Study on Division of Landscape Character Areas of River Corridor in Northwest Arid Area Based on LCA Method——Take Zhangye Section in Heihe River Basin as an Example

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Abstract: The division of landscape character areas is an effective way to plan the corridor of river corridors with rich natural and human resources. Based on the method and advanced experience of landscape character assessment in Europe, this paper summarizes the steps of landscape character areas classification and the evaluation index system of landscape character assessment for river corridors in the arid region of Northwest China. Taking Zhangye section in Heihe River Basin as an example, the area was divided into 11 landscape character areas in watershed scale. At the same time, the mapping of landscape character areas and the description of the landscape character areas were carried out.

1. Introduction
In recent years, the level of urbanization in our country has increased at an average annual rate of 1.2%. The rapid development of urbanization has led to great changes in the regional landscape. The overall performance is fragmentation and simplification of the land mosaic, the diversity of landscape types and the continuity of landscape pattern have been destroyed, as well as the development of modern society led to the regional landscape planning out of the traditional landscape characters and land use patterns [1]-[2]. The Heihe River Basin is located in the intersection of the Qinghai-Tibet Plateau and the Mongol Plateau where the weather is arid and dry. The natural and cultural resources along the river are abundant. The landscape type of the whole basin is extremely complex with alpine, oasis, desert and Gobi deserts [3], but the ecological environment is fragile, the middle reaches of the river basin face the homogeneity of a variety of landscapes and the loss of regional characteristics. Meanwhile, as an important part of the national ecological security barrier and eco-economic function area, Heihe’s healthy development of the environment is crucial to the economic development and ecological security of the entire Hexi Corridor [4]. The division of the landscape character area of Heihe River Basin is of great strategic significance for more scientific and targeted protection of the ecological health of the river basin, building the base of Heihe River Basin harnessing and ecological planning as well as providing reference for the planning of river-type corridor with rich natural and human resources.

2. Research Area Overview
The Heihe River flows 185 kilometers from Yingluo Gorge to Zhengyi Gorge and flows through the Hexi corridor irrigation area (Gaotai County, Linze County and Ganzhou District), and is called "the middle reaches of the Heihe River." The scope of the study area includes the entire middle reaches of
the Heihe River basin, namely Gaotai County, Linze County and Ganzhou District of Zhangye City, Gansu Province, with the administrative scope as the boundary.

3. Methodology - Landscape Characters Assessment

Landscape character assessment (LCA) method began in the United Kingdom where Carys Swanwick and Christine Tudor clearly defined the landscape character assessment in an official document issued by the agency, in which said Landscape Character Assessment as addressing both the characterisation process, involving identifying, mapping, classifying and describing landscape character, and the process of making judgements based on landscape character to inform a range of different decisions [5]. Similar concepts Landscape character and landscape character areas often come along, where landscape character is a distinct, recognisable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse While Landscape Character Areas are single unique areas which are the discrete geographical areas of a particular landscape type. Each has its own individual character and identity, even though it shares the same generic character with other types [6]. The LCA methodology is now mainly used in areas such as regional development, urban planning, land use, conservation of nature and landscapes, sectoral resource planning and impact assessment of sustainable development.

3.1. Landscape Character Assessment Steps

It does not involve the quantitative appraisal of the value, but pays more attention to the regional history and culture, the field investigation and the sensory evaluation of the experts and related stakeholders in the landscape character assessment. Based on this principle, and with reference to the assessment steps of universal landscape characters in Europe, the division of landscape character areas in the Zhangye section of the Heihe River Basin mainly includes the following processes (Figure 1).

3.2. Landscape Character Assessment Index System

The European Landscape Convention states that landscape is an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors[7]. Swanwick C. also believes that landscape includes natural factors (geology, soil, climate, hydrology, vegetation, etc.), human factors (residential form, enclosure, land use and other human intervention) and cognitive aesthetics (smell, memories, associations, preferences, sounds, Touch, symbols, etc.][5]. It can be seen that river landscape is a comprehensive concept. Human factors, natural elements and visual perception are all important evaluation indicators for the assessment of landscape characters of river corridors. Therefore, on the basis of natural landscape characters, cultural landscape characters and perceptual characters, the evaluation index system for landscape characters at watershed scale consists of two levels of indicators, including eight first-level indicators and eight second-level indicators (Table 1).

