Landscape Design for Mountain Heritage and Its Application in Boundary Identification:

A case study for Bogda

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***Abstract*—Bogda is one of the three sites in Xinjiang Tianshan that merit nomination as natural World Heritage. To apply for recognition as world natural heritage, it is necessary to demonstrate the value of the landscape of the nominated property. In this paper, 3D visualization of remote sensing images is applied to describe the landscape of the nominated site, and the 3D visualization module of ArcScene, which is one module of ArcGIS Desktop, is used as the platform for three-dimensional visualization. Using a digital elevation model (DEM) expressing terrain elements and remote sensing images representing the land-cover condition, the landscape visualization of the nominated property was achieved. Based on the three-dimensional view of the nominated property, detailed understanding of the nominated property can be obtained, and this can provide decision support for boundary identification. After boundary identification, virtual three-dimensional roaming is also implemented to show the landscape of Bogeda. In this paper, the spatial information expression-and-visualization method that is used is a novel application for work on natural World Heritage.**

Keywords-mountain heritage; nominated property ; Bogda; landscape visualization; "3S"technology; World Heritage

I. INTRODUCTION

The identification of the boundary of Bogda, which is a site that is nominated for World Natural Heritage designation, is an important part and the first step in applying for recognition as world natural heritage. It is necessary to understand the environmental characteristics, such as the pattern of the landscape, land use, vegetation and climatic characteristics before a boundary can be determined. The work of boundary identification can be done scientifically base on observation of the features of the nominated site. However, mountain heritage usually has complex and difficult terrain conditions and field reconnaissance is usually carried at a specific time and by a particular route. Thus, it is difficult to examine the entire landscape of the nominated site only by field observation. In this situation, the identification of boundary according to subjective experiences would be unscientific. Therefore, to obtain a rational and scientific solution to the problem of boundary determination, it is necessary to analyze and understand the detailed conditions of the site. Traditional reconnaissance usually requires much manpower and resources and a valid overall assessment cannot usually be obtained in this way.

Landscape visualization is technology that was introduced in the 1970s and which has been developed rapidly and has been adopted widely [1]. It has been used by domestic and overseas scholars in landscape planning [2-3], and to examine landscape change [4-5], urban landscapes [6-8], a virtual campus [9] and in other research fields. The improvement of existing technologies and the continuous development of new sensors, data capture methodologies and multi-resolution 3D representations are contributing significantly to the 3D documentation and digital presentation of heritage and conservation [10]. While there are case studies on multi-resolution 3D natural landscapes using large data sets, research about the landscape visualization of mountain heritage is limited. This paper examines the landscape characteristics of Bogda natural heritage and three-dimensional visualization and dynamic roaming of the mountain heritage are realized based on 3S technology, which can, thus, provide decision support for boundary identification of the nominated site.

II. SURVEY OF THE STUDY AREA AND DATA SOURCES

A. Survey of the Nominated Site of Bogda

Xinjiang Tianshan merits nomination as natural World Heritage property, including Bogda, Tomor and the mid-Tianshan region. The nominated site of Bogda is located in Urumqi and Fukang, Xinjiang Uighur Autonomous Region. It is the most prominent peak of the eastern section of the Tianshan Mountains, with an altitude of 144 – 5 445m. Bogda peak was created by tectonic movement and rises above the surrounding mountains, making the landmark of the eastern Tianshan Mountains and the southeastern margin of the

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Junggar basin. Bogda Man and the Biosphere Reserve were included in the UNESCO "Man and Biosphere Reserve" in 1990 to protect the biological diversity of Bogda and the natural landscape of Tianshan Tianchi. In this nominated site, within a distance of only 80km from north to south, there are six natural vertical zones of alpine snow and ice, alpine meadow, subalpine meadow, forest, steppe and desert zones. It is an ideal arena for the study of the desert ecosystems [11]. The Tianshan Mountains meet World Heritage criteria (vii) and (ix) and are considered to have the potential to be recognized as World Natural Heritage. The Chinese government submitted a preliminary list to the World Heritage Committee on February 1, 2010.

