Spatial difference features and organization optimization of cities and towns in Tarim River Basin

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Spatial difference features and organization optimization of cities and towns in Tarim River Basin

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Abstract: This paper analyzes the urban spatial structure of Tarim River Basin from the perspectives of urbanization, urban density, grading scales and spatial evolution patterns, using geographical theories and methods, such as fractal theory, principle component analysis, urbanization imbalance index, urban scale imbalance indicator, and urban spatial interaction. The results show that the urban spatial structure displays balanced distribution in the overall pattern, while an imbalanced distribution in each region. The development of town pattern tends to be gathering to the central towns in the oasis of Tarim River Basin and a development axis has begun to form along the southern Xinjiang railway. Based on the division of urban hinterland, and the development characteristics of oasis economy, this paper puts forward an urban spatial organization model. This model uses “breakpoint model” and divides Tarim River Basin into five urban clusters: Korla urban cluster, Kuqa urban cluster, Aksu urban cluster, Kashgar urban cluster and Hotan urban cluster. As a conclusion, this article puts forward an overall framework of urban spatial organization in Tarim River Basin: “one axis, double core, and five groups”.

Keywords: Tarim River Basin; urban system; spatial structure; spatial organization

1 Introduction
The urban spatial differentiation is the indicator of regional development, which is the distribution pattern of regional cities and towns and their geographical agglomeration through mutual actions, and integration under the given level of productive force. According to the objective law of urban spatial development, the spatial organization optimization is to adjust the unreasonable spatial structure and makes the urban spatial development more reasonable and effective (Lu, 2001). Its basic theories include the growth pole theory, the urban spatial interaction theory, the Pole-Axis spatial structure system theory, the urban network theory, the urban spatial fractal theory. According to these theories, the optimization of urban spatial organization complies with the general spatial variation rule of point, line and area, but not completely identical. Since a relation exists between the general transportation and the economy among the regional cities, the optimization may start from the point-field space or the corridor space, but the form of network space is always the final spatial orientation of the urban spatial organization.

There is a long history of the regional urban spatial analysis, ranging from Howard (1898) through Saarinen (1918) and Christaller (1933) to Duncan (1950) and also Hagerstrand (1968). Some of the theories of urban spatial structure were proposed, such as the garden city theory, the organic dispersal theory, the central-place theory, the urban system theory and the innovation spatial diffusion theory. Geddes (1915) mentioned that there had been three phases in the urban spatial evolution: the urban area, the conurbation and the world city. Since the metropolis belt (Gottman, 1957) and the mega-urban region (McGee, 1987) were proposed, this kind of emergent urban spatial structure has aroused the widespread interest. Scott (1988) analyzed the formation and evolution of the metropolitan spatial structure in North America from the perspective of regional division of labor, and focused on a kind of urbanization spatial phenomenon which is different from the compact urban districts that are only
linked by area, called the global city region, produced by the influence of economic globalization. Bamett (2001) named it New Metropolitanism, while Hall (2006) argued that the metropolis belt is evolving to the polycentric metropolis. In the meanwhile, followed by a rapid change in the producing technology and organization; the swift development of information and knowledge economy; and the fast economic globalization, Post-fordism (Amin, 1994), Post-industrial society (Castells and Hall, 1994) and Post-modem (Soja, 2001) became the exterior linguistic environment of the contemporary regional urban spatial structure research. The perspective was also diversified from the “static small-range structural domestic research” to the “dynamic wide-range overseas causal research” (Smith, 2003; Batty, 2007; Helsley and Strange, 2007). In recent years, the hotspot of urban space research are mainly about urban regional spatial structure and the evolution characteristics (Wallis, 1994; Mori, 1997; Gustavo, 1999); economic ties with the space flow and urban interaction model (Schönharting et al., 2003; Hesse and Rodrigue, 2004); and the control of regional space (Savitch and Vogel, 2000; Frisken and Norris, 2001).

