Potential of Using a GIS-based Natural Visual Landscape Evaluation Tool in Large-scale Urban Planning

A Comparative Study in Dongshan New Town

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Natural visual landscape is under deterioration due to improper construction and planning in modern development of China. One of the main reasons is the feebleness in planning supporting methodology and technology in respect for natural visual landscape. In such supporting information, landscape evaluation always acts as a significant component. Especially in comprehensive planning, it is the only approach to access visual value distribution in large-scale region. In this paper, we present a GIS-based natural visual landscape evaluation tool through a case study. By an integrated rating statistics function of this tool, visual quality of natural landscape is quantified through analysis in visibility, landuse, and visual resource quality. Then we make comprehensive planning strategies based on this scientific supporting tool. Furthermore, we discuss the potential of this tool by comparing these strategies with schemes of the same project conducted through traditional planning module. This comparative study reveals the efficiency and effectiveness of the tool as well as its implementation in large-scale comprehensive urban planning.

***Keywords**: Landscape evaluation; GIS; Comprehensive urban planning; Natural visual landscape.*

1. Introduction

During urbanization in China, more and more improper constructions destroy natural landscape. The feebleness in methodology and technology of natural visual landscape consideration is one of the main reasons. Many cities' comprehensive planning do not include concrete and operable strategies in recognizing and preserving natural visual landscape resources. Or at least the validity and utility of the planning operations for those purposes are doubted because of the absence of scientific support. Besides, visual quality is also hard to master in large-scale urban planning. One of the possible solutions of the above-mentioned problems is introducing landscape evaluation (LE) to assess the visual quality of natural landscape through scientific approaches. Consider comprehensive planning, LE is the only way to comprehend visual values in large-

scale region. Combine with GIS, LE can offer the spatial distribution data of visual quality of natural landscape, which is essential to natural landscape respecting planning.

In this paper, we present a GIS-based analysis tool to evaluate the natural visual landscape quality in comprehensive planning of large-scale urban region. The proposed tool is a part of an analytic prototype system, which we have been developing to study the Visual Sustainability of urban natural landscape. The prototype system functions in conjunction of viewshed analysis, visual sensibility assessment and 3D simulation based on GIS technology (He and Tsou, 2001; He, 2001). It offers reliable scientific references to support urban planning.

We discuss the potential of this tool in large-scale urban planning application by comparing planning modules and products of different technical support. The comparative study is based on different comprehensive planning project schemes of Dongshan New Town in Jiangning County of Nanjing, Jiangsu Province, China. The site, which is rich in natural visual landscape resources, is more than 150 square kilometers. The west, east and southeast are surrounded by mountains. There are two main rivers flowing through the site. Small lakes and ponds are also disseminated in the whole region. All planner groups in this study do pay their attentions to visual landscape conservation.

2. The GIS-based natural visual landscape evaluation

We consult the natural landscape visual assessment methodologies from Litton (1982). Most part of the technology is inherited from our former study on mountain landscape (He, 2001; He and Tsou, 2001, 2002b). In order to support comprehensive urban planning, we also introduce the concept of "landscape planning priorities" from the Soil Conservation Service (SCS) of USDA (1968) for the purpose of classifying different landscape qualities in large-scale planning mission.

2.1 Visual landscape assessment on different aspects

We first calculate the viewshed of important natural landscape elements, including mountain skylines and water. Distribution of these visible scopes and the ratio of their spatial superposition reflect the visual significance of different locations within the site. Concurrently, visual distance, visual angles and climatic factors are also translated into spatial parameters and introduced to engender internal divisions in various visual qualities of the landscape. Visual Potential Scopes (VPS) is calculated from overlapping visible areas and visual quality parameters for certain landscape element (He and Tsou, 2002a). Visibility value estimation of overall natural visual landscape recourses is derived from VPS overlaying and quantified through spatial statistics (Figure 1).

On the other hand, following the methodology of SCS of USDA (1968), we also consider the landuse effect as well as the visual resource characteristics. Landuse information of both built-up reality and planned development are rated into value points. Similar numerical values are also employed to translate visual resource features, such as landform, vegetation, water, man-made constructions and so on, into countable data (He and Tsou, 2002a).

