Article

Spatial Suitability Evaluation of an Arid City Based on the Perspective of Major Function Oriented Zoning: A Case Study of Urumqi City in Xinjiang, China

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Abstract: The realization of regional sustainable development has been a popular research topic during the process of urbanization. To explore the coordination relationships between urban development and ecological security—taking Urumqi city, a representative arid city in Xinjiang, China, as a study area—this study has constructed a framework of spatial suitability evaluation based on the characteristics of a Mountain–Oasis–Desert System (MODS) in an arid area under the framework of major function oriented zoning (MFOZ). A spatial overlay analysis using Geographic Information System (GIS) with a 5 m × 5 m grid or towns and streets as the basic unit was applied to comprehensively evaluate spatial suitability. The results showed that the study area was zoned into a forbidden development zone (as patches set in towns and streets), an ecological protection zone (nine towns or streets), a moderate development zone (16 towns or streets), and a key development zone (82 towns or streets), accounting for 30.35%, 32.50%, 23.79%, and 13.36%, respectively. The zoning results provided a basis to pointedly put forward the development and protection strategies of each administrative unit; and the research framework can be applied to other arid areas for the decision-making related to the urban space layout and environmental management.

Keywords: spatial analysis; relationships development and protection; urban sustainable development; ecological management; GIS

1. Introduction

With the continuous improvement of urbanization, the social–economic–ecological system of cities is undergoing huge changes [1,2]. On the one hand, cities supply good living environments, a large number of employment opportunities, convenient infrastructure, rich amounts of food and clothing, and other material aspects [3,4]. On the other hand, with the expanding of city scale and the decline of the countryside, the built up area is sprawling, urban space is eroding natural ecological space, and its change has caused the waste of land resources, natural resource depletion, soil erosion, urban ecological landscape fragmentation, degradation of ecosystem service function, and pollution [5]. These factors have profound influences on the spatial pattern of regional development [6,7]. Cities are under increasing pressure from both ecological protection and construction. In particular, arid cities possess that have the typical characteristic of a Mountain–Oasis–Desert System (MODS) [8], ecological basis are more vulnerable than other regions. Ecological factors are a limiting factor that cannot be
ignored in arid urban development [9]. Therefore, the realization of regional sustainable development has been a hot issue, and more and more attention has been paid to urban ecological security by the government and social organizations from all walks of life.

China has entered the comprehensive development phase of an ecological civilization [10,11], and many state-level space planning projects have been carried out to safeguard ecological security, such as the implementation of the “multiple planning integration” [12] and regional spatial planning [13] and the evaluation and early warming of the environment and resource carrying capacity of county in China [14], recently. The government department managers gave strategies and suggestions for the division of production space, living space, and ecological space under the Major Function Oriented Zoning (MFOZ) framework to realize the regional harmonious development [15,16]. Therefore, the rationality of urban space layout is a fundamental principle to measure regional harmonious development during the process of urbanization: Administrators must verify regional development background and explore the way to resolve regional development issues involving life-production-ecological space. Space suitability evaluation is necessary from the perspectives of ecological protection and space development potential.

The concept of Major Function Oriented Zoning (MFOZ) was first proposed to explore the coordination relations between urban development and ecological security by Chinese scholars [17,18]. According to the carrying capacity of resources and the environment, the density of existing development and the development potential, the MFOZ is divided into the urbanized area that provides industrial and service products as its main function, and the agricultural area that provides agricultural products as its main function, and the ecological area that provides ecological products as its main function [19–21]. Ecological products include the nature elements, namely fresh air, clean water, and a pleasant climate, that maintain ecological security, ensure ecological regulation, and provide a good living environment [22,23]. So, the concept of MFOZ provides ideas for small-scale spatial suitability evaluation [24]. Carrying out space suitability evaluation and dividing different functional areas according to development content is the scientific basis for optimizing the development pattern of land space and coordinating regional sustainable development, and it is also an important embodiment of implementing the strategy of MFOZ [25]. The completion of the MFOZ planning in China has raised the attention to environmental management in economic and social development.

According to the concept of Major Function Oriented Zoning (MFOZ) to balance the spatial relationship between development and protection, territory spatial layout in MODS is divided into a key development zone, moderate development zone, ecological protection zone, and forbidden development zone [26]. As shown in Figure 1, according to the different roles of regional development (B) and government regulation of the legal reserve, the relationship between development and protection of the natural element (C) is clarified, and ultimately, the type of spatial development (D) is determined in the different natural units (A), forming a preliminary judgment on the natural conditions and development layout of the study area. Therefore, city management can quickly move towards coordinated regional development in which urban construction land meets the needs of urban development and food safety, and ecological land ensures a stable pattern of regional ecological security.

