Scientific
Research
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Examination of Urban Landscape Aesthetics through Mapping Using Geotagged Social Media Data from Flickr

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Abstract

Landscapes are part of the earth's surface, and include terrestrial, aquatic, natural, and anthropogenic features with differing dominance. The evaluation of Landscape Aesthetics (LA) and scenery is helpful for the understanding landscapes. The mapping of LA is increasingly being recognized in urban and landscape planning. Examining the flow and capacity of LA is an essential element in understanding the sustainability of urban landscapes. An explicit methodological approach was proposed for mapping LA using social media data (geolocated photographs) from Flickr to study the spatial distribution of LA in Xi'an, China. The LA flow and LA capacity were conceptually distinguished and assessed. The LA flow was analyzed with 10,278 geotagged photographs from Flickr to express people's actual appreciation of LA. The LA capacity was examined by spatial criterion evaluation, combined the weight of landscape features. LA flow and LA capacity differ in both spatial extent and quantity, although there was a spatially explicit balance between them. The results show that LA flow largely occurs in the urban core zone and that LA capacity is concentrated in certain parts of Xi'an due to the imbalanced distribution of historical cultural heritage sites. This research contributes to a better understanding of LA values and the relationships between LA values and landscape characteristics. The results can support the integration of cultural services in landscape planning and land use policy.

Keywords

Landscape Aesthetics, Mapping, Social Media Data, Social Value

1. Introduction

Aesthetics can be defined as the sensory or sensory-emotional values of people's

immediate and intuitive perceptions (Lazdāne et al., 2013; Langemeyer et al., 2018). They also can reflect humans' understanding and appreciation of landscapes by combining historical and cultural identities (Nogué & Vicente, 2004). Landscape perception has become the key process for connecting humans with ecological phenomena (Gobster et al., 2007). People are powerfully and regularly engaged by aesthetic experiences evoked through their perception of the landscape. However, aesthetics goes beyond art appreciation or sublime experience (Saito, 2007). The evaluation of the aesthetic quality of a landscape is influenced by assessment standards (Jorgensen, 2011). It makes people acquire what social value of Landscape Aesthetics (LA) and meaning in the context of LA and recognize as a LA experience. The value of LA has been addressed more in socioecological research, besides in the public perception (Howley, 2011).

LA has been valued in many studies based on direct and indirect valuation approaches. The conventional methods for assessing LA include hedonic pricing valuation (Estruch-Guitart & Vallés-Planells, 2015), contingent valuation (Dupras et al., 2018), revealed preference techniques (Kong et al., 2007) and stated preference techniques (Poder et al., 2016). Estruch-Guitart and Vallés-Planells (2015) estimated the total economic value of the LA in Albufera Natural Park (Valencia, Spain) using the analytical multicriterion valuation method with the aid of a set of experts. Van Riper et al. (2012) collected and analyzed on-site and mailback survey data to measure the social value and natural resource conditions in Hinchinbrook Island National Park, Australia. Zhang et al. (2019) obtained social value data from questionnaires in Taibai Mountain National Forest Park and used the ecosystem service model to evaluate the social value of the Qinling Mountains. Schirpke et al. (2019) aimed to evaluate the historic development of aesthetic values from a perception survey using 10,536 observer points and calculated landscape characteristics for each observer point using a regression model. These studies used limited samples to express people's perceptions of the environment around them and cannot provide spatial information. To understand cross-cultural and continent-scale landscape values, LA assessments must rely on fragmented, diverse and biased cases (van Zanten et al., 2014). Social media data can overcome the abovementioned challenges associated with mapping landscape values. The use of social media data to study societally relevant questions across large-scale geographic extents is novel (van Zanten et al., 2016).