The domestic research on urban space mainly involves type division, mode evolution, dynamic mechanism, and regional spatial reorganization, etc (Liu et al., 2008). Zhang (2000) reviewed the basic idea and principle of cities group spatial construction and discussed its spatial evolution mechanism thoroughly. Fang (2005) and Li (2006) studied the Chinese urban spatial heterogeneity patterns and regional spatial structure type. Chen (2007) analyzed the evolution of the spatial structure of the Yangtze River Economical Zone and proposed the regional spatial re-organization. In recent years, the domestic scholars have paid enormous attention to the influence of the urban space by economic globalization and information growth (Liu et al., 2004). Some scholars have also studied the ecology of urban spatial structure (Gou et al., 2004). The research methods, mainly based on the traditional qualitative research, combined with GIS, fractal analysis and statistical analysis, offer a stronger vitality (Liu and Chen, 1999; Yue et al., 2004; Ma et al., 2008).

Although an accelerating progress on the urban spatial structure’s research has been made at home and abroad for many years, the studies mainly aim at the single urban interior regional structure and the urban clusters which grow well, and concentrate either on the areas where society and economy are developed or concentrate on the national scope, while the research on the spatial structure characteristics of the cities in northwestern China and the configuration of organization are few. As an independent physical geography unit in the arid area of northwestern China (Zhang, 1997), the social economy of Tarim River Basin in Xinjiang are undeveloped. Under the arid background, and interaction of many factors, such as the unique historical origin, the economic society structure, the cultural characteristic as well as multi-ethnic living together, fusion and other such factors, the cities in this area display multi-composite characteristic. Besides, the oasis cities in Tarim River Basin are such regions where human activities are most centralized and the ecological problems are most prominent (Du and Liu, 2005). On the basis of earlier work (Zhang, 1997; Du and Liu, 2005; Li, 2006), this article uses geographic correlation theories and quantitative investigation methods, for the system analysis of the Tarim River Basin’s cities from spatial angle. The study proposes urban spatial organization’s overall frame in the Tarim River Basin in the hope that it shall provide the guiding function to local sustainable development.

2 Materials and methods

2.1 Study area and data acquisition

The study area is located at the southern Xinjiang, between Tianshan Mountains and Kunlun Mountains. It consists of the catchments of one mainstream and four headstreams—the Aksu River, the Yarkant River, the Hotan River and the Kaidu-Kongque River, 1100 km from east to west, 600 km from south to north (Fig. 1). It is the biggest inland river basin in China, with typical temperate continental arid climate. It is rich in light and heat resources. The whole basin is dry and windy, with large variation in day temperatures, low precipitation and excessive evaporation. The administrative area covers Bayangol Mongolian Autonomous Prefecture (BMAP), Aksu Administrative Division (AAD), Kizilsu Kirgiz Autonomous Prefecture (KKAP), Kashgar Administrative Division (KAD) and Hotan Administrative Division (HAD). It covers to-
Fig. 1 Sketch map of the study area

together 3 divisions and 2 prefectures, with 42 counties and cities and 103 towns. According to the statistic data in 2007, the entire basin has the total population of $9.505 \times 10^6$, of which $7.974 \times 10^6$ are minorities, accounting for 83.39% of the total, Uygur being the main part of them. Since the 1990s, with the exploration of oil and gas in Tarim River Basin, the construction of national cotton base, the opening of the southern Xinjiang railway line, especially the implementation of national western development strategy, the cities and towns of the basin have developed rapidly.

In our datasets, the social and economic statistical data were collected from the Xinjiang Statistical Yearbook in 2000 and 2007 (NBSC, 2001; 2008), Annual Bulletin of Urban Statistics for Xinjiang in 2000 and 2007, while the date of highway transportation took from the highway traffic map of Xinjiang (2005); and the spatial data took from the 1:4000000 administrative map of China.

2.2 Methods

2.2.1 Urbanization imbalance index

Taking the town as a unit, the article used urbanization imbalance index (Yao, 1992) to weigh urbanization convergency degree of the Tarim River Basin.

\[ I_a = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \sqrt{\frac{1}{2} (Y_i - X_i)^2} }, \quad i=1, 2, 3, \ldots, n, \quad (1) \]

where, \( n \) means the amount of towns, \( Y_i \) means the rate which is \( i \) town’s non-agriculture population occupies the regional town’s non-agriculture total population, \( X_i \) means the rate which \( i \) cities’ area occupies the region total area. When \( I_a \) value is more bigger, the urban population relative to the area imbalance is more remarkable, which is also means the regional difference of cities distribution is more remarkable. When \( I_a \) tends to 0, the urban population relative to land area assumes the balanced distribution.