Based on the framework of MFOZ and the development characteristics of natural and social factors in arid areas, this study seeks to emphasize the harmonious development of the production, living, and ecological spaces, to assess the natural foundation and socioeconomic development potential for the rational distribution of urban space, and to maintain rationality of land use and ecological safety under the influence of human disturbance. Therefore, we comprehensively considered the benefit of the socioeconomic and ecological environments. The aim of this study was to perform a research method of maintaining ecological security and urban harmonious development from the relationships of development and protection. The results provide scientific references for policy makers, planners, and project implementers in future work.
Figure 1. The relationship between natural units and the path of functional zoning in a Mountain–
Oasis–Desert System (MODS).

The main purposes of this study were: (1) to establish an index system of urban harmonious
development in an arid area from the perspectives of development and protection using GIS
spatial analysis methods; (2) to simultaneously evaluate the spatial suitability of natural units and
administrative units in order to build a new production-living-ecological space under the framework
of Major Function Oriented Zoning that meets the requirements of coordinated development at a small
scale; (3) to present a comprehensive research framework using aspects of urban economic and social
development ability, land suitability, water resources carrying capacity, and ecological background
that could be helpful in urban land use planning decisions and management of ecological environment
in an arid area.

2. Literature Review

There have been many studies on the rationality of urban spatial layout during the process of
urbanization. The suitability evaluation based on GIS was firstly proposed by McHarg in the 1960s,
he developed the “pastry mode” of land suitability assessment in the book “Design with nature”,
and then the method has been applied to the coordinated development of land use planning, urban
planning and green space planning [27]. With the wide application of GIS technology and RS data in
spatial analyses, their use has been gradually increasing for spatial suitability evaluations based on
overlay analysis [28]. In particular, the scholars are more interested in ecological suitability evaluation
that gradually develop from a single-factor assessment such as water security [29], biodiversity
conservation [30], and soil erosion protection [31] to multifactor comprehensive evaluation, such as
the landscape evaluation model [32], ecological vulnerability evaluation [33], ecological importance
evaluation [34], ecological function analysis [35], and multicriteria land suitability evaluation based on
GIS [36]. These changes can better reflect the inter-relationship between urban land expansion and
ecological protection.

Previous studies on spatial suitability evaluation applied in human geography usually have the
following features. Firstly they have been applied in many fields, such as regional planning [37],
landscape and environmental impact assessments [38], agricultural land suitability evaluations [39],
suitability of land spatial development evaluations [40], the suitability of underground space
exploitation and utilization [41], and ecological suitability evaluations of tourism development
land [42]. Secondly, the evaluation scales have been dominated by counties and cities in cross-regional research [43]. FANG Chuanglin proposed the concept of ‘multiscale urban agglomeration spaces’ for the optimization of Chinese land development, urbanization, agricultural development, and ecological security [44] The scale tends to become smaller in single city studies—the spatial resolutions in previous small scale studies have been 5 m, 10 m, and 30 m, etc. [45,46] and the resolution has mainly been 30 m, while it is 5 m in this study. The study area has gradually shifted from the plains to the mountainous areas that are ecologically fragile [47,48], and the research emphasis has been ecological factors [49,50]. Liu Xiaofu assessed the ecological suitability of Xiamen’s land under the consideration of ecological value, ecological sensitivity, and ecological function [51]. New methods, new models, and new perspectives are emerging in the development process of land suitability evaluation. Artificial intelligence methods promote the development of land suitability evaluation, Bennett et al. proposed a method for combining a land-based suitability evaluation based on the Agent model and artificial neural network technology in a GIS environment, and achieved good results [52]. Amin Tayebi proposed an urban growth boundary model using neural networks, GIS, and radial parameterization to estimate future urban growth boundaries under new perspectives [53]. The multifactor integrated overlay model based on GIS is widely used, which improves the accuracy and reliability of evaluation [54–56]. Thanh Tuan Nguyen designed a GIS-based multicriteria land suitability analysis that integrates agro-ecological aptitude, environmental impact, and socioeconomic feasibility criteria in a step-wise procedure combining recent advances in indicator selection, evaluation, and weighting of exploiting information from various data sources with functional mathematical combination procedures [57]. The selection of factors, the construction of indicator systems, and the setting of weights in the evaluation process are the main differences between various suitability evaluations. The selection of the evaluation factors and the determination of the weights are mostly based on the Delphi method and the analytic hierarchy process [58]. The current research hotspot in China is the optimization of spatial development patterns based on the ecological-production-living space [59–61]. However, most studies have mainly focused on some aspects of natural ecology, and they do not fully reflect the spatial characteristics of the socioeconomic–ecological system in study area because they lack comprehensive consideration of development and protection under the influence of human disturbance.

