Research on spatial ecological response mechanism of Hexi Corridor

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Abstract. This paper focuses on the ecological problems that hinder development, such as lack of water resources and desertification in the Hexi region. On the basis of the impact of urbanization in the Hexi region on the ecological environment, this paper focuses on the ecological environment response brought by the process of urbanization due to the change in the ecological land, living land and production land of Sansheng Space Structure through quantitative analysis, explores its underlying reasons and puts forward strategies to protect and upgrade the ecological environment in the process of urbanization in Hexi.

1. Introduction
The Hexi Corridor is located in the central part of the Silk Road, starting from Wushaoling in the east and reaching the junction of Xinjiang and Gansu in the west. The whole territory includes Jiayuguan, Zhangye, Jinchang and Wuwei cities and the west of the Yellow River in Lanzhou, Baiyin and Hui Autonomous Prefectures of Linxia. It is not only the only pathway to the western regions, Central Asia and Western Asia from the Central Plains, but also the junction of the Mongolian Plateau and the Qinghai Tibet Plateau. It is the main transport artery of the silk road connecting the east and the west, as well as the frontier of the Central Plains dynasties in the Northwest. Due to the typical region of the Hexi Corridor, which integrates various elements such as commerce, history, and culture, it has attracted more and more attention at home and abroad. However, its natural and geographical ecological environment improves slowly, and the ecological degradation is obvious, which has severely restricted regional development.

2. The ecological basis of urban development
The origin, evolution and development of the towns within the Hexi Corridor are particularly affected by the natural ecological environment. For example, the water source of the Hexi Corridor comes from Qilian Mountain, because the three major rivers in the Hexi Corridor area—Shiyang River, Heihe River and Shule River all come from the snow melting of Qilian Mountain.
The origin and development of cities and towns complement regional ecological conditions. Good ecological conditions are the key to support the sustainable development of cities and towns. The cities and towns in the Hexi Corridor area are generally distributed on oasis, and the changes of oasis and ecology depend on the change of water source; the conditions of urban development depend on the spatial and temporal evolution of oasis and the types of spatial organization and their relationship. The water-based migration characteristics and the migration of “town-oasis-water resources” are highly coupled with watershed units. This results from coordinated development between human activities and the natural environment in arid regions with inland climates[1]. Although the Hexi Corridor stretches a vast land area, including the Gobi, deserts, mountains and cold deserts that are not suitable for use account for most of it, the proportions of deserts and Gobi deserts in the Hexi Corridor in history are not as large as they are now.

3. Ecological problems in the urban development in this region

3.1. Slow evolution of the ecological environment
For a long time, the improvement of natural and geographical ecological environment in the Hexi Corridor is slow. Therefore, the cities and towns in this region are constrained by the regional resource and environmental capacity with relatively stable scale and grade. Consequently, it is difficult to develop and grow, and the regional urban system has been in a state of balanced development for a long time[2]. This also proves that the development of cities and towns cannot be separated from the support of ecological conditions. Therefore, the retention and development of cities and towns in the Hexi Corridor mainly depend on natural selection.

3.2. Ecological degradation leads to desertification
Today's Hexi Corridor, human activities are concentrated in an oasis with good natural conditions, where the land is flat and the agriculture is developed. Thus the cities and towns are highly popularized. This shows that water is still the basic condition for the existence and development of its cities and towns, and it is also the most basic constraint for urban development and spatial organization. Currently, the ecological environment in the Hexi Corridor area is seriously deteriorating. For example, in the case of the oasis in Minqin County, where the upstream water diversion and the excessive development of local diversion irrigation are discovered, the ecological environment is getting worse. Deserts basically surround Minqin County, and the area of decertified land accounts for 94.5%. It is difficult to develop Minqin County without ecological support.

4. Spatial ecological response analysis of cities and towns
The response of the ecological environment in the Hexi region to the urbanization process is manifested by the obvious changes in land use structure. And the land expansion for urban construction is more prominent with decreasing cultivated land area.

4.1. Analysis of changes in land use structure
The orderly advancement of urbanization is inseparable from the land resources. The spatial process of urbanization has brought about changes in the land use structure. The most significant changes are the decrease in cultivated land and ecological land and the rapid increase in the amount of construction land.

This study refers to the classification system of land use and the land serves as ecological land, productive land, living land, compound land and unused land. Among them, ecological land, productive land, living land and compound land are collectively referred to production-living-ecological land[3]. Unused land mainly includes sandy land, Gobi, saline land, marshland, bare land, bare rock texture, etc. According to the statistical results of map spots, the composition and changes of various land areas in the four counties of Hexi are summarized.
Table 1. Statistical table of changes in land use and unused land in the four counties of Hexi Area. Data source: Resource and Environment Data Center of Chinese Academy of Sciences (http://www.resdc.cn)