2.2.2 Urban scale imbalance index

In order to measure the imbalance condition of the urban-scale rank system, we use the imbalanced index \( S \) (Xu et al., 1996), which reflects imbalance degree of various ranks of urban distribution. Equation can be given as:

\[ S = \frac{\sum_{i=1}^{n} x_i - 50(n+1)}{100n - 50(n+1)}, \quad n=1, 2, 3, \ldots \quad (2) \]

where, \( S \) means the imbalance index, \( X_i \) means the scale rank, \( n \) means the number of rank. If the distribution among various ranks is in equilibrium, then
$S=0$; if the distribution is extremely imbalanced and concentrates in a rank, then $S=1$.

2.2.3 Spatial correlation dimension
In certain regions, where the interaction and the spatial relation exist, “the correlation dimension of the fractal theory” was used to simulate the interaction and the spatial relation among the cities. The urban system's space correlation function (Grassburge and Procacia, 1983) is defined as:

$$C(r) = \frac{1}{N^2} \sum_{i,j=1}^{N} H(r - d_{ij}), (i \neq j),$$

$$H(r - d_{ij}) = \begin{cases} 1, & d_{ij} \leq r \\ 0, & d_{ij} > r \end{cases},$$

where, $r$ means the assigned distance scale, such as the straight distance from $i$ city to $j$ city in the urban system; $H$ means the Heaviside’s step function (Yue et al., 2004). If the spatial distribution of urban system is fractal, the scale should have invariability, namely:

$$C(\lambda r) \propto \lambda^D C(r),$$

or $$C(r) \propto r^D,$$

where, $D$ means the correlation dimension which reflects the equalization of urban system spatial arrangement from perspective of geographical significance. Generally, $D$ ranges from 0 to 2, when $D$ tends to 0, regional cities are mostly distributed only in one place (forms a primacy city); when $D$ tends to 1, factors of urban system focus in one geographical line; when $D$ tends to 2, the distribution of cities is quite even, meaning that city distribution density is evenly changing with a certain city as its center (Liu and Chen, 1999).

2.2.4 Breakpoint model
Breakpoint model was used to measure the central cities’ attracting scope. Computation model (Gu, 1991) is as following:

$$D_p = \frac{D_{rp}}{1 + \sqrt{\frac{C_p}{C_r}}},$$

where, $D_p$ means the road distance from city $r$ to the breakpoint; $D_{rp}$ means the road distance between the two cities $r$, $p$. $C_p$, $C_r$ mean city $p$’s and the city $r$’s scale.

3 Results and analyses
3.1 Urban spatial actuality features
3.1.1 Urban spatial distribution
The oases in Tarim River Basin are partly located at the edge of alluvial fan, with its primitive river course being used by a part of local population for natural irrigation, distributed in the middle and lower reaches of rivers plain or in the downstream delta (Qian and Hao, 1999). The macroscopic layout characteristics, determined by the water and soil, expands along with the well ditch, surrounds the basin and be entrenched before the mountain (Ma and Gan, 2006). The spatial distribution of the cities and the oases are in uniformity and display three types. The first type distributes along rivers like a string of beads (Fig. 2). The 2nd type is distributed along the line of communication, such as Korla, Luntai, Kuqa, Aksu, Kashgar; along the 314, 315 national highways and southern Xinjiang railway, assuming a ring-like pattern (Fig. 3). The 3rd type distributes along the frontier, mainly refers to cities of Wushi, Akqi, Wuqia. Many cities and towns have 2 or 3 types of spatial distribution patterns at the same time.
The town density in Tarim River is low while its spatial distribution is dispersed. The town density is 1.01/(10^4 km^2) and the urban density is 0.05/(10^4 km^2) and the designated town density is 0.96/(10^4 km^2). The spatial difference of town density in Tarim River Basin is big. The town density in north and northeast basin is bigger than that in south and southeast area. The smallest one is 0.48/(10^4 km^2) in HAD, the next one is 0.51/(10^4 km^2) in BMAP. The biggest one is 2.42/(10^4 km^2) in AAD, which is 5 times than that in HAD and 4.74 times than that in BMAP. Cities like Korla, Aksu, Kashgar and Hotan in first-level urban system are away from each other by over 500 km.