3. Methods

3.1. Principles of Index Selection

The main purpose of spatial suitability evaluation of an arid city is to provide a basis for the optimization of a spatial development pattern, i.e., to find out the promoting roles of population and economic factors to regional development (space development potential), the capacity of soil and water resources to regional development (space development foundation), and the constraint factors of the natural environment to regional development (space development constraint). According to the natural and social attributes of arid areas and their operability, spatial suitability evaluations should include evaluation of the ecological background, water resources carrying capacity, land construction suitability, and social and economic development ability, and they should also consider the influence of policies and regulations on the spatial layout. The evaluation process and specific indicators of spatial suitability are shown in Figure 2.
The selection of social and economic development ability indexes

Social and economic development ability is one of the most important indexes to reflect the status of social and economic development in urban development. Socioeconomic data is collected through the statistical yearbooks, Google maps, and field surveys, and the indicators are set by the frequency statistics method, the theoretical analysis method, and the expert consultation method. Therefore, three indexes that characterize the foundation and potential of economic development were selected to evaluate the social and economic abilities of the arid city: population trend, economic potential, and transportation advantage. The population trend reflects the population density and population agglomeration, and higher values indicate a high population density and strong vitality of population flow in the region. Economic potential reflects changes in per capita GDP and GDP growth rates. A higher evaluation rating shows a higher strength of economic development in the region. Transportation advantages, including road and railway network density, reflect the ability of the transportation infrastructure to support the economic and social development of administrative units, so higher scores show a greater ability to support regional development.

Selection of land suitability indexes

The land suitability evaluation is to assess the suitability of certain types of land use for construction land. Considering the urban development goals, the current situation of urban land use, and the existing problems in current urban construction, four factors—slope, elevation, land cover status, and landform—are measured. The existing land cover directly determines the spatial suitability of land development. Through the digitization of the land use status map, the land cover vector is obtained, and the construction suitability is scored according to different land cover types. Larger values indicate the type. The vector map of land cover is obtained through digitizing present land-use map, and then it is scored according to different land cover types, and higher scores indicate that the type of land cover is more suitable for construction. Based on the Vertical Planning of Urban Land Use (CJJ 83-99) and combined with the local actual situation, the slope and elevation are assigned.

Figure 2. The ideas and processing of spatial suitability evaluations.
The geomorphic factors have very important impacts on the ecological environment which determines the type of land use.

(3) Selection of water resources carrying capacity indexes

The water resources carrying capacity determines the economic development planning and scale; excessive exploitation of water resources will lead to ecological and environmental disasters. There are many factors that affect the carrying capacity of water resources, including the factors of water supply and water demand, natural factors, and socioeconomic factors. Based on the local characteristics of the water supply and utilization, with reference to the national water supply—demand analysis index system, combined with different expert opinions and relevant literature [62,63], the water resources carrying capacity evaluation indexes system includes four factors—water endowment, water supply capacity, water-saving potential, and external water allocation.

(4) Selection of ecological background indexes

The ecological background assessment, which includes assessment of ecological vulnerability, ecological importance and natural disasters risk, reflects the natural basis of the study area. According to the Urumqi City Soil and Water Conservation Plan and the actual situation, the ecological vulnerability of the arid area mainly includes two factors: land desertification and soil erosion. In combination with the list of related animal and plant protections in the country and autonomous regions, the ecological importance includes the importance of water conservation and ecological diversity factors. Natural disasters are mainly concentrated in mountainous areas. The main disaster factors include floods, landslides, mudslides, and earthquakes.