| City   | Type of land                  | In1980 | In1990 | In2000 | In2010 | In2018 | Decrease or increase (km²) |
|--------|-------------------------------|--------|--------|--------|--------|--------|---------------------------|
| Jiayuguan | Production-living-ecological land | 201    | 205    | 215    | 238    | 322    | +121                      |
|        | Unused land                   | 1131   | 1127   | 1117   | 1094   | 1010   | -121                      |
| Zhangye | Production-living-ecological land | 16321  | 16361  | 16520  | 16730  | 17336  | +1015                     |
|        | Unused land                   | 22115  | 22075  | 21916  | 21706  | 21119  | -996                      |
| Wuwei  | Production-living-ecological land | 11574  | 11652  | 11662  | 11897  | 12176  | +602                      |
|        | Unused land                   | 20949  | 20871  | 20861  | 20626  | 20403  | -546                      |
| Jiuquan | Production-living-ecological land | 10629  | 10545  | 10573  | 11059  | 11966  | +1337                     |
|        | Unused land                   | 155472 | 155550 | 155522 | 155036 | 154106 | -1366                     |

It can be seen from the table above that in the four counties of Hexi from 1980 to 2018, the reduction of unused land and the increase of land for production, living as well as ecology in Jiayuguan City were in balance at a slow pace. The increase in production-living-ecological land in other cities is larger than that of the decrease in unused land, indicating that ecological land continues to decrease and the ecological environment deteriorates. Especially from 2010 to the end of 2018, it can be seen from the figure below that the unused land in Hexi Corridor accounts for the vast majority of each city, and in less than ten years, the area of unused land in four counties in Hexi has a cumulative reduction of more than 50% over 40 years, which shows that that the urban and rural development and agricultural production after 2010 has broken the original land use structure, unused land has begun to decrease, cultivated land resources have slowly increased, construction land has increased significantly. However, ecological land remains unchanged.
4.2. Underlying problems of urbanization development and land use

4.2.1. The unused land is not used. According to the above statistics of changes in land use, we hold that the unused land will decrease, the production-living-ecological land in the Hexi region will increase, and the ecological environment will be greatly improved. Because we believe that people prefer to unused land in the choice of newly-cultivated land and build-up areas. It can be roughly assumed that the area of unused land reduction at least equals to the increase of the area of production-living-ecological land, but in fact unused land does not reduce but increases. It can be seen from the figure (Statistical map of changes in ecological land area from 2010 to 2018) that except for Zhangye City, which has increased significantly after the decrease from 1990 to 2010, the ecological land of other regions in the four counties of Hexi has decreased or remained unchanged. This shows that during the long-term development of the Hexi Corridor, ecological problems have not been solved from the regional level. The reduction in unused land is quite different from the increase in cultivated land and built-up area. If we take into account ecological land such as forest land and grassland, the gap will be even greater. There are two main reasons for this: One is because the focus is on the economic benefits of urban development. Cultivated land is improved on the basis of unused land, while the built-up area continues to expand on the existing basis, occupying existing production, ecological and other land, resulting in continuous reduction of ecological space. The second reason is that the existing ecological conditions cannot support the rapid development of urbanization. The newly-added cultivated land and built-up area make use of the existing unused land, but when focusing on urban construction and economic development, the substantial reduction of ecological space can be ignored.

Figure 1. Map of land use changes in the four counties of Hexi from 1980 to 2018. Data source: Resource and Environment Data Center of Chinese Academy of Sciences (http://www.resdc.cn)

Figure 2. Statistical map of changes in ecological land area from 2010 to 2018. Data source: Resource and Environment Data Center of Chinese Academy of Sciences (http://www.resdc.cn)
4.2.2. Cultivated land resource increases slowly. The effect of urbanization on the land use structure is manifested by the continuous expansion of the urban built-up area and the encroachment of various production and ecological spaces in the surrounding area. In 2010, the cultivated land in Gansu Province was 34336.6 square kilometers, and in 2017 the province's cultivated land was 36820.4 square kilometers, an increase of 7.23%. As shown in Figure 3 (Graph of cultivated land area change in Hexi Corridor from 1980 to 2018), from 2010 to 2017, the increase of cultivated land in the cities in the Hexi Corridor area was generally small, especially in Wuwei City, where the increase in cultivated land was less than the provincial average. For a large land with a small population, such as the Hexi Corridor, the slow increase in cultivated land is sufficient to show that the ecological environment in the Hexi Corridor area is improving slowly, and the bottleneck of urbanization is prominent.

![Map of Cultivated Land Change in Hexi Region](http://www.resdc.cn)

**Figure 3.** Graph of cultivated land area change in Hexi Corridor from 1980 to 2018. Data source: Resource and Environment Data Center of Chinese Academy of Sciences (http://www.resdc.cn)

4.2.3. Urban built-up area expansion does not equal to population growth. Urban expansion is the product of a certain stage of urban development. In the context of new urbanization, the phenomenon of extensive urban land use, blind expansion and other land "being urbanized" has caused prominent human-land conflicts. At present, urban expansion is not uncommon in all cities in China at this stage. The rapid expansion of the urban built-up area in the Hexi Corridor and the inequality of population growth are also relatively obvious.

As shown in Figure 4, the area of the built-up area in the Hexi Corridor area is growing faster; the average annual population growth in the Hexi Corridor area is 0.26%, which is lower than that of the whole country and the province. This means that the urbanization of cities and towns in the Hexi region has neglected the urbanization of the population, and the slow growth of the urban population will inevitably affect the development vitality of the cities and towns, which is difficult to play the role of the aggregate economic benefits and scale economic benefits.