B. Date Sources

The data sources used in this paper include a 1:10 0000 topographic map, Landsat images taken in the summer of 2008 (resolution 15m), and a digital elevation model (DEM) of the nominated site. There are also GPS data including geospatial information of essence landscape, modern buildings, settlements, quarries, mining sites and hydroelectric projects. These data were collected during the field reconnaissance in September, 2010. In addition, socio-economic statistics pertaining to the nominated site were collected as a secondary source of information.

III. METHODS AND DATA PROCESSING

A. The methods for data acquisition and processing

GPS has positioning capabilities, and the geospatial information of essence landscape, modern buildings, pasture and grazing sites, quarries, mining sites and hydroelectric projects in the nominated sites can be accurately measured by GPS. In addition, it can be used for the positioning of remote sensing images and their ground correction. RS technology provides a macroscopic view, accuracy, objectivity, dynamism, comprehensiveness and limited contact with the site. Thus, the current and overall situation of the Bogda nominated site can be obtained by RS technology. Conventional GIS has the functions of geospatial data acquisition, management, operation, analysis, modeling and display. Three-dimensional GIS has gradually become a prominent topic in GIS research, allowing immense amounts of multi-dimensional spatial information to be used to solve complex planning and management issues.

In addition, the use of multiple sources and spatial analysis of rich data are key to describing the landscape, including the merging of multi-band remote sensing images, as well as the integration of data in different formats, such as GPS data, a digital elevation model, vector maps, attribute data and so on.

B. The platform for overall landscape analysis

In this paper, taking the Bogda nominated heritage site as an example, Erdas IMAGINE 9.2 software is used in the processing of remote sensing images and the ArcScene module, which is one module of ArcGIS 9.3, is used as the visualization (VR) system platform. As the most important 3D display module in the three-dimensional GIS system, the ArcScene module can be used to create a three-dimensional display of landforms and surface features through the use of elevation data and remote sensing images. The three-dimensional display on the platform of the ArcScene module can create intuitive and immersive effects and this kind of display also meets the requirements for the overall treatment, analysis, evaluation, decision making and visualization of the landscape.

C. GPS data processing

During the field reconnaissance of the Bogda nominated site, a GPS receiver was used to locate various elements including the buildings, pasture and grazing sites, quarries and mining sites, hydroelectric projects, typical geological features and landscapes, as well as the reconnaissance route. After the field reconnaissance, waypoints and track information was collected by the GPS receiver and was then imported into Mapsource and saved as a DXF file, allowing the Mercator projection to be set up with ArcGIS.

D. Pre-processing of remote sensing images

For this paper, referring to the 1:100000 topographic map, geometric rectification of imagery was implemented using the binary quadratic polynomial re-sampling method. After the geometric correction of the single-band images, the standard false color image can be generated by combining the 4, 3 and 2 bands, with image de-noising and enhancement. Then, the TM images were fused with ETM to improve the resolution. To achieve the desired results of image matching and landscape visualization, image registration is necessary. In addition, in the calibration and registration process, the interpolation of pixel gray is implemented by the nearest neighbor method to ensure that the pixels of the corrected mosaic image correspond with those of the uncorrected image. Image mosaic was implemented after image rectification in case that sectional inaccuracy negatively affects the overall accuracy.

Accurate positioning of 34 sample sites obtained during the field reconnaissance was saved in the GPS receiver. Based on these GPS data and supplemented by visual interpretation, the 34 sample sites were located on the standard false color images in ArcGIS. Then the buildings, pasture and grazing sites, quarries and mining sites, hydroelectric projects, and typical geological and landscape features were fixed on the remote sensing image.