3.2. Frame of Index System for Spatial Suitability Evaluation

According to the above principles of index selection and the objectives of the study, a three-level space suitability evaluation index system involving the Analytic Hierarchy Process (AHP) was established to evaluate urban sustainable development from the perspectives of production, living, and ecology (see Figure 2). The first level of the index system is the object layer, namely, a comprehensive evaluation of the spatial suitability to explore the coordinated development path of urban space. The second level is the item layer, namely, the four sub-items that affect the evaluation of space suitability, that is, the ecological background, water resource carrying capacity, land construction suitability, and socioeconomic development ability, respectively. The third level is the index layer, which includes 14 individual indexes that reflect the appraisement roles of space development potential, space development foundation, and space development constraint.

3.3. Grading Criteria of Indexes of Spatial Suitability Evaluation

Different types of indexes have varied impacts and contributions to the evaluation of spatial suitability. Based on the opinions of several experts in relevant fields, and according to the actual situation of Urumqi, and referring to the grading criteria of indexes in the related special plan that are soil and water conservation planning, the planning of creating national environmental protection model’s city, ecological function area planning, the report of water resource utilization planning, the three red lines of water control implementation plan, land use planning, and other related types of planning, we discussed, amended, and evaluated indexes to get reasonable classification standards in arid areas. According to the literature [64,65], and in order to increase the spatial differentiation of the index factors, the principle of noncontinuous assignment was adopted, and each grade level was assigned to 1, 3, 5, 7, or 9, respectively; the specific classification standards are listed in Table 1.
Table 1. Grading criteria and assigned score for the indexes of spatial suitability evaluation.

| Index                                | Assigned Score |
|--------------------------------------|----------------|
|                                      | 1   | 3   | 5   | 7   | 9   |
| Population trend                     | 1–2 | 3–4 | 5   | 6–7 | 8–9 |
| Economic potential                   | 1   | 2   | 3–4 | 5   | 8   |
| Transportation advantage             | 2   | 3–4 | 5–6 | 7–8 | 9   |
| Population trend                     | 1   | 2   | 3–4 | 5   | 8   |
| Economic potential                   | 2   | 3–4 | 5–6 | 7–8 | 9   |
| Land cover                           | Not suitable | Low suitable | Medium suitable | High suitable | Extremely suitable |
| Slope (°)                            | >25 | Null | 15–25 | Null | <15 |
| Elevation (m)                        | >3000 | 2500–3000 | Null | 2000–2500 | <2000 |
| Topography                           | Not suitable | Low suitable | Medium suitable | High suitable | Extremely suitable |
| Water endowments                     | 1–2 | 3   | 4   | 5–6 | 7–9 |
| Water supply capacity (m³/ per person)| <100 | 100–500 | 500–1000 | 1000–2000 | ≥2000 |
| Water-saving ability (10⁴ m³)        | <100 | 100–1000 | 1000–5000 | 5000–10,000 | ≥10,000 |
| External water allocation (10⁴ m³)   | 0 | 3278 | 3852 | 4258 | 8616 |
| Ecological vulnerability             | 0–1 | 2   | 3   | 4   | 5–9 |
| Ecological importance                | 0–1 | 2   | 3   | 4   | 5–9 |
| Hazard assessment of natural disasters| 0–1 | 2   | 3   | 4   | 5–9 |
3.4. Computation of Indexes

Following the systematic, scientific, objectivity, independence, and operability principles, the index system should give a space relationship between development and protection. On the basis of GIS, spatial data were evaluated by polygon overlay analysis and merge calculation of attribute data. The overlay analysis of spatial space is divided into two categories: vector polygon superposition and grid superposition. The overlay analysis rules of vector data are (1) point-polygon, where a point in one layer falls on another polygon layer to implement attribute merging; (2) polyline-polygon: A polyline in one layer falls on another layer of polygon to implement attribute merging; (3) polygon-polygon, where the overlay analysis of polygons in different layers can be divided into synthetic superposition and statistical superposition. Grid data computing rules are raster-raster, i.e., new properties are created at the corresponding positions when grids in different layers are overlaid. Attribute element merge methods are as follows:

The weighted summation method is the most commonly used method, because it is easily carried out in the raster ArcGIS environment. Each evaluation factor is generated into a single layer, and different weights are assigned. Finally, each layer is weighted and superimposed to obtain a result. The equation is as follows:

\[ P = \sum_{i=1}^{n} w_i d_i \]  

where \( P \) is the unit merging value, \( n \) is the number of factors, \( w_i \) is the weights of the indexes, and \( d_i \) is the value of factor \( i \).