![Map of the area and population size of the built-up areas in the cities of the Hexi Corridor from 2010 to 2017](http://www.resdc.cn)

**Figure 4.** Map of the area and population size of the built-up areas in the cities of the Hexi Corridor from 2010 to 2017. Source of data: Statistical Yearbook of Gansu Province in 2011 and 2018
4.2.4. The urbanization rate is not consistent with the increased rate of built-up area. Judging from the overall situation of the Hexi Corridor, the expansion of municipal jurisdictions is also very obvious. An in-depth analysis shows that the park’s construction is the main factor of spatial expansion. The urban expansion of Jiuquan and Jiayuguan areas is generally faster, and the growth rate of the built-up area is faster than that of the urbanization rate.

As shown in Figure 5, the urban spatial expansion speed of cities in Hexi Corridor is fast, stable and sustainable on a whole, mainly because the Hexi Corridor is mostly plain, the urban expansion speed and scale are fast, and the expansion type is mainly extended. In addition, the construction of new city and new area is the main driving force for the rapid growth of urban built-up area.

Due to the small population in the region and the weak driving force of cities and towns in attracting external population caused by the natural environment, the rate of urbanization rate has both a sudden increase and a sudden decrease, which indicates that the urbanization of space is not consistent with the urbanization of population, and the population size is not enough to support the rapid urbanization of space. It should be said that this is a typical negative urbanization phenomenon.

![Figure 5](image)

**Figure 5.** A comparison chart of the growth rate of urban built-up areas and urbanization rate of various cities in the Hexi Corridor from 2010 to 2017. Source of data: Statistical Yearbook of Gansu Province in 2011 and 2018

5. Regional ecological development strategy

On September 18, 2019, General Secretary Xi Jinping pointed out at the symposium on ecological protection and high-quality development of the Yellow River Basin that it is essential to intensify constraints on the water resources in city, land, people and production and coordinate the development among population, city and industry. This strategic once again proves that urban and rural development is organically coupled with the development of the ecological environment system. The only way out for the healthy development of regional ecology is an ecologically balanced urban-rural environment. Land and space planning combines urban and rural planning with land and resource planning properly. It is imperative to achieve ecological sustainability and high-quality development of the entire urban and rural area.

5.1. Development positioning based on water resources carrying capacity

As the core area of the Silk Road culture, the water shortage in Hexi Corridor is extremely inconsistent with its strategic position; resource water shortage has become an important constraint factor for the development and construction of ecological civilization in Hexi corridor. The development orientation of each city exceeds the current carrying capacity of water resources, and short-term economic growth comes at the expense of long-term ecological environment. Regarding ecological environment response regulation and control, we should rely on regional resources and environmental carrying capacity to
scientifically determine the appropriate size of towns, improve resource utilization efficiency and optimize resource utilization structure[4].

5.2. Strict water environmental protection and treatment measures
Severe water pollution has reduced the number of available water resources, and the water environment has deteriorated, further exacerbating the shortage of water resources. Population growth has brought about a simultaneous increase in domestic sewage discharge. The demand for industrial products is becoming stronger, and the "three wastes" of industrial production are also increasing. Sewage discharge directly affects the water quality of surface water bodies. For example, in the Qilian Mountains pollution incident, local ecological environment was severely damaged due to illegal approval and construction without approval.

5.3. Rural rational contraction under regional coordinated development
In a more special area such as the Hexi Corridor, the excessively high rate of urbanization cannot be pursued. Facts have proved that the villages in the Hexi region have shown a trend of irrational continuous contraction during rapid urbanization, and the cost in the urbanization process is incalculable. Therefore, we must pay attention to the capacity of the ecological environment and its development and improve the quality of urbanization in terms of sustainable urban and rural development. [5]. New urbanization should be based on the regional urban and rural space and the harmonious development of social, economic, and ecological environments.

5.4. Build an ecological pattern of regional coordination and complementary advantages
The differentiation trend of regional economic development is obvious, and the spatial structure of economic development is constantly undergoing profound changes. Therefore, we must adapt to new forms, plan new ideas for regional coordinated development, establish and improve market-oriented diversified ecological compensation mechanisms, and encourage various compensations for industries, talents, etc. between the upstream and downstream in the basin, give play to the comparative advantages of each region, promote the rational flow and intensive use of elements, promote relative balance in development, and build a new ecological pattern with complementary advantages.

6. Conclusion
An ecologically balanced urban and rural environment is the only way out for healthy and sustainable development. Therefore, it is imperative to realize the ecologically sustainable and high-quality development of the overall urban and rural areas. The ecological environment in the Hexi region is generally fragile and the protection tasks remain arduous. We should rely on national policies such as the Belt and Road Initiative and Western Development to resolutely implement the ideological connotation of ecological civilization, correctly handle the relationship between economic development and environmental protection, and get rid of the dependence on agriculture, industry and mining. We should restore the ecology and realize the green transformation and high-quality development in the Hexi region.

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