E. Building a database using GIS

In the process of overall landscape description, data of multiple formats was processed to realize landscape visualization. In order to be access the data efficiently, it is necessary to build a database to store the data systematically. The storage and management of multiple data sets was implemented in the ArcCatalog module, which is one module of ArcGIS. The database includes DEM data, GPS data, various attributes of the nominated site, remote sensing data and a vector land-use layer and vegetation, roads, rivers, administrative boundary layers and so on.

IV. RESULTS

A. Visualization of the natural landscape in the Bogda nominated site

3D visualization of the nominated site can be realized in the ArcScene module in three different ways. The first involves superimposing the image and vector layers upon the DEM, the second involves setting the vector layer attributes to reflect the field values of each feature of the vector layer by the height of a three-dimensional column and, third, the vector layer can be converted into three-dimensional space by the three-dimensional conversion tool in the 3D analysis module [12]. In this paper, the first method was adopted to realize landscape visualization. On the visualization platform of ArcScene, a three-dimensional visualization map of the nominated site was created using the above pre-processed data. In this way, the landscape of the Bogda nominated site was displayed.

The creation of a highly realistic three-dimensional landscape representation provides a macro picture of the landscape in the Bogda nominated site. The three-dimensional visualization map shows that the elevation differences of the nominated site are substantial and the distribution of the glaciers, the water system and the tourist facilities in Tianshan Tianchi Scenic Spot are visually displayed. It is can be readily observed that the Sangong River system is dominant and the water system and terrain are clearly portrayed. The distribution of the tourism activity, roads, walkways and bridleways can also be viewed. No mineral exploitation occurs from the north slope of Bogda Peak to the river valleys around Tanshan Tianchi but some mines exist on the south slope of Bogda Peak, even in the periglacial zone.

B. Boundary identification

This is done by ensuring the integrity of heritage values and trying to avoid human activities including mine exploitation, hydroelectric station constructing, overgrazing and so on. At the same time, border identification should rely on boundaries of existing protected areas and regionalism that are constructive to management institution, laws, regulations, ordinances and other protective measures to be formulated to protect the heritage site. On the above mentioned principles for boundary identification, boundaries of the nominated heritage site and the buffer area can be initially determined by referring to the relief map of the nominated site and scanning the overall landscape on the three-dimensional visualization platform. (Fig.1). The the central geographical coordinates of the Bogda nominated heritage site are N 43°48′48″, E 88°17′25″ the area of the nominated site is 34494 hm^2 and that of the buffer area is 30965 hm^2.

Centred around the Bogda Peak of Tianshan Tianchi, the nominated heritage covers various kinds of landscape and topography including alpine mountains, snow peaks, glaciers, meadows, river valleys, lakes, forests and rock paintings, such as the Alpine Botanical Garden to the south of Tianchi and numerous glacial lakes and glacial landforms. Thus, the integrity of the aesthetic value is preserved. The nominated heritage covers the headstream of the water system and the mainstream, the Sangong River, as well as the upstream tributaries, which maintains the integrity of the water system. The tourist reception centres, roadways and parking lots, which may adversely affect the integrity of the heritage values, are excluded from the nominated heritage. There are no human activities or exploitation of mineral resources from the south slope of Tomor Peak to the Tianchi, and mining activities on the south slope are excluded from the nominated heritage to reflect the heritage values.