2.2 Integrated rating for planning priority

The numerical ratings given to the visual landscape, including visibility of mountain (Vm) and water (Vw), landuse (LU), and visual resource quality weighting in region and form (VRQ), are added to determine an integrated rating for each area. This procedure can be achieved through GIS overlay operation and spatial-oriented statistics. In our case study, the combined ratings are verified from 0 to 17 points. These ratings illustrated

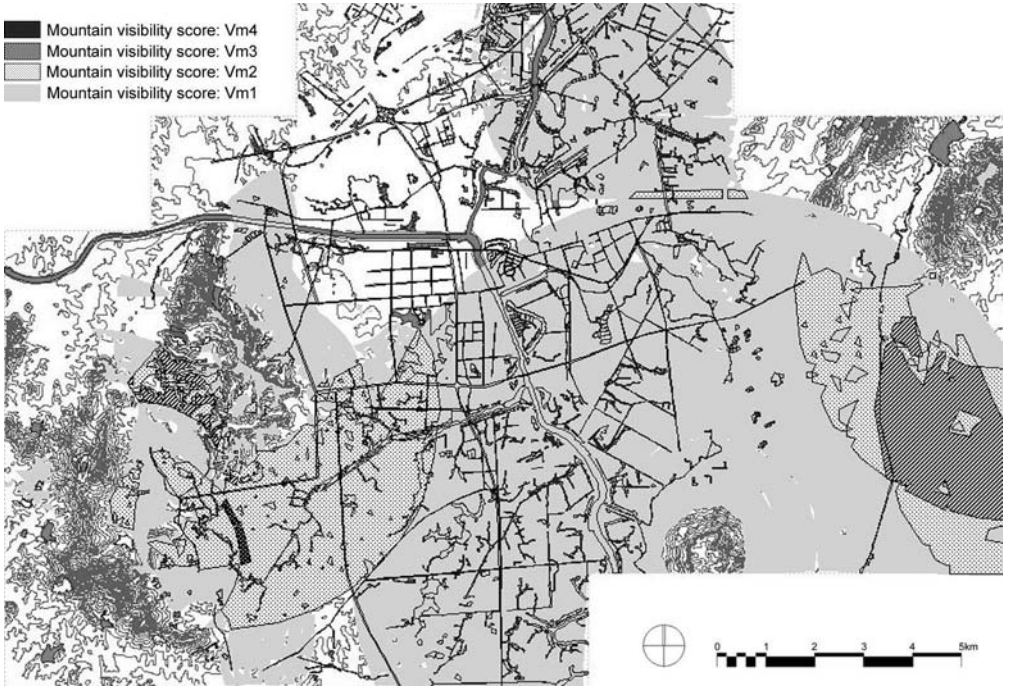

Figure1. Visibility value mapping of mountain landscape

the visual quality classifications of natural landscape within the planning scopes (Figure 2). Therefore, priority of natural visual landscape consideration in comprehensive urban planning can be educed according to these classifications (Table 1) (He and Tsou, 2002a). It offers reliable and accurate information to support planning decision making.

3. Comparative study

The above-mentioned natural visual landscape quality ratings will be adopted into a final comprehensive urban planning done by a professional design group through traditional planning module. Since this planning project is still in progress, the advantages and shortcomings of this tool reflected in the whole mingling processing are impossible to be recorded in this paper. Yet, we try to suggest some planning strategies according to our founding through the proposed tool. Moreover, to understand the potential of using this GIS-based tool in large-scale urban planning, our solution is compared with those comprehensive planning of the same project conducted by other planners in traditional module.

3.1 Planning strategies supported by scientific LE data

The planning strategies suggested by our research group are illustrated in figure 3. There are three important conclusions drawn from the scientific supporting (He and Tsou, 2002a):

- Leaving open space to introduce the southeast dominant mountain landscape into central urban area along the river. The south intersection of two rivers is the most suitable place to situate a leisure park because of its richness in