3.1.2 Urbanization characteristics

The urbanization level in Tarim River Basin is low, which is only 27.00% by the non-agricultural population caliber statistics of 2007. Accordingly, it falls behind the Xinjiang average level 43.32% and consistent with the industrialization initial stage of the economy in Tarim River Basin. The urbanization level in the interior region shows “higher north, lower south”, so the urbanization level of BMAP and AAD in north and northeast of Tarim River Basin are high, but HAD in the south of the basin is only 16.50%.

Taking the town as a unit, the article uses urbanization imbalance index to weigh urbanization convergence degree of the Tarim River Basin. Based on Eq. (1), the urbanization imbalance index of each region (shown in Table 1) is 4.01. Obviously, urbanization imbalance indices of individual region in Tarim River Basin are bigger than that of the entire basin, so the urbanization aggregation degree of each region in Tarim River Basin are higher than that of the entire basin which explain that while each region is imbalanced, Tarim River Basin’s urbanization aggregation degree in overall pattern is balanced. BMAP gets the highest urbanization imbalance index, which is 2.06 times than that of KAD, being the lowest. The next is HAD, AKD and KKAP. Although the urbanization level is quite low in HAD, the aggregation degree is pretty high, as shown in the table below.

<table>
<thead>
<tr>
<th>Region</th>
<th>Urbanization level (%)</th>
<th>Urbanization imbalance index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMAP</td>
<td>49.60</td>
<td>18.95</td>
</tr>
<tr>
<td>AAD</td>
<td>30.95</td>
<td>10.94</td>
</tr>
<tr>
<td>KKAP</td>
<td>28.12</td>
<td>10.23</td>
</tr>
<tr>
<td>KAD</td>
<td>22.35</td>
<td>9.20</td>
</tr>
<tr>
<td>HAD</td>
<td>16.50</td>
<td>13.90</td>
</tr>
<tr>
<td>TRB</td>
<td>27.00</td>
<td>4.01</td>
</tr>
</tbody>
</table>

Note: TRB=Tarim River Basin

3.1.3 Grade scale characteristics

The primacy indices of the cities in Tarim River Basin include 2-city index (primacy index), 4-city index and 11-city index, being 1.21, 0.48 and 0.5, respectively. Compared to the areas with higher urban system level in northern Xinjiang, the indices are smaller. According to the urban rank-scale theory (Xu et al., 1996), the primacy index value is 2, and the 4-city index and 11-city index are 1 when the urban population distribution is uniform. While the primacy index is bigger than 2, and the 4-city index and the 11-city index are bigger than 1, the cities scale belongs to the primate city distribution. Otherwise, the cities size distribution belongs to the sequence size distribution. Obviously, the urban scale of Tarim River Basin belongs to the typical sequence size distribution, and is still at the primary stage of urban system evolutionary process.

Urban system's primacy indices in BMAP, AAD, KAD, KKAP and HAD are 9.57, 2.53, 1.33, 2.69 and 2.27, respectively. Obviously, the BMAP urban system is the typical primate city distribution, while the KAD belongs to the sequence size distribution, and the urban-scale rank in each region is not balanced.

In order to measure the imbalance condition of the urban-scale rank system, we used the imbalanced index, which reflects an imbalance degree of various
scale ranks of urban distribution. When the 42 cities and towns in Tarim River Basin are divided into 42 ranks, it lead the various ranks of population accumulation percentage to Eq. (2), and the imbalance index $S$ is 0.52. Obviously, the imbalance situation is very serious. The big city’s scales are small with an imbalanced distribution of various ranks. This blocks the urban system's integrated function. The essential organic connections are lacking among big, medium and small cities, which restricts the radiation function further.

### 3.1.4 Fractal Features

Utilizing fractal theory and Eqs. (3)-(6), with the aid of geographic information system software, we measured the straight distance matrices (42×42) between the cities and towns in Tarim River Basin by taking the length of stride $\Delta r = 50$ km as the distance scale $r$. Finally, a series of spots pair $(r, C(r))$ were obtained (Table 2).