Social media data are produced and used to exchange information via texts, images or videos generated by the users on virtual community platforms (Cui et al., 2018a). Different types of data can be captured by various social media platform sensors. Particularly, social media sites support geotagged information submission and sharing and the platforms amass a large amount of spatiotemporal data. There is a large amount of unexplored information, providing a special perspective on the evaluation and quantification of aesthetic values. Lee and Son (2018) used text mining methodologies to assess the perceptions of the

Taean Coast National Park embedded in text uploaded to the "Taean Travel" blogpost. Cui et al. (2018b) studied social media and mobility landscapes with social media data using a three-step methodological framework to uncover the spatial patterns of urban human mobility. It has been shown that social media data are very useful for analyzing various types of content out an expert's point of view, and can be used to analyze various aspects of how people perceive and enjoy landscapes by integrating landscape objects, images and activities.

Flickr, a popular photo-sharing social network, has a large number of user-generated digital photos. Each uploaded photo that expresses aesthetic values can supply several kinds of data, including visual content, geolocation data, an observed date and a description (Spyrou & Mylonas, 2016). Tenkanen et al. (2017) systematically assessed park popularity and temporal visitor counts in 56 national parks in Finland and South Africa from Flickr photographs with high-precision visitor statistics. Langemeyer et al. (2018) used social media data from Flickr to map the spatial distribution of the LA of the cultural ecosystem services and enhance their consideration in land use policies and landscape planning. Van Zanten et al. (2016) evaluated the usefulness of Flickr and quantified the landscape values in Europe on a continental scale. Figueroa-Alfaro and Tang (2017) used geotagged photographs from Flickr and ArcGIS software to examine the spatial patterns of the aesthetic value of cultural ecosystem services in Nebraska. These researchers mapped and explained where specific landscape values occur. Their results considered the different stakeholders and land use groups and revealed place-specific perceptions, attitudes and preferences. Furthermore, individually perceived landscape values were spatially aggregated and the diversities among people, communities and places were also revealed. Ginzarly et al. (2019) proposed a diversity of methods to visualize specific behavioral patterns and landscape perceptions based on social networking platforms. The results can improve the understanding of the diversity of heritage sites and attributes for decision-making processes in heritage site planning and management. Oteros-Rozas et al. (2018) found a positive (albeit weak) relationship between landscape diversity and cultural ecosystem service diversity by analyzing 1,404 photos from the Flickr and Panoramio platforms. Social networking platforms offer a novel opportunity for researchers to collect large-scale diversity data. Spatial patterns can be used to measure and value the distribution and diversity of LA using social media data. These data and methods have potential to operationalize and allow their mainstream use in landscape management and environmental decision-making.

To assess the current LA value of Xi'an, geotagged Flickr photographs of Xi'an were used to identify and map LA values, both as an evaluation of the method and as a case study in China. To better understand LA, LA flow and LA capacity were conceptually distinguished and determined. LA flow is identified as the actual realization of benefits through landscape appreciation on a point in time and space (Villamagna et al., 2013; Langemeyer et al., 2018). LA flow assessment

has been used in aesthetic and cultural ecosystem service evaluation, although it has not historically been done with geotagged social media data (Pastur et al., 2016; Plieninger et al., 2013; Richards & Friess, 2015; Yoshimura & Hiura, 2017). LA capacity is an expression of physical landscapes and their features or landscape diversity (Langemeyer et al., 2018) and helps to inform land use or land change policies. Moreover, the relationships between LA flow and LA capacity can provide information for land use decision-making (Baró et al., 2016). In this study, assessing and mapping LA flow and LA capacity is particularly relevant. Urbanization impinges upon the capacity of landscapes to provide sustained LA flows, and the high density of the human population and human assets usually results in high demands for LA. This assessment delivers key information for landscape planning in Xi'an and helps to directly and indirectly improve the level of regional landscape services.