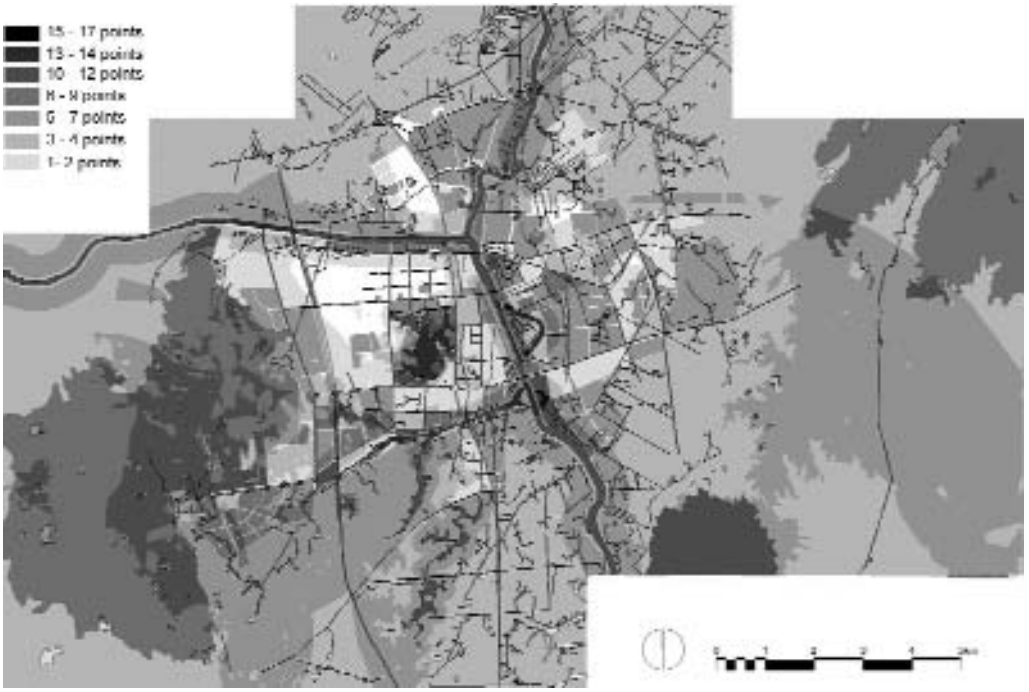

Figure 2. Integrated ratings mapping of natural visual landscape quality

Priority of planning consideration	Natural visual quality ratings	Natural visual quality classification	Description of natural visual landscape consideration
Ultimate consideration	15 – 17	Perfect	Visual protection of natural landscape is the most important principle for further development
1st priority consideration	13 – 14	Best	Respect to natural landscape must be considered and taken higher priority in balancing different aspects
	10 – 12	Better	
2nd priority consideration	8 – 9	Good	Special consideration on natural visual landscape need to be taken in comprehensive planning
Normal consideration	5 – 7	Acceptable	only need ordinary consideration in planning processing
	3 – 4	Bad	
No consideration	1 – 2	Worse	No consideration on natural visual landscape should be made in planning.
	0	Worst	

Table 1. Priority of natural visual landscape consideration in comprehensive urban planning

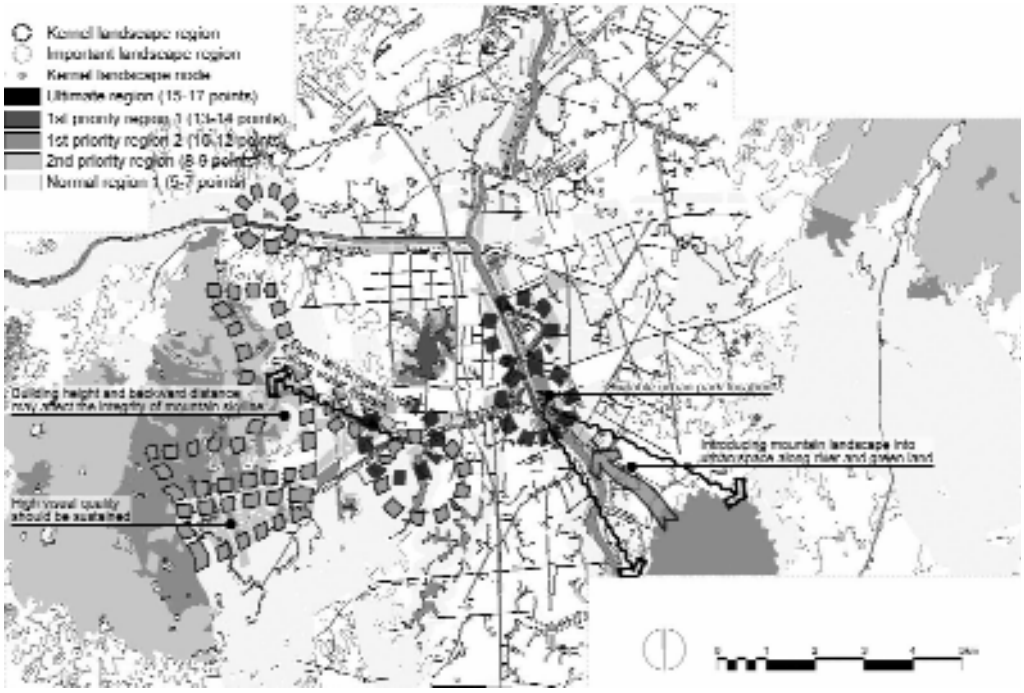

Figure 3. Comprehensive natural landscape respecting planning strategies suggested by the research group

natural scenery.