Table 1. The evaluation index system of landscape characters Assessment.

| Regional general indicators | First-class indicators | Second-class indicators |
|-----------------------------|------------------------|------------------------|
| Natural landscape characters| Terrain                | Landform type          |
|                             | soil                   | Soil erosion           |
|                             | Hydrology              | Average annual groundwater depth distribution |
|                             | creature               | Biodiversity           |
| Cultural landscape characters| Land use               | Evolutionary characters of land use function |
|                             | cultural heritage      | The degree of cultural heritage gathering |
### 4. Results - Category and Description

#### 4.1. Layered Description

**Figure 1.** The flow chart of LCA steps.
4.1.1. Landform type. According to the topographic data, the landform type of the study area is plotted (Figure 2). Most of the Heihe River basin is alluvial plain in the study area. Only the northern part of Gaotai and Liyuan River and the southern part of Heihe River in Ganzhou are flood plains. Specific circumstances as shown in Table 2:

| Name             | Landform type  | Elevation (m) | Slope (%) |
|------------------|----------------|---------------|-----------|
| Gaotai County    | Alluvial plain | 1283-1300     | 0%—15%    |
| Linze County     | Alluvial plain | 1283-1500     | 0%—15%    |
| Ganzhou District | Alluvial plain | 1300-1600     | 0%—15%    |

*Source: Zhangye City Land Resources Bureau.*

4.1.2. Soil. Drawing a map of the state of soil erosion in the study area (Figure 3), we can see that the Heihe River Basin is strongly eroded in Linze County, and most of them are moderately eroded in Ganzhou District and Gaotai County. The north and south of Gaotai County are extremely eroded and the central part of the plateau is slightly eroded. The Heihe River basin is slightly eroded in the east of Heihe, Linze County, moderately eroded in the west, moderately eroded in the north of Liyuan, and strongly eroded in the middle. While the southern part is slightly eroded. The Heihe River basin is moderately eroded in northern Ganzhou, the central part is slightly eroded and the south is moderately eroded.

4.1.3. Hydrology. According to the map of groundwater depth (Figure 4) and river distribution (Figure 5), the depth of groundwater in the study area is shallow, most of which is in the range of 50m and the depth of the area away from the main trunk of Heihe River is more than 300m. There is a narrow transitional section and a great depth gap.

4.1.4. Creatures. There are about 3 animals in the west of the northern Heihe River basin in the northern part of the Gaotai County while a rich distribution of animals on the west side of the Center, with about 37 species of animals; There are about 4 kinds of western part of Linze County and about 5 kinds of animals in the Liyuan River, including Black Stork, Short-eared Owl, Barn Owl, Goshawk and Redtail. At the same time, about seven species of animals are distributed in the northern part of the Ganzhou District of the Heihe River Basin (Figure 6). The Heihe River basin distributes the desert vegetation such as Sympegma regelii and Reaumuria in the northern part of Gaotai County and Salt meadow such as Glycyrrhiza inflata in the middle part of the Heihe River floodplains, while the southern part distributes more plant species including tall grass meadow like Calamagrostis brachytricha and the desert vegetation like Sympegma regelii and Reaumuria. In addition, there is a distribution of tall grass and Calligonum mongolicum in part of the south of Linze County while Ganzhou District prefers to grow apples, pears and other fruit trees and farmland-based (Figure 7).

4.1.5. Land use. According to the detailed classification data from the Land and Resources Bureau, the land use map (Figure 8) was drawn. It can be seen that the middle reaches of the Heihe River Basin are the main farmland planting area.

