattern of "large dispersion, small concentration," presenting a continuous spatial pattern in the southeast and a dispersed pattern in the northwest. Medium-high density areas are mainly concentrated in Dunhuang's central urban district, northwestern Mogao Town, and northern Yueyaquan Town—the core area of Dunhuang's desert oasis—where attractive territorial spaces are interconnected and spatial agglomeration effects are significant. Low-density areas are mainly scattered in the northern desertified regions of Dunhuang with potential value, where attractive territorial spaces are relatively discrete, with long spatial distances and insignificant spatial agglomeration effects.

According to the resource types of attractive resource points, existing attractive resource points are classified into natural resources, humanistic resources, cultural heritage protection units, and tourist attractions; potential attractive resource points are classified into cultural heritage protection units, mountain valleys, water resources, and Gobi deserts. Based on the value potential and attractiveness degree of each resource type, scores are assigned to obtain the classification system of Dunhuang's attractive resource points. Using this classification system and standard deviation ellipse analysis, the spatial direction and central distribution of Dunhuang's attractive territorial space are obtained (Fig. 7). In terms of ellipse area, the standard deviation ellipse area of existing attractive resources is smaller than that of potential attractive resources overall, indicating that existing attractive resources have a higher degree of spatial agglomeration. In terms of ellipse axes and rotation angle, Dunhuang's attractive space is primarily oriented east-west, with the standard deviation ellipses of Gobi desert attractive space, water resource attractive space, and cultural heritage protection attractive space having the strongest summarizing capability for Dunhuang's attractive territorial space, indicating that Dunhuang's attrac-

tive space is most heavily influenced by the Gobi desert, oasis water systems, and historical culture.

3.1.4 Identification of Dunhuang's Attractive Territorial Space

Based on the analysis of Dunhuang's attractive territorial space pattern, combined with evaluation factors and perspectives of natural resource endowments, historical and cultural values, and socio-economic development, a multi-level spatial development system of points, lines, and areas for Dunhuang's attractive territorial space is proposed. This forms an attractive territorial spatial system structure of "attractive cities leading development, attractive corridors linking development, and attractive nodes shaping through classification" (Fig. 8). Attractive cities are primarily based on areas with kernel density values greater than 2.1 from the attractive territorial space identification kernel density analysis results, combined with the distribution of ellipsoid centers of standard deviation ellipses for different resource types from the attractive resource point standard deviation ellipse analysis, forming the artistic pastoral city attractive spaces of Shazhou Prefecture City, Dunhuang County City, Qili Sub-center, Mingsha Mountain-Yueya Spring Area, and Mogao Area. Attractive corridors link discontinuous patches with kernel density values between 0.2 and 2.1 from the attractive territorial space identification results, while incorporating linear resources such as the Silk Road, frontier passes, and the Great Wall to form three attractive corridors: the Silk Road style attractive corridor, the desert frontier attractive corridor, and the Great Wall culture attractive corridor. Attractive areas are patches with kernel density values greater than 0.2 from the attractive territorial space identification results, combined with the distribution of attractive cities, the direction and size of standard deviation ellipses for different resource types from the attractive resource point standard deviation ellipse analysis, and the spatial distribution of Dunhuang's historical culture, oasis agriculture, and desert ecology to form three major attractive areas—cultural, agricultural, and ecological—comprising seven attractive spaces.

Based on the above identification results, relying on the three major patterns of Dunhuang's attractive space, historical and cultural protection, and tourism development, attractive resources with relatively high value and capable of representing Dunhuang's characteristics are selected as the core for construction. According to the value and attractiveness of natural, historical, humanistic, and social elements in the formation process of attractive territorial space, existing spaces are refined, integrated, and optimally laid out, ultimately forming six characteristic high-quality attractive territorial spaces of Dunhuang: Mogao Reverence, Yuequan Sand Ridge, Eternal Yangguan, Yumen Solitary Pass, Magical Yadan, and Nanquan Wild Interest (Fig. 8).

3.2.1 Mogao Reverence High-Quality Attractive Territorial Space

The Mogao Reverence high-quality attractive territorial space consists of the key protection zone and general protection zone of the Mogao Grottoes, as well as the Sanwei Mountain scenic area. It borders the Mingsha Mountain-

Yueya Spring scenic area to the west, adjoins the Mogao Area to the north, and faces Shazhou Prefecture City to the northwest. The spatial development strategy for this area should first strictly protect the core zone of the grottoes complex, second, excavate the Buddhist cultural value of Sanwei Mountain, rely on the foundation of Mogao Town, combine with the digital center and the "See Dunhuang Again" performance project, and enhance the area's landscape with the theme of Silk Road culture.

3.2.2 Yuequan Sand Ridge High-Quality Attractive Territorial Space

The Yuequan Sand Ridge high-quality attractive territorial space uses the Mingsha Mountain-Yueya Spring scenic area as its spatial carrier. Relying on the existing tourist attractions, it aims to improve the quality of core area infrastructure and services, while connecting surrounding homestays, Leiyin Temple, Dunhuang History Expo Park, and other scenic spots to form a Dunhuang desert leisure resort area. In terms of tourism experience, it should strengthen innovation in desert sports products and increase leisure offerings such as desert exploration, convalescence, vacation, and performance activities.

3.2.3 Eternal Yangguan High-Quality Attractive Territorial Space

The Eternal Yangguan high-quality attractive territorial space consists of the Yangguan ruins, Yangguan Museum, Wowachi Wetland Park, Shouchang ruins, and Yemawan Natural Scenic Area. It is a high-quality attractive territorial space that integrates frontier pass cultural situational experiences with oasis leisure and vacation. The development focus relies on the museum to deeply explore the connotation of military culture and strengthen living inheritance and situational experiences.