- Another urban location with abundant mountain and water landscapes is in the southwest end of the water system near the west cordilleras. Mountain landscape can extends through or along at least three directions. The northwest should be the best visual corridor location.
- High quality visual perception to the west and east cordilleras is limited in close ranges to the mountains. Development in other urban areas can ignore the effects of those mountain landscapes.

3.2 The landscape planning scheme of "Comprehensive Urban Planning of Dongshan City"

This comprehensive planning of Dongshan city is conducted by Nanjing Planning and Design Research Institute and proved by the government for urban development instruction during 2000 to 2010. The project planners proposed their landscape planning strategies in a separate landscape planning theme (Figure 4) (Nanjing Planning and Design Research Institute, 2000). Their general idea in natural visual landscape consideration is combining important viewpoints, visual corridors through main streets or water spaces and natural visual resources into landscape nodes within urban space to introduce natural visual landscape.

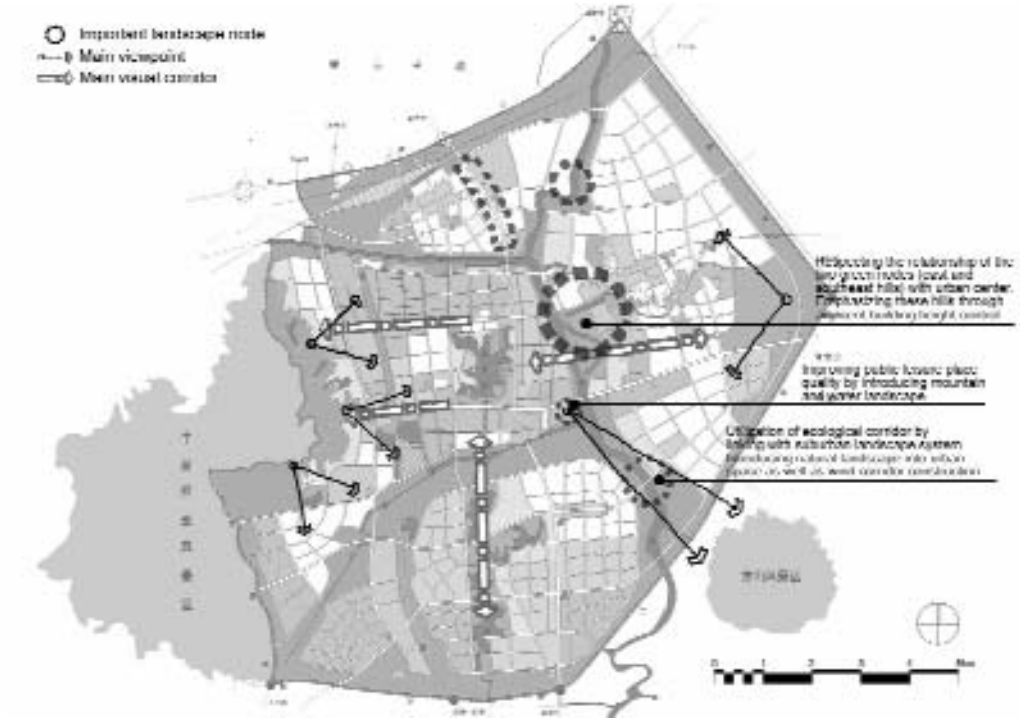

Figure 4. Visual landscape planning strategies in "Greenland and landscape system planning theme" of Nanjing Planning and Design Research Institute (2000)

3.3 New comprehensive planning scheme of Dongshan New Town

An independent German planning group provides a first step draft of this planning project which our research is serving. Since there is no monographical landscape planning in this phrase, the research group has to elicit their strategy on natural visual landscape consideration and examine the possibility of integrating our analysis with their work in the future to optimize the final master plan. The overall landscape planning strategy of this scheme is similar to the last one. The main difference is emphasizing a landscape axis throughout the whole east-west extension (Figure 5). The axis utilizes a center peak of a foreground west cordillera as the west end opposite landscape. The east end opens to the cordilleras background. A small hill is employed as the foreground. This planning scheme seems trying to build this axis by leaving visual corridor which connects a serious of landscape resources along the central urban avenue. This axis intersects with other linear landscape regions along the river system at an adjunctive curve of the main river, in which planners locates the new urban center.