The multiplication method is as follows:

\[ S = \prod_{k=1}^{m} d_k \]  

where \( S \) is the unit merging value, \( m \) is the number of factors that influence the spatial unit division, and \( d_k \) is the value of factor \( k \).

The dynamic weighted summation method is another analysis method based on Equations (1) and (2), and it is also called the “rigid and elastic analysis method”. The evaluation factors are divided into rigid and elastic factors. Elastic factors show the characteristics, which range from being extremely unsuitable to extremely suitable, such as slope, transportation advantage, and water resource carrying capacity. Rigid factors without these features directly become suitable or inappropriate, for example, natural disaster areas, nature protection districts, land cover, and landforms, etc. The equation is as follows:

\[ G = \prod_{j=1}^{L} f_j(x_j) \sum_{i=1}^{n} w_i d_i \]  

where \( G \) is a unit merging value, \( L \) is the number of limiting factors, \( n \) is the factor that influences the spatial unit division, \( f_j(x_j) \) is the limiting coefficient of limiting factor \( j \), and \( 0 \leq f_j(x_j) \leq 1 \). The greater the value of \( f_j(x_j) \) is, the less restrictive it is, and vice versa. \( w_i \) is the weights of the indexes, and \( d_i \) is the value of factor \( i \). Based on the above principles, the socioeconomic foundation and development potential was represented by three aspects: the population trend, economic potential, and transportation advantage. The water resource carrying capacity evaluation system was composed of four indicators: water resource endowment, water supply capacity, water-saving potential, and external water resources allocation. The ecological background assessment reflected the natural basis of the study area, including an ecological vulnerability assessment, ecological importance, and risk assessment of natural disasters. Formulas (1)–(3) were used to calculate the grid attributes in batches. Meanwhile, four factors—slope, elevation, land cover, and landform—were overlaid to evaluate the suitability of land construction. The equation is as follows:

\[ SSE_{CL} = \text{Max}(S_1, S_2, S_3, S_4) \]  

\[ \text{Max}(S_1, S_2, S_3, S_4) \] means to find the maximum value among \( S_1, S_2, S_3, \) and \( S_4 \).
where \( \text{SSE}_{\text{CL}} \) represents the subitem evaluation of land construction in the spatial suitability evaluation index system, \( S_1 \) represents the assigned land cover score, \( S_2 \) represents the assigned slope score, \( S_3 \) represents the assigned land cover score, and \( S_4 \) represents the assigned landform score.

According to the large differences between groups and small differences within groups, the sub-evaluation results were divided into five grades using the classification standard in Table 1 by ArcGIS. And then, the comprehensive evaluation method was used to evaluate the regional functional suitability of Urumqi, mainly based on the natural boundary [26]. The equation is as follows:

\[
\begin{align*}
\text{SSE} &= K \times \sqrt{\frac{1}{3} \left( P^2 + E^2 + T^2 \right)} - \max(\text{EV}, \text{EI}) \\
K &= f \left( \frac{\min(\text{SSE}_{\text{CL}}, \text{SSE}_{\text{WRCC}})}{\max(H)} \right)
\end{align*}
\] (5)

where \( \text{SSE} \) is the spatial suitability of integrated evaluation for the study area, \( P, E, \) and \( T \) represent the demographic trend, economic potential and traffic advantage indicators that could reflect the potential of social and economic development, respectively. \( \text{EV}, \text{EI}, \) and \( H \) represent the assessment indicators of ecological vulnerability, ecological importance, and risk of natural disasters in the ecological background evaluation. \( \text{SSE}_{\text{CL}} \) is the land construction suitability index and \( \text{SSE}_{\text{WRCC}} \) is the water resource carrying capacity evaluation index. Function \( f \) is an appropriate function that matches the inter-relationship between the resource environment and socioeconomic development in the region, and the value of function \( f \) is between 0.9 and 1.1. It was used to reclassify the evaluation results for the development and construction area, the ecological economic zone, and the ecological protection area by ArcGIS.

In order to determine the main geographical features in each administrative unit (street or town), the key statutory reserve areas that include the basic farmland, the first-grade water protection zones, and key ecological protection zones were taken as the correction factors. The development and protection functions of each administrative unit were determined by the area proportion and leading factor correction methods. Finally, the natural boundary evaluation results were reclassified into four types of spatial suitability: the key development zone, the moderate development zone, the ecological protection zone, and the prohibited development zone.