<table>
<thead>
<tr>
<th>SN</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>1150</td>
<td>1100</td>
<td>1050</td>
<td>1000</td>
<td>950</td>
<td>900</td>
<td>850</td>
<td>800</td>
<td>750</td>
<td>700</td>
<td>650</td>
</tr>
<tr>
<td>$C(r)$</td>
<td>1681</td>
<td>1675</td>
<td>1665</td>
<td>1651</td>
<td>1619</td>
<td>1547</td>
<td>1491</td>
<td>1443</td>
<td>1393</td>
<td>1333</td>
<td>1277</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SN</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r$</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td>400</td>
<td>350</td>
<td>300</td>
<td>250</td>
<td>200</td>
<td>150</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>$C(r)$</td>
<td>1179</td>
<td>1079</td>
<td>957</td>
<td>867</td>
<td>743</td>
<td>625</td>
<td>535</td>
<td>447</td>
<td>345</td>
<td>257</td>
<td>191</td>
<td>97</td>
</tr>
</tbody>
</table>

Note: SN= Sequence number

By taking $\ln C(r)$ as coordinate and $\ln r$ as abscissa, we worked out the plot (Fig. 4). Carrying on the linear regression simulation, we obtained urban spatial structure fractal dimension of Tarim River Basin which were $D=0.9575$ and $R=0.9912$. The relativity is good. Likewise, the fractal dimension of urban spatial structure in BMAP, AAD, KKAP, KAD and HAD are 0.4652, 0.8188, 0.3357, 0.8977 and 0.6505, respectively.

$D<1$ indicates that the urban system spatial distribution in Tarim River Basin is centralized. Although the distance among majority of cities is long in Tarim River Basin, such as Korla to Taxkorgan is 1032 km and Ruqiang to Wuqia is 1120 km, the distances among some regional cities are actually short, which forms the relatively independent urban group. While analyzing intuitively from the geographical position, there are three typical urban groups: (1) the BMAP urban group which is located at northeast of Tarim River Basin. With Korla in the center, it includes Hejing, Heshuo, Yanqi, Bohu, Yuli and Luntai, with average straight distance of 96 km; (2) the AAD urban group which is located at the middle of Tarim River Basin, takes Aksu city as a center, including Kuqa, Xinhe, Wensu, Xayar, Baicheng, Wushi, Kalpin and Awat, and their average straight distance are 170 km; (3) the western urban group, taking Kashgar city as a center, includes the cities of KAD and KKAP and their average straight distance are 155 km.

It can be seen that the characteristic of urban spatial arrangement in Tarim River Basin is disperse under the premise of the concentration, or small concentration, big dispersion. The correlation dimension reveals that the spatial structure of urban system in Tarim River Basin, influenced by the partial concentration must be higher than the overall dispersion. The result from correlation dimension model shows that the spatial structure of urban system in Tarim River Basin is multi-central structure called “weak pole, many cores”.

Since the closed feature of oasis cities is strong, the urban spatial arrangement seems to be restricted by landform, resources, transportation and other such factors (Fang and Sun, 2006). The urban pattern in Tarim River Basin shows a linear distribution that
concentrates in the natural resource-rich regions, and disperses as a whole while concentrates as a local. Because the scale structure and the function division of labor are similar, competition among partial cities group is bigger than the cooperation. Within each city group, the distance is long, the traffic condition is unitary and the cost of spatial relation is high, so the inter-city function is weak. It seriously influences the interaction among cities, and restricts the urbanization process, the perfect urban system functions and the regional economies development in Tarim River Basin.

3.2 Urban spatial evolution characteristics

The urban scale, the urban economic output, urban social life, the urban infrastructure and the urban ecological environment are chosen to construct an valuation index system which contains 14 indices (Table 3) in this article, while the principal components analytic method is used to measure the overall strength of 42 cities and towns of Tarim River Basin in 2000 and 2007. The result reflects by ArcGIS in Fig. 5.

<table>
<thead>
<tr>
<th>Standards layer</th>
<th>Index layer</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban scale</td>
<td>Urban population</td>
<td>people</td>
</tr>
<tr>
<td></td>
<td>Urban built-up area</td>
<td>km²</td>
</tr>
<tr>
<td>Urban economic output</td>
<td>Area production total value</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>Industry total output</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>Local finance earning</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>Fixed assets investment</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>People average production total value</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td>Urban social life</td>
<td>Society consumable retail money</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>Employee average wage</td>
<td>Chinese Yuan</td>
</tr>
<tr>
<td></td>
<td>Gas penetration</td>
<td>%</td>
</tr>
<tr>
<td>Urban infrastructure</td>
<td>Drainpipe density</td>
<td>km/km²</td>
</tr>
<tr>
<td></td>
<td>People average road area</td>
<td>m²</td>
</tr>
<tr>
<td>Urban ecological environment</td>
<td>People average greenbelt area</td>
<td>m²</td>
</tr>
<tr>
<td></td>
<td>Urban greening cover rate</td>
<td>%</td>
</tr>
</tbody>
</table>