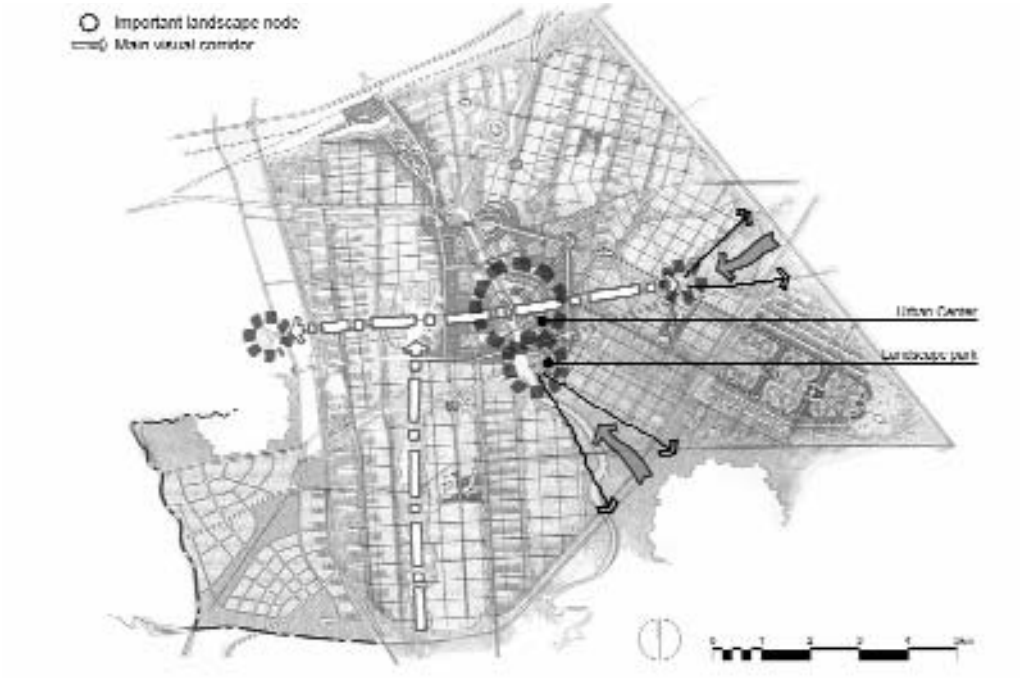

Figure 5. Analytical sketch on natural visual landscape consideration of the Dongshan New Town comprehensive planning in the first phrase

3.4 Comparison among the planning strategies based on scientific supporting and traditional modelers

Comparing with the landscape planning strategies among different planning groups, we can draw several conclusions on the similarities and noticeable differences. Firstly, those three schemes all agree to the following three aspects:

- Leaving open space along the river in order to introduce the southeast mountain scenery as well as combining mountain and water landscape. Important viewpoints are also established on the river conjunction.
- Treating the urban space around the main river adjunctive curve as another valuable landscape node to settle important urban functions.
- Similar solution of the linear style lakes system of the north part

That means, in dealing with some typical spatial construction or more obvious general knowledge oriented approaches, such as the aspect one, planners' insight can be in same level with or without such scientific supporting from the proposed tool.

But on the contrary, there are also opposites among the following planning strategies:

- In schemes in traditional planning modules, both planning groups try to extend visual perception of peaks and water surface alongside a linear space. But according to our GIS analysis, valid visual scopes of peaks are quite limited. For farther distance, the mountain skylines may be ignored by human vision or blocked by artificial constructions because of its shrinkage eyeshot. Moreover, its vertical