2. Material and Methods

2.1. Case Study

Xi'an, which is located in northwestern of China and is the capital of Shaanxi Province, is used as an example in this study and located at the northwest of China. The city has a total area of 10,096 km^2 with a resident population of 9.6 million people (Xi'an Statistical Yearbook, 2018). Xi'an, which has a history of more than two thousand years and recognized as one of the most important cities in China, was the capital of 13 dynasties and the eastern starting point of the Silk Road. Xi'an has a rich physical heritage and intangible cultural heritage, and these characteristics increase public awareness. The length and breadth of Xian's historical legacy has an iconic status in both the domestic and international tourism markets. Figure 1 shows the studied areas and the main attractions of Xi'an found in the Flickr data. The main attractions are depicted in Table 1.
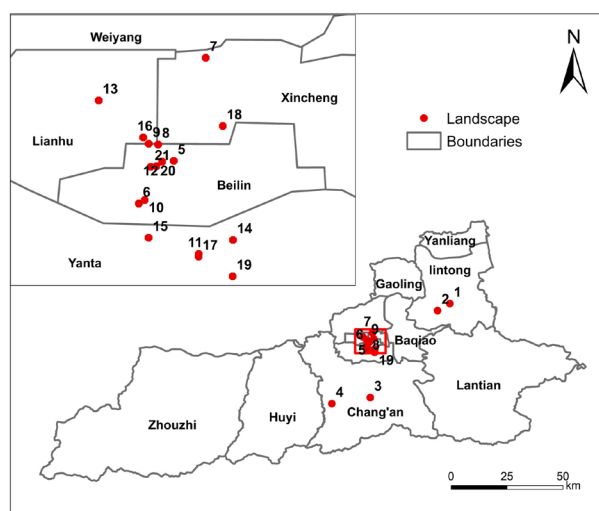

Figure 1. An overview of the study area and the main attractions of Xi'an in the photographs from Flickr.

Table 1. The main attractions of Xi'an analyzed in this study (Zhao et al., 2018).

Attraction No.	Attraction	Topic
1	Emperor Qinshihuang's Mausoleum Site Museum	Cultural relics
2	Hua Qing Palace	Cultural relics
3	Guanzhong Folk Art Museum	Cultural relics
4	Ancient Guanyin Monastery	Cultural relics
5	Stele Forest Museum	Cultural relics
6	Xi'an Museum	Cultural relics
7	Daming Palace	Cultural relics
8	Bell Tower	Cultural relics
9	Drum Tower	Cultural relics
10	Small Wild Goose Pagoda	Cultural relics
11	Giant Wild Goose Pagoda	Cultural relics
12	Shuyuan Gate	Cultural relics
13	GuangRen Lama Temple	Cultural relics
14	Qinglong Temple	Cultural relics
15	Daxingshan Temple	Cultural relics
16	Great Mosque of Xi'an	Cultural relics
17	Ci'en Temple	Cultural relics
18	Yongxingfang	Theme park
19	Tang Papadise	Landscape
20	City wall	Cultural relics
21	City Moat	Cultural relics

2.2. Mapping Landscape Aesthetics Flow

Photographs from Flickr were used to assess the LA flow. Flickr is an image and video hosting website. The landscape photos uploaded to the Flickr platform were of landscape considered aesthetically pleasing. Herein, the photos of Xi'an in Flickr from 2017 to 2018 were analyzed to assess the LA flow. There is a total of 10,278 photographs in this dataset. Photographs were discarded if they did not represent a landscape feature or the correct geographical location. The discard details are as follows: 1) the photos were located in the wrong place or outside of Xi'an; 2) people, pets or developed environments were the main subject; 3) the photos were taken indoors; 4) the photographs did not relate to the landscape; 5) the photographs could not be identified or were not available; 6) the photos were copied or uploaded repeatedly. The final subsample of 1812 relevant photographs was selected and mapped onto a 200 × 200 m resolution grid. The mapping was carried out with an ArcGIS software according to the following Equation (1):

$$f_i = \sum\nolimits_i p_i \tag{1}$$

where f_i, the flow in cell i, is the total photographs in cell i, and p is the photo number.

To examine the landscape diversity and research the LA flow related to landscape complexity, the coexistence of landscape features in the photographs was calculated according to the following Equation (2):

$$E_{ij} = \frac{\text{Total } p_j}{\text{Total } p_i} \times 100 \tag{2}$$

where E_{ij} is the coexistence value, total p_j is the photographs representing the landscape feature j among the landscape feature i, total p_i is the total photographs of the landscape feature i.