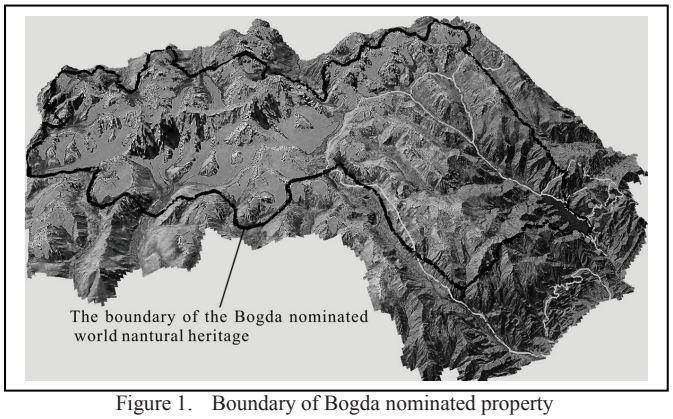

Figure 1. Boundary of Bogda nominated property

C. Realization of 3D scene roaming

The virtual scene of the nominated site can be created using virtual reality technology, aiming to reveal the hypsographic changes and the distribution of landforms dynamically. After the initial boundary identification, flight animation of the Bogda nominated heritage can be created, through which a dynamic display, from macro to micro, is revealed. A dynamic perspective of the nominated heritage can be gained from the flight animation, which reveals the landscape in a lifelike fashion and makes it possible to observe objects according to a changing perspective, scenic properties, location and time [13]. Three-dimensional scene roaming can be realized by controlling the viewpoints and viewing angle.

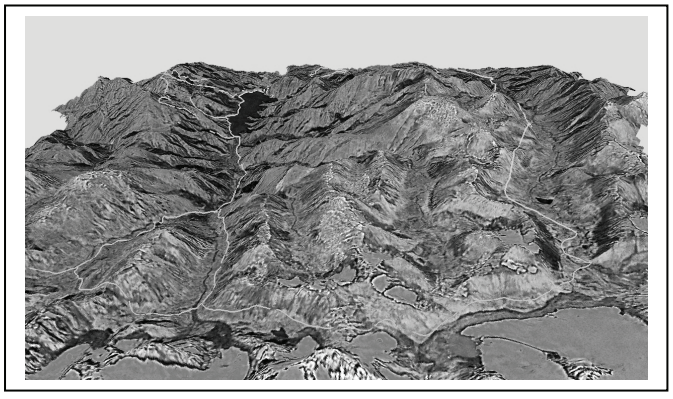

Figure 2. Three-dimensional scene roaming of the heritage

The three-dimensional animation can be generated in five different ways in the ArcScene module. For this paper, the animation of the nominated heritage area was created by importing a 3D flight path. Using a predetermined flight path along the Sangong River for flight recording, the AVI animation can show the landscape of the Bogda nominated

natural heritage, thereby exposing observers exposure to the virtual environment. The three-dimensional animation can also provide a base and reference for the design of tourist routes. It can be used to demonstrate and report the attributes in to the heritage to the public (Fig. 2).

V. CONCLUSIONS

Based on GIS data, remote sensing images and field survey, and using 3S technology, picture of the landscape of the Bogda nominated heritage was created on the visualization platform of ArcScene. The process involved the overlay of two-dimensional remote sensing images, vector layers and a digital elevation model. The resulting three-dimensional landscape is clearly pictured and scene roaming of the nominated heritage is realized. For this paper, the technology for visualization of spatial information was applied to portray mountain heritage, involving complex topography and surface terrain. The realistic three-dimensional terrain image that was generated provides macro information for observers and displays an overall picture of the landscape, making up for the shortage of field reconnaissance. Using the principles of boundary identification, the boundaries of the nominated heritage and its buffer area were initially determined. By establishing a particular flying path, observers can scan the overall landscape of the nominated heritage area from different viewpoints and elevations. This has wide applications in resource evaluation and environmental monitoring of the nominated heritage and can provide visual information and a platform for decision making.

The accuracy of the DEM and the resolution of the remote sensing images influence the three-dimensional display and virtual walkthroughs. In this study, DEM accuracy and the resolution of remote sensing images needs improvement. Only DEM of high accuracy and images of high resolution can generate a high-precision three-dimensional scene and animation that will give policy-makers the feeling that they are looking from an aircraft. Besides, as it is quite difficult technically, only a preliminary display of the three-dimensional landscape of the Bogda nominated heritage has been created so far. There are still many issues which need further research, such as the precise modeling of the surface features, the fluency of 3D walkthroughs, and the operation of the spatial and attribution query function in two-directions [14].

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