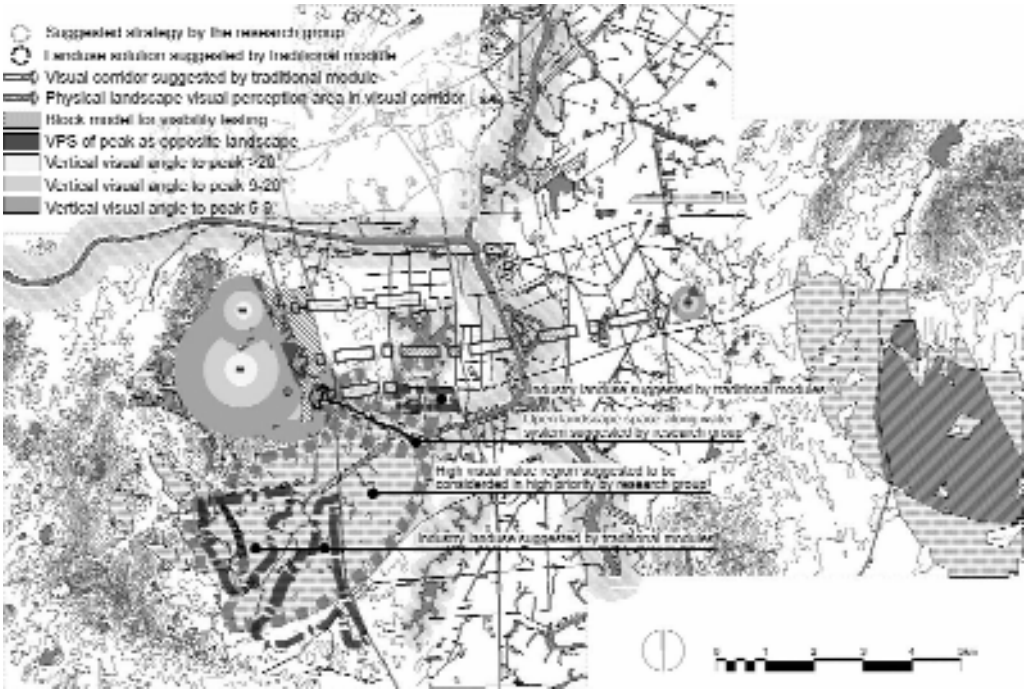

Figure 6. Illustration of the major differences in the comparison study

view angle is less than the minimal distinguishing requirement. Therefore, three of the four visual corridors planned in Nanjing's scheme actually do not exist in reality. Same problem happens in the central landscape axis of the German scheme. Moreover, since the VPS and visibility of water surface are much more restricted than mountain landscape, visual perception to natural landscape recourses is absolutely not consecutive along the axis. Intervals between visible natural landscape sceneries will be much more than affordable human walking distance. People cannot experience the landscape appreciation that the planning intends to provide.

- Neither of the two traditional modular based schemes recognizes the value of the southeast end water system. Several potential landscape nodes are ignored.
- The southeast region adjacent to the west cordilleras is planned to be industry locations according to the Nanjing and German schemes. In fact, this place is the most valuable area for the cordilleras visual perception. Even in integrated ratings, second natural landscape consideration priority is suggested in most of this region.

Comparing to the former similarities, these distinctions occur in some more "homogeneous" districts. There is less complexity or representative in spatial or landscape formation in those districts. The relationship of landscape resources is also in a more fuzzy condition. There is no general regulation to settle the visual landscape in such

conditions. On the other hand, general planning knowledge may be misused due to the fuzzy situation.

4. Conclusion

We can summarize that the potential of the proposed GIS-based natural visual landscape evaluation tool is more efficient in the circumstances which planning oriented information are too weak to apply common sense or traditional planning modules reliably. Especially in large-scale comprehensive planning, such information is more abstract. The visual value score mapping can directly illustrate the potential landscape regions based on visual quality or natural landscape consideration. On the other hand, this scientific supporting tool is also proved to be no conflict to planner's experiences in proverbial disciplines. Therefore, it will be positive to use this tool as a basic analytical procedure in conducting comprehensive urban planning. Not only will this tool improve the validity of planning decision making, but also it is helpful to avoid the possibility that the visual landscape value of some districts to be wasted by improper landuse planning.

How to adapt the analytical data into the final planning production and integrate scientific supporting with planners experience more effectively are still under discussion. Some analysis premises are still questioned, such as accuracy of the natural landscape estimation, and the balance of artificial contribution in natural visual landscape consideration. Our research group is endeavoring optimizing the procedure by developing technologies as well as theoretical support in those fields. We also plan to improve its 3D simulation function, which is valuable in overcoming the difficulty in mastering site map information. It is also essential in large-scale comprehensive urban planning control.

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