2.3. Mapping Landscape Aesthetics Capacity

The LA capacity was studied with criterion weights that represent the impact of single landscape features on the LA capacity. These criterion weights were determined to calculate the value of landscape features. A survey was conducted in which respondents were asked to rank landscape features. The criterion weights were calculated according to a landscape aesthetic model (Kerebel et al., 2019). The values of the LA capacity were mapped onto a 200 × 200 m grid. The value expressing the LA capacity was obtained according to the following Equation (3):

$$C_i = \sum_n^N \left(v_{n,i} \times w_n \right) \tag{3}$$

where N is the total number of landscape features in cell i, $v_{n,i}$ is the visibility (1 = visible; 0 = invisible) of landscape feature n in cell i, and w_n is the value of the criterion weight assigned to landscape feature n.

2.4. Comparison between LA Flow and LA Capacity

Various landscapes are located in different districts or counties of Xi'an. To enhance the planning and management of Xi'an, the spatial distribution of the LA flow and LA capacity was studied. The LA flow related to a district or county was calculated using the following Equation (4):

$$f_i = \frac{\sum p_i}{A_i} \tag{4}$$

where f_i is the LA flow in the district (or county) i, and A_i is the surface area of district (or county) i.

Furthermore, the LA capacity related to a district or county was calculated according to Equation (5):

$$C_i = \frac{\sum_n^N \left(v_n \times w_n \right)_i}{A_i} \tag{5}$$

The LA flow and LA capacity were divided into four groups, from the lowest to highest values. Four combinations (low-low, low-high, high-low and high-high) were used to compare the LA flow and LA capacity.

3. Results and Discussion

3.1. LA Flow Analysis

Xi'an, with the fast-growing industries and city expansions, is located in the Guanzhong Basin, and there are 11 districts and 2 counties within its jurisdiction. The landscapes of Xi'an that were found in the Flickr photographs are located in the districts of Lianhu, Xincheng, Beilin, Yanta, Lintong and Chang'an (Figure 1). There are rich historical and cultural heritage features in these districts. Figure 2 shows the strong imbalance of the LA flow of Xi'an. Very high levels of LA flow exist in the districts of Lianhu, Xincheng, Beilin, Yanta ans Lintong. A total of 43.5% of the photographs are of the famous Terracotta Warriors of Qinshihuang's Mausoleum in the district of Lintong. The Emperor Qinshihuang's Mausoleum Site Museum is regarded as one of the iconic global heritage sites. There are 6.8 million and 8.5 million tourists visiting the terracotta warriors in 2017 and 2018, respectively (available online:
http://www.bmy.com.cn/html/gov/xw/bwgyw/bd2bc231169a47009c65431a0fcb7d81.html). The City Wall and the Bell Tower of the Ming dynasty are located in three districts (Lianhu, Xincheng and Beilin), and ranked second and fourth, with 16.2% and 7.1% of the photos, respectively. These distinguished historical heritage sites attract a large number of tourists. The fountain had the third largest representation and was featured in 8.3% of the photographs. Footpaths, including Muslim Street, were present in 6.3% of the photos. It is clear that most landscapes are distributed in the main urban area of Xi'an. Langemeyer et al. (2018) used Flickr photographs to examine and map spatial distribution of the LA in Barcelona of Spain. They found that the high levels of the LA flows in urban landscapes of Barcelona were due to the interaction between developed infrastructure and other more "natural" landscape features. Complex landscape
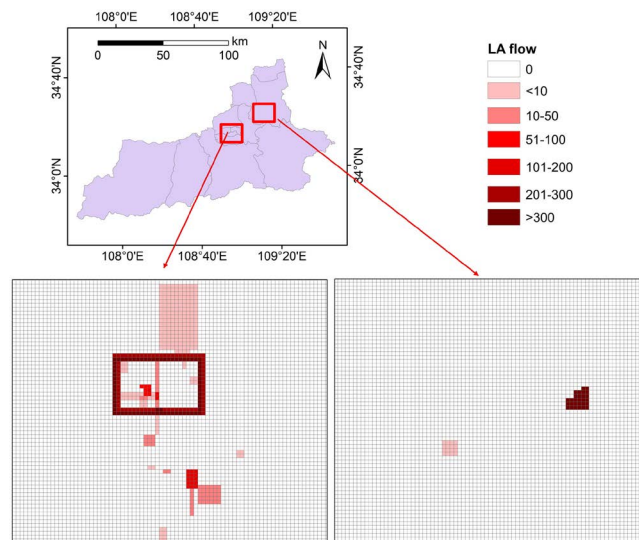