Fig. 5 The distribution of urban overall strength of Tarim River Basin in 2000(A) and 2007(B)

3.2.1 The cities development expands along certain rule

Compared to the level of urban spatial development pattern between 2000 and 2007 in Tarim River Basin, it is obvious that the rapidly developing cities have expanded outward from several centers. These centers mainly include the capital cities of the prefectures, Korla and Aksu which are in the north of Tarim River Basin. Along these centers, the high levels of development of the peripheral cities were more in 2007 than in 2000. But the cities with low level of development concentrate in HAD that are located in south of Tarim River Basin, for the reason that where the natural conditions are poor, and the transportation accessibility is bad, and the economic base is weak, and the transportation accessibility is bad.

3.2.2 The growth axis of the cities appeared initially

Since 2000, as the growing center above expanded outward in space, the urban growth axis in the Tarim River Basin emerged gradually, which formed initially an urban development belt along southern Xinjiang railway, especially from Aksu to Korla. It is mainly caused by the oil-gas exploitation in the southern Xinjiang petrochemical industry belt in recent years. Because of the exploitation and its consequent impacts on the economy, the non-native population was attracted to the area, enhancing its urban scale and, resultantly, the urban economy grows fast.
3.2.3 Difference in change trend of urban development

From Table 4, it can be seen that, based on the analysis, the absolute difference among the cities trend to increase since 2000 in Tarim River Basin. The urban overall strength index's coefficient of variation was 0.599 in 2000, reduced to 0.577 in 2007, but the coefficient of variation in the state stratification increased from 0.275 to 0.322. The results revealed that the levels of relative difference are small among the urban development, but in the state stratification, these have been expanded.

<table>
<thead>
<tr>
<th>Years</th>
<th>The state overall strength index</th>
<th>The urban overall strength index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard deviation</td>
<td>Mean value</td>
</tr>
<tr>
<td>2000</td>
<td>0.656</td>
<td>2.387</td>
</tr>
<tr>
<td>2007</td>
<td>0.946</td>
<td>2.939</td>
</tr>
</tbody>
</table>

Note: The state overall strength index represents that the mean value of urban overall strength index in the prefecture.

3.3 The spatial organization based on urban center regionalization

3.3.1 Spatial organization idea

Since the urban spatial development is restricted by the mountain and poverty in Tarim River Basin, it can only be developed by across the oasis. Accordingly, during succession to the high-level network spatial pattern, the pattern of “the line” becomes the natural barrier of the oasis cities, which is very difficult to cross through the conventional economy technology. This is the one of main reason that the oasis cities maintain the pattern of “the line”, “the circle” for a long time. But such a restraint is quite small among the internal oasis area, where group type development model is applicable. The study thus proposes to take the urban center regionalization as the foundation to carry out the urban spatial organization in Tarim River Basin.

3.3.2 The determination of the center city

The overall strength of 42 cities and the spatial distribution of Tarim River Basin in 2007, combining with the actual situation of each big branch, revealed that Korla, Aksu, Kuqa, Kashgar, Hotan are the center cities in Tarim River Basin. Although Luntai's overall strength is slightly stronger than Hotan, but because of its location among Korla, Kuqa and Kuqa, where overall urban strength is comparatively more, it belongs to BMAP in the administration and exists in Korla's influence area. Artux also has the same problem. Because of its borders with Kashgar, it accepts Kashgar's formidable radiation, and does not have the function to organize and regulate its economic development. Therefore, we do not take these two cities as the central city of the region.

3.3.3 Region division of group cities

We used breakpoint model to measure the central cities’ attracting scope. Since the distance of the breaking point is essential to spot external influence between the two neighboring cities, therefore, using the urban overall strength score for 2007 in the preceding text replaces the urban scale which conforms to the breakpoint formula in its essential meaning. Based on Equation (7), the result (Table 5) of the attracting scope of the five central cities is contained in the five prefectures and autonomous prefectures administrative units while the breakpoint position being mostly in the edge of the county in the regional administrative unit, is not far from the prefecture boundary of the administration unit.