4. Study Area and Data

4.1. Study Area

The study area (86°37′33″–88°58′24″ E, 42°45′32″–45°00′00″ N) was Urumqi city in the Xinjiang Uygur Autonomous Region (Figure 3), which is located in the hinterland of Eurasia, and lies at the Northern foot of Tianshan Mountain and the Southern edge of Junggar Basin. It covers an area of 13,753 km\(^2\), and the resident population is 2.22 million. The natural environment is a typical MODS which is composed of Southern mountains, a central oasis, and a Northern desert. It belongs to the central temperate continental arid climate, and has an annual average temperature of 6.9 °C and the average annual rainfall is 286 mm. The social environment is a multi-ethnic integration area, and the ecological environment is a high ecological pressure area. Its natural, economic, social, and cultural features are typical of Xinjiang, and the principle of index system is of great significance for the spatial suitability evaluation of Xinjiang.
4.2. Data

Date from RS images and DEM were provided by the Geospatial Data Cloud of Computer Network Information Center, Chinese Academy of Sciences. Thematic maps of land use, topography, land desertification, soil erosion, water conservation, biodiversity, natural disasters, distribution of water resources, landforms, transportation, and other factors were derived from the government departments of Urumqi, such as the Planning Bureau, Development and Reform Commission, and Environmental Protection Bureau. The economic data regarding the GDP and population were derived...
from the Urumqi statistical yearbook. Firstly, we registered and digitized thematic maps. Then, we input the index into an attribute table and then established the vector database for the spatial suitability of Urumqi. Finally, we used the ArcGIS spatial analysis tool to calculate and reclassify the results of the evaluation.

Prior to the processing operations, all graphical data were preprocessed with projection conversion, registration, and digitization and resampling. The adopted coordinate system was Beijing_1954_GK_Zone_15N, and for the projection, equal-angle transversal elliptic cylindrical projection (gauss-Kruger projection) was used. The spatial resolution of grid factors that reflected the natural spatial characteristics of resources, ecology, and disasters was $5 \text{ m} \times 5 \text{ m}$, and the economic and social factors used a street or town as the evaluation unit.

5. Results and Discussion

5.1. The Identification of Spatial Suitability in Urumqi

The evaluation of urban spatial suitability based on GIS technology is used for land layout and ecological management. There is a prominent contradiction between the development of construction land and ecological protection in arid areas because of the shortage of water and soil resources. This study established the four subitem index system that is constructed of social economic development, land suitability, water resource carrying capacity, and the ecological background based on the spatial forms and spatial structure characteristics of arid urban development. At the same time, in order to improve the precision of the study, this article reasonably absorbed the special planning results from different departments and related areas that were highly consistent with the principles, objectives, factors, and methods of this study. This is of great significance to the optimization of the spatial structure and the implementation of the “integration of multiple regulations” in Urumqi. The results detected the development foundation to optimize the structure of urban land use, alleviating the contradiction between ecological protection and construction land expansion. The results of each spatial suitability evaluation are shown in Figures 4 and 5.

The social and economic development ability results are shown in Figure 4a. The total ‘super-high’ and ‘high’ area of is 263.7 km$^2$, accounting for 8.29% of the total area. This is mainly concentrated in the city proper which is the high value area of developing potential. There are areas of a large population live, socioeconomic activities, and high dominance of traffic in the central oasis. Although the proportions of these areas are small, they play important roles in promoting socioeconomic development. The area with low scores is 9521.15 km$^2$, accounting for 69.19% of the total area. This is mainly concentrated in the Southern mountainous area and the Northern desert area; they are the zones that we need to specially protect.

In regard to the land construction suitability evaluation, Figure 4b shows that the suitable area for construction is 5260.39 km$^2$, accounting for 38.25% of the total area. This is mainly distributed in the plains of central oasis and the southeast valley. The area with low scores is 6813.45 km$^2$, accounting for 49.54% of the total area, distributed in the desert and mountainous areas. Land cover is the main limiting factor in the Northern desert. Slope, elevation, and topography are the main limiting factors in the Southern mountains. In general, the suitability of land construction decreases from the middle to the edge, and the land use type gradually transfers from development to protection in Urumqi.