Figure 2. Landscape aesthetic flow in Xi'an. (The sum photographs at the 200 × 200 m pixel level).

features can enhance LA flow. In Barcelona, the built-infrastructure appears in association with other landscape features. Xi'an is qualitatively different from Barcelona in many ways, including its history, culture, landforms, recreation and inspiration. Table 2 shows that most landscapes of Xi'an include the built-infrastructure features. Xi'an has developed by humans for 1000 years and has an abundance of cultural heritage sites (72 imperial tombs and over 700 ancient buildings). Six historical sites are included in the "World Heritage List" (the terracotta warriors, Giant Wild Goose Pagoda, Small Wild Goose Pagoda, Daming Palace, Weiyang Palace, and Pagoda of Xingjiao Temple). Thus, LA values of Xi'an are associated with cultural heritage sites.

Table 2. The landscape characterizations of Xi'an based on Flickr photographs from 2017 to 2018.

Landscape feature class	Landscape feature	Occurrence % (Photograph number)	Rank	Criteria weights (%)
	Emperor Qinshihuang's Mausoleum Site Museum	43.5 (789)	1	7.1
	Shaanxi History Museum	0.6 (11)	6	3.3
Museum	Stele Forest Museum	0.2 (4)	17	1.6
	Xi'an Museum	0.2 (3)	15	1.2
	Guanzhong Folk Art Museum	0.1 (2)	22	0.7
	City wall	16.2 (293)	3	6.9
	Daming Palace	0.2 (3)	8	1.2
	Bell Tower	7.1 (129)	2	6.6
Monumental building	Drum Tower	3.7 (67)	9	5.8
	Hua Qing Palace	0.3 (6)	5	2.1
	Small Wild Goose Pagoda	2.3 (41)	10	5.0
	Giant Wild Goose Pagoda	4.3 (78)	4	6.1
Built-infrastructure features	Shuyuan Gate	0.5 (9)	21	2.9
	GuangRen Lama Temple	0.3 (6)	25	2.4
	Ci'en Temple	0.6 (11)	11	3.3
	Qinglong Temple	0.1 (2)	14	0.7
Temple	Ancient Guanyin Monastery	0.4 (7)	16	2.6
	Daxingshan Temple	0.06 (1)	26	0.3
	Great Mosque of Xi'an	3.6 (65)	27	5.6
	Roads	3.1 (57)	23	5.3
	Footpaths	6.3 (115)	19	6.3
	Buildings	0.7 (13)	20	3.7
	Sculpture	0.9 (16)	24	4.2
	Park	1.7 (31)	7	4.5
	Yongxingfang	0.3 (5)	12	1.9
Water features	City Moat	1.8 (33)	13	4.8
	Fountain	8.3 (15)	18	4.0

The use of landscapes as a touristic resource is beneficial for the creation of new prospects for sustainable development, and tourism is a flourishing industry and a key driver of the economy. In 2017, the number of tourists and the total tourism earnings in Xi'an were 180 million and 163 billion Chinese yuan, respectively (Xi'an Statistical Yearbook, 2018). Tourism promoted the development of the economy of Xi'an. Furthermore, it has been shown that the number of days the average international tourists stayed in Xi'an remained at 2.9 from 2004 to 2017. The time spent in Xi'an can be used to analyze tourist movements. Tourist movements can be identified as the behavior of a tourist from a place of origin to certain destinations. The number of photographs represents the popularity of attractions. Understanding the spatial distribution of the popularity of the attractions can help to identify tourists' preferences for visiting various sites. The results show that the tourist movements in Xi'an aggregated in specific sites. According to Table 2, it is obvious that a large number of tourists were attracted by the historical heritage sites. The aesthetic landscape values are high mainly in the site of terracotta warriors and City Wall. However, historical heritage sites do not compel tourists to stay very long. These results can be provided to policymakers to improve the sustainable interaction of tourism development in Xi'an. Policymakers can use the cultural resources of Xi'an to enhance the attractiveness of cultural relics by integrating resources and supervising personnel services (Zhao et al., 2018).