<table>
<thead>
<tr>
<th></th>
<th>The distance of the breaking point between central cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korla—Kuqa</td>
<td>176.77</td>
</tr>
<tr>
<td>Korla—Hotan</td>
<td>709.88</td>
</tr>
<tr>
<td>Aksu—Kuqa</td>
<td>139.92</td>
</tr>
<tr>
<td>Aksu—Kashgar</td>
<td>251.94</td>
</tr>
<tr>
<td>Kashgar—Hotan</td>
<td>281.17</td>
</tr>
</tbody>
</table>

Note: The breakpoint is the spot to be away from the preceding urban in the table; unit: km.

According to the above analysis, the Tarim River Basin was divided into five urban groups and named by the central city as the Korla urban group, the Kuqa urban group, the Aqsu urban group, the Kashi urban group and the Hetian urban group (Table 6).
Table 6 The affected area of the central cities in Tarim River Basin

<table>
<thead>
<tr>
<th>The sequence</th>
<th>The central city</th>
<th>The affected area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Korla</td>
<td>Yanqi, Yuli, Hejing, Heshuo, Qiemo, Luntai, Ruoqiang, Bohu</td>
</tr>
<tr>
<td>2</td>
<td>Kuqa</td>
<td>Xinhe, Baicheng, Xayar</td>
</tr>
<tr>
<td>3</td>
<td>Aksu</td>
<td>Wensu, Wushi, Awat, Kalpin, Aqji, Bachu</td>
</tr>
<tr>
<td>4</td>
<td>Kashgar</td>
<td>Yopurga, Akto, Shufu, Yengisar, Jiashi, Shule, Taxkorgan, Shache</td>
</tr>
<tr>
<td>5</td>
<td>Hotan</td>
<td>Pishan, Qira, Lop, Yutian, Moyu, Minfeng, Hotan</td>
</tr>
</tbody>
</table>

3.3.4 Spatial organization plan

Based on the urban hinterland regionalization and according to the distribution characteristics of Tarim River Basin’s oasis cities; and the Xinjiang urban system plan, the urban system construction in Tarim River Basin should follow the Pole-Axis regional developing pattern. The proposed framework of urban spatial organization in Tarim River Basin ("one axis, double core, and five groups.") focuses on molding of the situation of Tarim River Basin in term of the overall economic growth by (i) promoting healthy competition and cooperation between various urban groups; (ii) priority development of Korle and Kashgar as the regional central cities to radiate towards the entire Tarim River Basin; and (iii) rely on three mainly channels which are southern Xinjiang railway and 314, 315 national highways to construct Tarim River Basin taking urban development axis along the railway line. Various urban groups take the central city as a core and give it prominence to the basis of its attraction and its radiation, playing a lead role as a regional central city. Through the organization and the coordination among the five urban groups which are rich in the required characteristics; and have the needful vigor, the natural environment in Tarim River Basin could be developed for its people, society and natural resources through coordinated efforts for social and economic development.

4 Conclusions

Based on the special historical background, the cultural brand mark, the unique natural environment and the socio-economic structures, the cities and towns in Tarim River Basin present the unique development process and multi-composite characteristics. In the view of historical evolution, Zhang (1997) explained the reason that forms the urban pattern of Tarim River Basin; and promulgated its spatial distribution and the evolvement rule; and proposed the urban development model of ‘multi-poles, multi-stages, multi-networks’. Based on the above analyses, this paper investigated the urban spatial structure of Tarim River Basin, which provides guidelines for development optimization of arid area cities to a certain extent. With geographical theories and methods such as fractal theory, principle component analysis, urbanization imbalance index, urban scale imbalance indicator, urban spatial interaction, this paper has analyzed the urban spatial structure of Tarim River Basin, taking the overall urban strength as the basis to choose the central cities, and carried on the urban hinterland regionalization using the breakpoint model, and then general ideas for developing urban spatial optimization were proposed. The results are representative of the actual urban development situation of Tarim River Basin, and provide the theoretical guidelines for the future development of Tarim River Basin. However, the regional urban spatial optimization not only needs to consider the urban system and the industrial structure, but also considers the overall evaluation aspects, such as infrastructure, protection of the ecological environment, and the local cultural features. Being a complex situation, further research is required.

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References

Batty M. Agents, cells, and cities: new representational models for simulating multiscale urban dynamics. Environment and Plan-
Chen X Y. The formation, evolvement and reorganization of spatial