4.1.6. Cultural heritage. The study area is rich in cultural protection resources where distributed a variety of types of cultural relics, ancient sites, ancient tombs, modern architecture, cave temples and stone carvings. There are altogether 201 cultural protection units of various types in Ganzhou District with concentrated distribution in or around Ganzhou City, 113 units in Linze County and 168 in Gaotai County. The cultural heritage sub-concentration map (Figure 9) drawn by the distribution of cultural heritage points shows that Ganzhou District concentrates most of the national and provincial cultural protection units.
4.1.7. Economy. With the town as the smallest unit of statistical size, residents living along the Heihe River have higher incomes, where per capita income of rural residents is above 11,000 yuan (Figure 10).

4.1.8. Perceptual characters. According to field investigation records, the Heihe River Basin has hilly and low mountains in the vicinity of Zhengyi Gorge in northern Gaotai County, with a semi-enclosed field of view. The central area is composed of trees and shrubs where the terrain is flat and the field of vision is wide, and the south area is far from the centre of Gaotai County with a wide view; Most of the farmland and villages in the western part of Linze County have a wide field of vision and many hilly areas in the east have semi-closed horizons, and there is a flat terrain and wide field of vision in Liyuan River; On both sides of the northern part of Ganzhou District, the Heihe River Basin is characterized by an open horizon of farmland and rural residential land. On the east and west sides of the centre are urban parks, farmland and industrial parks, with a broader field of vision and there is no tall buildings in the south with a broader horizon.

Figure 2. Landform type map. (Data source: Land and Resources Bureau)

Figure 3. Soil erosion status map. (Data source: Zhangye Eco-environmental Protection Planning [5])

Figure 4. Annual groundwater depth map. (Data source: Multi-process Coupling of Agricultural Water Conversion and Efficient Water Regulation Project in the Middle Heihe River Basin)

Figure 5. River distribution map. (Data source: Zhangye Water Authority)
Figure 6. Animal Distribution. (Data source: Zhangye Wetland Nature Reserve Planning)

Figure 7. Plant Distribution. (Data source: Zhangye Eco-environmental Protection Planning)

Figure 8. Land use map. (Data source: Land Bureau of Zhangye)

Figure 9. Cultural heritage sub-concentration map. (Data source: Land Bureau of Zhangye)

Figure 10. Rural resident per capita disposable income distribution. (Data source: Statistical Yearbook of all counties)

4.2. Watershed-Scale (Superimposed) Landscape Characters Zoning and Description
The middle reaches of the Heihe River basin in the study area were summed up into the above-mentioned evaluation index system of LCA. At last, the final watershed-scale landscape characters
were formed according to the elements of the landscape characters in each layer. Demarcation is based on distinguishable characters on the ground such as roads, geographical elements, and land-use types [8].

| Landform type |
|---------------|
| Soil erosion  |
| Average annual groundwater depth distribution |
| Biodiversity |
| Evolutionary characters of land use function |
| The degree of cultural heritage gathering |
| Rural residents disposable income |
| Landscape view of the water body boundary |

Figure 11. Watershed-scale landscape character area.
Gaotai County is divided into three watershed-scale landscape character areas: Gaotai downstream section, Gaotai midstream section, Gaotai upstream section, of which the demarcation line between Gaotai downstream section and midstream section is the boundary of county road 221 while the midstream and upstream section line is Heihe Bridge in Heiquan Township, Gaotai County and County Road 214; Linze County is divided into 5 landscape character areas: Linze Heihe upstream segment, Linze Liyuan River downstream segment, Linze Liyuan River midstream segment, Linze Liyuan River upstream segment, of which the dividing lines are respectively Heihe Bridge in Pingchuan Town and county road 214, county road 217, forest land boundary, 218 Linli County Road, Linze County; Ganzhou is divided into three watershed-scale landscape character areas that Ganzhou downstream segment, Ganzhou midstream segment, Ganzhou upstream segment, and the dividing lines are respectively Ganxin Heihe River Bridge and Provincial Highway 213.