Moreover, heritage sites can provide attractive activities for tourists, such as historical reconstitutions, historical event reenactments and festivals. Generally, landscape features can appear in different combinations. The coexistence between landscape features was analyzed from the photographs of Xi'an on Flickr (Table 3). Table 3 shows that monumental buildings occur more frequently

Table 3. Coexistence between the landscape features of Xi'an.

	Museum (%)	Monumental building (%)	Temple (%)	Roads (%)	Footpaths (%)	Building (%)	Sculpture (%)	Park (%)	Modern tourist spot (%)	City moat (%)	Fountain (%)
Museum	100	5.1	0	0	0	0	1.0	0	0	0	0.37
Monumental building		100	1.8	0	2.4	0	0	0	0	5.3	1.4
Temple			100	0	0	0	0	0	0	0	9.8
Roads				100	14	12	11	0	0	58	0
Footpaths					100	1.7	1.7	0	0	0	0
Building						100	0	0	0	0	0
Sculpture							100	0	0	0	0
Park								100	0	0	0
Modern tourist spot									100	0	0
City Moat										100	0
Fountain											100

than other landscape features. Roads, parks and modern tourist spots remain as the individual features that sustain the LA flow. The coexistence of landscape features is relatively low in Xi'an due to the distribution of heritage sites. To enhance the landscape complexity of Xi'an, officials making land use policies should consider the significant differences in the area, activity degree, and transfer mode of lands with different tourism purposes (Liu et al., 2018).

The development of the tourism industry requires a variety of functional spaces, such as site for transportation, accommodation, catering, sightseeing, shopping and entertainment. The attractions are mainly located in the core zone of Xi'an, and the transportation and accommodation services become saturated in the districts of Lianhu, Beilin, Xincheng and Yanta. With the rapid urbanization of Xi'an, officials should account for changes in the spatial distribution of functional spaces by developing the tourism industry in the suburban districts/counties.

3.2. LA Capacity Analysis

The LA-capacity of Xi'an was investigated to inform the spatial multicriteria analysis (Figure 3). The LA-capacity was deeply influenced by the historical and cultural elements of Xi'an. Although the distribution of the LA-capacity is unbalanced, there are two or more landscape features in the districts of Lianhu, Beilin, Yanta, Xincheng and Lintong. It is obvious that the built-infrastructure features are seriously impacted by the museum and historical monumental buildings. The water features are limited by geographical and historical factors. There are eight rivers and streams (Wei River, Jing River, Chan River, Ba River, Jue River, Lao River, Hao River and Feng River) surrounding Xi'an. In particular, the Wei River has had a significant impact on Chinese civilization. The most popular of water features are City Moat and the fountain in the north square of
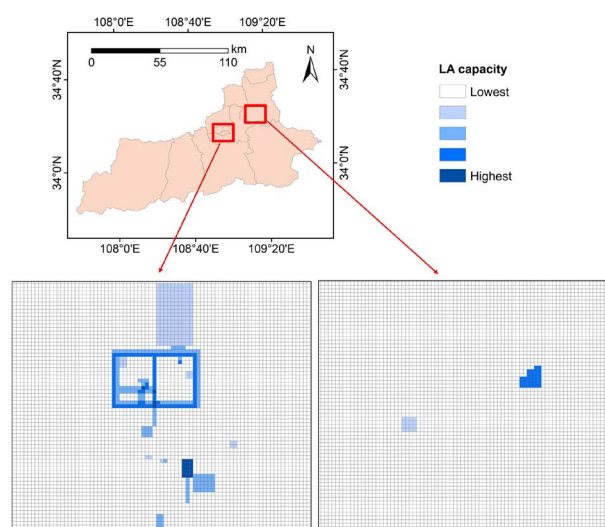

Figure 3. Landscape aesthetic capacity in Xi'an. (The sum photographs at the 200 × 200 m pixel level).

the Giant Wild Goose Pagoda. However, the natural landscape features in Xi'an are not very popular.