In terms of the water resource carrying capacity, the area with the highest score is 2210.22 km$^2$, accounting for 16.07% of the total area. The area with high bearing capacity is the largest, with a total area of 6917.26 km$^2$, accounting for 50.30% of the total area. This is mainly concentrated in Southern mountainous areas with rich water resources and strong water supply capacity (see Figure 4c). The carrying capacity of water resources in Urumqi has great spatial differences. Regions with abundant water resources are concentrated in the Southern mountains and valleys. The water resource carrying capacity of the central urbanization area is significantly lower than that of the
surrounding areas, and it forms a circle-like structure that is characterized by external abundance and internal scarcity.

Figure 4. The sub-evaluations of spatial suitability in Urumqi: (a) evaluation of social and economic development ability; (b) land suitability evaluation; (c) evaluation of water resource carrying capacity; (d) ecological background evaluation.

As shown in Figure 4d, regarding the ecological background, the area with the highest score is 4682.40 km²; accounting for 34.05% of the total area, which is mainly concentrated in the Southern
mountains and the Southeastern valley. The main reasons for the concentration in the Southern mountains is that land desertification, soil erosion, water conservation, biodiversity conservation, and natural disasters, such as floods, landslides, and debris flows are concentrated in the region. In particular, the high alpine vegetation coverage zones are the most sensitive areas. The government should pay more attention to the Southern mountain area to protect the ecological environment and mitigate ecological risks, and to avoid large-scale development and construction activities.

The results of the assessment of spatial suitability types based on natural features are shown in Figure 5a. The ecological protection zone in Urumqi has the largest area: 897.67 km$^2$, accounting for 65.42% of the total area. These zones, located in the Southern mountains and Northern desert, are the important protected areas which cannot cope with the interference of urban development and other human economic activities in Urumqi. The moderate development zone, which has an area of 2329.04 km$^2$, accounting for 16.93% of the total area, is located in the Southern mountain valleys and suburbs. And they generally have fragile ecological economic system so large-scale high-intensity industrial and urbanization development activities cannot be carried out in these regions. The key development zone covers an area of 2426.83 km$^2$, accounting for 17.65% of the total area, mainly concentrated in the central oasis area, and it is the region that could focus on industrialization and urbanization in the future.

Then, the influences of human activities were considered, especially, the influences of statutory protected areas that are included nature reserves, wetland parks, forest parks, basic farmland, the first-grade water protection zone, the underground water core reserve area, geologic hazard incidental zones, mined-out areas, scenic spots, historical sites of cultural relics protection units, and other areas that need special protection and where industrialization and urbanization development must be prohibited. The spatial suitability evaluation results of towns and streets are shown in Figure 5b. The forbidden development zone in Urumqi covers an area of 4173.61 km$^2$, accounting for 30.35% of the total area. The region has implemented compulsory protection in accordance with laws, regulations, and relevant planning, and strictly controls the interference and destruction by human factors to the integrity of natural ecology and natural heritage. Based on the legal boundaries or natural boundaries, this is mainly distributed in the Eastern and Southwestern mountains; and is embedded in town or street administrative units as plaques. All kinds of development activities that do not conform to land use types should be strictly prohibited, and the gradual and orderly transfer of the population shall be guided to achieve “zero emission” of pollutants. The ecological protection zone, consisting of nine towns and streets, and covering an area of 4470.50 km$^2$, accounting for 32.50% of the total area, forms an ecological security pattern for the Southern ecological conservation area, the central water conservation area, and the Northern ecological barrier area. The main land use types are grassland, forest, and desert, and its main function is to guarantee ecological security, repair the ecological environment, and improve ecological products. The moderate development zone includes 16 townships and streets where priority is given to agricultural development located mainly in front of the mountains and in the valleys. This covers an area of 3271.51 km$^2$, accounting for 23.79% of the total area, and is a major area of agriculture and tourism development of Urumqi, it is also a key region that focuses on promoting balanced urban and rural development. The key development zone includes the city proper and its surrounding areas—a total of 82 towns and streets, covering an area of 1838.19 km$^2$, accounting for 13.36% of the total area. It includes the urban construction area, industrial agglomeration area and densely populated areas of Urumqi, and is also an important growth pole for economic development and transformation in Xinjiang.
which threatens the ecological security of the oasis area. The four types of spatial suitability have different land function and develop in different ways, with different protection content, and primary development tasks, but they have equally important roles in economic and social development. Newly established legal protected areas will be automatically included in prohibited development areas in future land management. The overall pattern of development and protection in Urumqi is based on the results of the spatial suitability evaluation to identify the ecological space, agricultural space, and urban space, and to form an overall pattern of cluster development, classified protection, and comprehensive management. Finally, it provides a basis for Urumqi city’s space planning decisions improves. It provides a methodical system based on the perspective of MFOZ to determine the overall pattern of development and protection in arid areas.