The specific scope of the landscape character areas covered by each landscape character type was drawn and drawn to form the watershed-scale landscape character areas of the Heihe River (Figure 11):
On the basis of zoning, the landscape characters were corresponding described in each landscape character area (Table 3):

| Name of Landscape Character area based on Watershed Scale | Description |
|----------------------------------------------------------|-------------|
| **Gaotai downstream section**<br>North Shore: Justice Gap - Tiancheng Village<br>South Shore: Justice Gap - Tiancheng Village | Landform type: Alluvial flood plain;<br>Soil: Very strongly eroded area;<br>Hydrology: Average annual groundwater depth of 0-50 meters;<br>Creatures: 3 kinds of animal distribution, plant distribution of desert vegetation such as Sympegma regelii and Reaumuria;<br>Land use: mainly farmland;<br>Cultural heritage: Distribution of 9 cultural heritage protection units, which are mainly beacon towers ruins and temple sites;<br>Economic: 10000-11000 yuan (per capita income of rural residents);<br>Visual perception: More hilly and low mountains, vision closed. |
| **Gaotai midstream section**<br>North Shore: Tiancheng Village - Great Bay scenery<br>South Shore: Tiancheng Village - Heihe Bridge in Heiquan Township | Landform type: Alluvial plain;<br>Soil: Lightly eroded area;<br>Hydrology: Average annual groundwater depth below 100 meters;<br>Creatures: 3 kinds of animal distribution, plant distribution of saline meadow such as Glycyrrhiza inflata Batal;<br>Land use: mainly woodland;<br>Cultural heritage: Distribution of 9 cultural heritage protection units, which are mainly beacon towers ruins;<br>Economic: More than 11000 yuan (per capita income of rural residents);<br>Visual perception: flat terrain, wide field of vision. |
| **Gaotai upstream section**<br>North Shore: Great Lakes Bay Scenic Area - East boundary of Gaotai County<br>South Bank: Heihe Bridge in Heiquanv Township - East boundary of Gaotai County | Landform type: Alluvial plain;<br>Soil: Very strongly eroded area;<br>Hydrology: Average annual groundwater depth of 0-50 meters;<br>Creatures: 4 kinds of animal distribution, plant distribution of High grass meadow;<br>Land use: mainly farmland;<br>Cultural heritage: Distribution of 9 cultural heritage protection units, which are mainly the Red Army cultural sites;<br>Economic: More than 11000 yuan (per capita income of rural residents);<br>Visual perception: Large farmland, flat terrain, wide field of vision. |
| **Linze Heihe downstream section**<br>North Shore: West Boundary of Linze County - Heihe Bridge in Banqiao, Linze<br>South Shore: West Boundary of Linze County - Heihe Bridge in Yanuan Township, Linze | Landform type: Alluvial plain;<br>Soil: Strongly eroded area;<br>Hydrology: The average annual groundwater depth is shallow;<br>Creatures: 2 kinds of animal distribution, plant distribution of High grass meadow;<br>Land use: mainly farmland;<br>Cultural heritage: Distribution of 9 cultural heritage protection units, which are mainly beacon towers ruins;<br>Economic: More than 11000 yuan (per capita income of rural residents);<br>Visual perception: Large farmland, flat terrain, wide field of vision. |
| Section                      | Landform type                  | Soil                          | Hydrology                                  | Creatures                                            | Land use              | Cultural heritage                                           | Economic                                      | Visual perception                                      |
|------------------------------|--------------------------------|-------------------------------|--------------------------------------------|------------------------------------------------------|-----------------------|------------------------------------------------------------|-----------------------------------------------|--------------------------------------------------------|
| **Linze Heihe upstream**     | Alluvial plain                 | Strongly eroded area          | The average annual groundwater depth is shallow | 2 kinds of animal distribution, plant distribution of desert vegetation such as Reaumuria; | mainly farmland;    | Distribution of 19 cultural heritage protection units, which are mainly beacon towers ruins; | More than 11000 yuan (per capita income of rural residents); | Large area of farmland with broad field of vision, east of farmland is short hill with semi-closed field of vision. |
| **Linze Liyuan River downstream** | Alluvial plain                 | Strongly eroded area          | Average annual groundwater depth below 100 meters; | 5 kinds of animal distribution, plant distribution of desert vegetation such as Kalidium; | mainly woodland;     | Distribution of 5 cultural heritage protection units, which are mainly ancient village ruins; | More than 11000 yuan (per capita income of rural residents); | Low trees and desert vegetation, broad vision. |