LA values contribute substantially to attracting visitors and enhancing socioeconomic well-being. LA, i.e. the understanding of beauty by human cognitive perception, consists of visual aesthetics formed by the appearance of the physical landscape (natural and man-made features developed in the landscape) and sensed aesthetics formed by human sensory perception (smell, sound, taste and touch) (Lazdāne et al., 2013). The intangible cultural heritage of Xi'an can be a "living bridge", linking aspects of cultural history and traditions; this is an important element of any destination's tourism resources. However, the visual landscapes are aggregated on some physical heritage resources. The landscape diversity of Xi'an tends to be homogenous. Landscape diversity is an important aspect of biodiversity (Noss, 1990) and consists of cultural and natural elements, considering the diversity of land uses, and structures and forms (Haber et al., 2008). To enforce and develop landscape diversity, local authorities should learn about tourists' preferences to increase the diversity of touristic attractions by promoting other natural and cultural landscape values beyond recreation. An increase in landscape diversity would result in an increase in the city scale and land use change, and a decrease in cultivated land. Moreover, tourist movements can be enriched, and the spent time in Xi'an could be increased owing its complex landscape diversity. Scientific and technological advancements can be used to create new forms of landscape aesthetics to enhance the image of Xi'an as a domestic and international tourism destination. The project of "Eight Rivers Regeneration" has been programmed to restore sustainable water management in Xi'an. Some waterfront parks will be engineered to mimic the landscape design of the tang dynasty according to ancient illustrations. The project will take advantage of diverse sources of natural precipitation, such as streams and reclaimed water, and build a quasi-natural urban water cycle. Furthermore, the engineering will lead to the perfect combination of water resources and attractive landscapes.

3.3. Comparison between LA Flow and LA Capacity

The comparison of the spatial distributions of LA flow and LA capacity in Xi'an is shown in Figure 4. The highest LA flow and LA capacity are observed in the districts of Lianhu and Beilin districts, and in Beilin, respectively. The district of Lintong shows high LA flow and low LA capacity due to its few landscape sites (the terracotta warriors and Huaqing Palace). The highest LA flow capacity appears around the core area of Xi'an, including the district of Lianhu, Beilin and Xincheng. There are many museums and historical viewpoints distributed in these districts. High-low-grade LA flow capacity is observed in the Yanta district, with some urban landscapes, such as parks, squares and footpaths. Unfortunately, other districts remain in a low grade of LA flow capacity. The districts/counties of Zhouzhi, Huyi and Lantian are located in the northern foothills
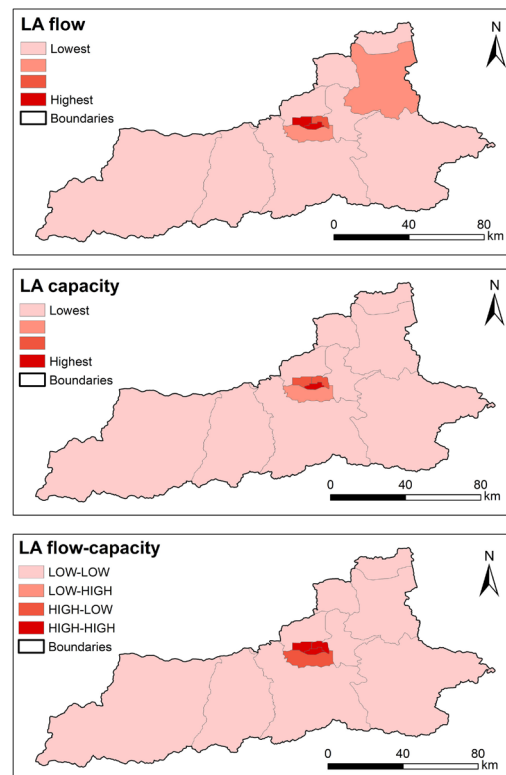
Figure 4. Comparison between LA flow and LA capacity.