The spatial suitability characteristics in Urumqi city are follows: overall, it presents a concentrated contiguous distribution and a mountain–oasis–desert gradient distribution pattern in space. The Southern mountainous areas are mainly ecological reserves and prohibited development zones, and their function is to maintain the coordinated development of urban areas and is an important barrier to protect the ecological security of the central oasis. The central oasis mainly consists of the key development zone and the suitable development zone that are the main areas of urbanization and agricultural production. The Northern desert area is the main ecological reserve for restoration purposes because it has low vegetation cover, a sensitive ecological background, and weak resilience, which threatens the ecological security of the oasis area. The four types of spatial suitability have different land function and develop in different ways, with different protection content, and primary development tasks, but they have equally important roles in economic and social development. Newly established legal protected areas will be automatically included in prohibited development areas in future land management. The overall pattern of development and protection in Urumqi is based on the results of the spatial suitability evaluation to identify the ecological space, agricultural space, and urban space, and to form an overall pattern of cluster development, classified protection, and comprehensive management.

**Figure 5.** Integrated evaluations of spatial suitability in Urumqi: (a) integrated evaluation based on natural units; (b) integrated evaluation based on administrative units.

5.2. Integrated Analysis between Conservation and Development in an Arid Area

By identifying land use types in Urumqi, the upper limit for the proportion of the Urumqi development area and the lower limit for the proportion of the protection area proportion were determined, and the direction of urban expansion and scope of agricultural production areas were clarified. The spatial suitability characteristics, and the advantages and disadvantages factors that affect each town or street’s development and protection were identified. The regional development and protection strategy can be targeted in future planning implementations so that the efficiency of Urumqi city’s space planning decisions improves. It provides a methodical system based on the perspective of MFOZ to determine the overall pattern of development and protection in arid areas.
management. Finally, it provides a basis for the demarcation of ecological red lines, and permanent red lines of basic farmland and urban development boundary in arid areas. Based on the analyses of socioeconomic development and the ecological protection characteristics of each town or street, this paper will aid in future land use planning decisions and ecological environment management in Urumqi.

The spatial suitability evaluation integrates the needs for comprehensive development of the socioeconomic–ecological system, and builds a scientific and reasonable urbanization pattern, industrial development pattern, and ecological security pattern. Therefore, considering the scenarios of the urbanization process, the changes in basic farmland and the establishment of legally protected areas, and to realize the harmonious development of regional space, the dynamic evaluation of regional spatial suitability based on multi-agent model is a practical and instructive research direction.

6. Conclusions

Water and soil resources are important factors that affect urban development in arid areas. This study established 14 specific index system factors from four aspects—social economic development ability, land suitability evaluation, water resource carrying capacity, and ecological background—and built a spatial database for Urumqi; and considered the influence of human activities on the space layout, especially the effects of laws, regulations, and planning. The spatial suitability evaluation method, which reflects the relationship between development and protection in an arid city based on the perspective of major function oriented zoning, is feasible.

The results show that the ecological protection zone and prohibited zone areas account for 62.85% of the total area, including the water resource protection area, wetlands, forest parks, national parks, and other natural reserves and scenic spots. They are the bottom lines of ecological security in Urumqi. Moderate development zones, which account for 23.79% of the total area, including major agricultural, animal husbandry, and tourism development bases, are areas that focus on promoting balanced development between urban and rural areas. Key development zones account for 13.36% of the total area, including urban construction zones, industrial agglomeration zones, and densely populated areas, which is the upper limit of urban development in Urumqi.

The space suitability evaluation was based on the real demands of urban coordinated development in arid areas, considering various factors influencing the relationship between development and protection, such as the social economy and land and water ecology, with emphasis on the spatial constraints of laws, regulations, and planning in Urumqi. This identified specific spatial suitability evaluation indexes. Based on ArcGIS technology, with the administrative units of towns or streets as the boundaries, a method was formed to realize coordinated development in spatial organization processes, and the specific spatial suitability partition of Urumqi was obtained. So, compared with previous studies, this paper optimizes spatial suitability indexes to make them more consistent with the regional characteristics of arid regions. The research idea can be applied to other arid areas, and the results provide an effective way for arid cities to realize sustainable regional development.

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