| **Linze Liyuan River midstream** | Alluvial plain                 | Lightly eroded area           | Average annual groundwater depth below 150 meters; | Poor animals distribution, plant distribution of desert vegetation; | mainly urban land;  | Distribution of 5 cultural heritage protection units, which are mainly ancient village ruins; | More than 11000 yuan (per capita income of rural residents); | Urban construction lands are located on both sides of the river, with a closed field of view. |
| **Linze Liyuan River upstream** | Alluvial plain                 | Moderately eroded area        | Average annual groundwater depth below 200 meters; | Poor animals distribution, plant distribution of desert vegetation; | mainly urban land;  | Distribution of 3 cultural heritage protection units, which are mainly the Red Army battle sites; | More than 11000 yuan (per capita income of rural residents); | Urban construction lands are located on both sides of the river, with a closed field of view. |
| **Ganzhou Heihe downstream** | Alluvial plain                 | Moderately eroded area        | The average annual groundwater depth is shallow; | 5 kinds of animal distribution, no plant distribution; | mainly urban land;  |                                     |                                              |                                              |
5. Discussion
In the European assessment method, in very general terms a national/ regional assessment may be carried out at 1:250,000 scale, a county assessment at approximately 1:50,000 scale, and a district assessment at approximately 1:20,000-1:10,000 scale, a site level/project based assessment might be carried out at around 1:2,500 scale [6]. In the overall research plan for the division of landscape character areas in the Heihe River Basin, the scale of division is carried out from two aspects: watershed scale and local scale. Watershed-scale landscape character area refers to the relatively same types of special landscapes in the characteristics with similar combinations of landform type, drainage landform type, vegetation, land use and settlement morphology [9]. At the local scale, the landscape character area is the smaller scale division of the watershed-scale landscape character area, where each division has commonality and also its own unique characteristics and definitions [10]. The results of this phase are reflected in the analysis of the history, landscape formation, changing trends and pressures of a region, forming a landscape character map and the description of features that are relatively non-value related [11]. The research on the division of watershed scale has been relatively complete at present and this paper also discussed the watershed scale only. The division of landscape character areas at the local scale will be the focus in the next research work.

6. Conclusion
Based on the assessment methods and advanced experience of landscape character assessment in Europe, this paper summarized the watershed-scale evaluation index system of landscape character assessment from three aspects of nature, culture and perceptions in the arid region of Northwest China,
and divided the landscape character areas in the Zhangye section of Heihe River. These drew to the following conclusion:

a) From the perspective of methodology, it is scientific and effective to use the LCA method based on the three aspects of nature, culture and perception characters, as well as eight factors including terrain, soil, hydrology, creature, land use, cultural heritage, economy, visual perception to divide the landscape character areas according to the multi-dimensional and complicated geographical conditions of the Zhangye section of Heihe River basin.

b) From the perspective of geographical practice, the study area was divided into 11 landscape character areas in the watershed scale after stratification and superimposition. The landscape character areas in the study area have similar landform type, soil, hydrology, flora and fauna, land use, Cultural heritage, the combination of economy. Each landscape character area has a shared landscape form that can be identified on site and on the map and each area can be identified in different areas of evaluation. The division of the landscape character area of Zhangye section in Heihe River basin provides the scientific guidance for the next step of the forest planning, spatial planning, ecological restoration, land consolidation and sustainable utilization in Zhangye based on regional characteristics.

7. References

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