of Qinling Mountain; however, they do not have any mountainous and natural landscapes. In high LA flow and LA capacity areas, a new development in the landscape cannot be accommodated without a significant and adverse impact on the landscape character. A small-scale development can be implemented, but the setting and form of the existing features and the characteristics and sensitivity of the adjacent areas should be considered. The low LA flow and LA capacity areas can accommodate larger amounts of development, although certain landscapes and visual features need protection.

It is obvious that the landscape sites are mainly gathered in the urban core zone of Xi'an. High-density landscapes can benefit city sustainability by reducing travel time and improving energy efficiency (Belchera et al., 2019). Cultural services can reach their upper limits in long-term high-density landscape areas. Therefore, high-density areas can show a decreased quality of life due to the social imbalances characterizing large cities. However, LA is the outcome of interactions between humans and landscapes. The demand for aesthetically pleasing natural landscapes has increased with an increase in urbanization (Sarukhán & Whyte, 2005). Furthermore, the quantity and quality of high-density landscape areas contributing to landscape aesthetics are declining (Frank et al., 2013). To ensure the sustainability of cities, future urban planning strategies should consider mechanisms for coping with different types of land use conflicts (Gavrilidis et al., 2016) address the conflict between ecological sustainability and environmental aesthetics.

3.4. Limitation and Future Direction

Based on economics and the resources of the information age, in situ social media data is a very attractive information resource related to cultural ecosystem services and can be used to examine LA flow. Landscape photographs contain the significant information on human relationships with landscapes, human practices in landscapes and landscape features (Oteros-Rozas et al., 2018).

Precise methods are needed to efficiently obtain information from and analyze the contents of landscape photographs. The relationships between human activity and landscape aesthetics can be investigated using analysis of social media data. Furthermore, the relationships between cultural ecosystem services and landscape features can be explored by combining the land use policies.

Social media data, which are freely and easily available from internet, are relatively inexpensive and less time consuming to collect than extensive surveys. The visual evidence demonstrates what people appreciate at each location and offers a qualitative insight into the concentrations of unexplained variation in the tourist patterns (Tieskens et al., 2018). Photographs from Flickr with geotagged data can be used to identify popular viewpoints in landscapes and understand landscape aesthetics in a spatial context (Chen et al., 2018). In this study, all the photographs of Xi'an from Flickr (2017-2018) were acquired, and less than one fifth-of them were selected for this work. Using these social media data is a novel approach to expand the assessment of LA and estimate the LA-flow from multiple observations in a spatially explicit form and across large scales. This method has the benefit of avoiding the participatory photography or social surveys used by many conventional studies to collect quality data. Comparable data from different social media sites, such as Flickr or Instagram, can be obtained to study different regions of the world. This can help researchers to compare multiple types of landscape features and more easily understand LA and land use policy. In this study, some places were visited less frequently due to incomplete demographic information in the social media data, and their LA values are difficult to express accurately. Therefore, gaps or blank spots may exist in this research. Future research will build automated models to analyze photograph contents and reduce manual work. This will allow us to analyze much larger samples and improve the data validity and reliability by efficiently extracting information from social media data, helping to establish a comprehensive database for the assessment of LA.

4. Conclusion

In this work, a methodological approach was developed to model their spatial distribution and quantify the appreciation and characterization of the structural elements of a landscape. Social media data, particularly photographs, provide a useful source for quantifying and mapping LA flow and LA capacity at the regional scale. This tool demonstrates that the crow-sourced geospatial data can be valuable for analyzing LA. The use of social media data is in its infancy and has

potential limitations; nevertheless, these data were used to explore the intangible values related to individuals, society and culture Xi'an, China. This research provides a spatial analysis method to understand LA and make LA assessment more operational and provides evidence supporting the integration of LA into land use policies and landscape planning.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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