3.2.4 Yumen Solitary Pass High-Quality Attractive Territorial Space

The Yumen Solitary Pass high-quality attractive territorial space consists of the Yumen Pass scenic area, Han Great Wall ruins, beacon towers, Hecang City, and the large and small Fangpan City. It is a high-quality attractive territorial space that integrates frontier pass cultural memory with desert ecological wild interest. Spatial development should center on protective exploitation, excavate frontier pass ruins and Silk Road culture, transform heritage into experiential, study-oriented, and visitable tourism products, strengthen creative display, improve supporting facilities such as tourism distribution centers, resorts, and catering, and enhance service functions.

3.2.5 Magical Yadan High-Quality Attractive Territorial Space

The Magical Yadan high-quality attractive territorial space consists of the Yadan National Geopark linked with other Yadan groups in Lop Nur and the Gobi Desert, forming a world-class geological-themed exploration and vacation high-quality attractive space. In the peripheral tourist areas outside the core protection zone, it should add themed and experiential leisure, sports, study, camping, photography, and other leisure experience and vacation projects to enhance the attractiveness and interest of Yadan scenic area tourism. Based on traditional

scenic area tours, it should increase technological tour innovations to improve the comprehensive service quality of the Yadan scenic area.

3.2.6 Nanquan Wild Interest High-Quality Attractive Territorial Space

The Nanquan Wild Interest high-quality attractive territorial space is mainly composed of the Shule River, Nanquan Wetland Nature Reserve, Hala Lake, poplar forests, and Han Great Wall ruins. The ancient Silk River channel connects oases, serving both as an ecological barrier and a migratory bird station. Nanquan Wetland is the core ecological area of Dunhuang's tourism ring. Development priorities include strictly protecting wetlands, carrying out ecological restoration and public welfare activities, adding Silk Road-style post stations and viewing platforms, and laying out themed camps along the river to reproduce Silk Road customs.

4 Discussion

This paper identifies Dunhuang's attractive territorial space based on the connotation of attractive territorial space, which closely aligns with Dunhuang's territorial spatial pattern and provides a theoretical basis for its territorial spatial system construction and attractive space identification, demonstrating certain innovation and breakthrough. The main contributions include: innovatively defining the connotation of attractive territorial space, starting from the value and attractiveness inherent in the term "charm," deeply analyzing the essence of attractive territorial space, dividing it into existing and potential categories with attractive resources as the carrier, covering all spatial types, highlighting the spatial attributes of resources, and guiding the determination of evaluation indicators; innovating identification methods and research approaches by establishing an evaluation index system through defining and interpreting territorial space connotation, employing spatial analysis methods such as kernel density analysis and standard deviation ellipse to identify Dunhuang's attractive territorial space, and refining and integrating it into Dunhuang's high-quality attractive territorial space in combination with high-quality development requirements, Dunhuang's regional characteristics, and various spatial protection and development patterns. The identification methods and research approaches are relatively novel, and the identification results are relatively accurate, holding significant meaning for shaping regional territorial spatial characteristics and promoting high-quality development of regional resources and environment.

Although this paper demonstrates certain innovation and breakthrough in the above aspects, the following issues remain for discussion: First, regarding the exploration of the identification index system. The attractive territorial space index system constructed in this paper has not yet evaluated urban development limiting factors (such as accessibility of transportation and other infrastructure, provision of public service facilities, etc.) and spatial control factors (such as ecological protection red lines, permanent basic farmland protection red lines), resulting in certain deviations in the identification results of attractive territorial space. Second, regarding the temporal dimension, attractive territorial space is

not only an important component of the current territorial spatial planning system but also an important spatial composition shaped by the integration of historical development stages and future development guidance. Therefore, the evolution of spatiotemporal patterns and future development prediction of attractive territorial space will be the focus of future research. The above discussions provide a theoretical foundation and spatial guidance for the high-quality development of urban territorial space and socio-economy, as well as for enhancing urban charm quality.

5 Conclusions

(1) Overall, Dunhuang's attractive territorial space exhibits a spatial distribution pattern of "large dispersion, small concentration," characterized by a continuous spatial pattern in the southeast and a dispersed pattern in the northwest. Medium-high density areas are mainly concentrated in Dunhuang's central urban district, northwestern Mogao Town, and northern Yueyaquan Town—the core area of Dunhuang's desert oasis—where attractive territorial spaces are interconnected and spatial agglomeration effects are significant. Low-density areas are mainly scattered in the northern desertified regions of Dunhuang with potential value, where attractive territorial spaces are relatively discrete, with long spatial distances and insignificant spatial agglomeration effects.

(2) In terms of evaluation factors, Dunhuang's existing attractive territorial space is closely related to medium-high density areas of attractive territorial space, with historical and humanistic value being the primary evaluation factor influencing existing attractive territorial space. Potential attractive territorial space is positively correlated with low-density areas of attractive territorial space, with natural ecological value being the main evaluation factor affecting potential attractive territorial space.

(3) In terms of identified spatial results, Dunhuang's attractive territorial space is oriented in an east-west direction, with the standard deviation ellipses of Gobi desert attractive space, water resource attractive space, and cultural heritage protection attractive space having the strongest summarizing capability for Dunhuang's attractive territorial space. Dunhuang's attractive territorial space has formed an attractive territorial spatial system structure of "attractive cities leading development, attractive corridors linking development, and attractive nodes shaping through classification," with six high-quality attractive territorial spaces constituting Dunhuang's high-quality territorial spatial development pattern.

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Note: Figure translations are in progress. See original paper for figures.