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Dynamic Analysis of Landscape Pattern in Natural Environment Protection Areas Based on GIS

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Abstract: With the rapid development of the times, people gradually began to pay attention to the environmental landscape pattern. According to the relevant literature, this paper decided to design a GIS-based dynamic analysis system of landscape pattern in natural environment protection areas. This system is mainly based on geographic information system (GIS). It models the dynamic data and dynamic mode of landscape pattern, and gives the corresponding analysis results and construction planning scheme according to the algorithm formula. After the performance test, the performance data of this system is compared with that of the traditional system. The results of data analysis show that the GIS system is slightly superior to the traditional system in all aspects. In the survey of system users, the GIS system has won the public praise of most people with 86% satisfaction rate and 84% willingness to use. After a series of hard work, the goal of improving the quality and efficiency of natural environment landscape pattern planning was finally achieved.

1. Introduction

With the improvement of living standards, more and more people begin to travel around the world, and those natural environment reserves have become the places that these people like to explore. In order to cope with more and more travel enthusiasts, local governments have also increased their attention to the landscape pattern planning of natural environment protection areas, providing a more beautiful tourist exploration destination for tourists. In the field of planning of natural environment protection areas, many scholars have conducted investigations and studies on natural environment scenic spots.

In the field of landscape pattern exploration, Lastrucci, L conducted a spatial landscape pattern analysis of the phenomenon of the reduction of reed beds in the Italian peninsula. He believed that the reduction of reed beds was caused by the arbitrary destruction of the environment by surrounding residents, and carried out landscape planning for the remaining reed beds [1]. Costanza, Jennifer K described and analyzed landscape ecology in detail, and proposed the concept of landscape model for systematic data analysis of environmental pattern [2]. Mohamed, Asfaw proposed a spatial pattern management method for the natural environment in Ethiopia's Addis Ababa and surrounding areas. He believed that the quantitative mapping of the natural environment landscape pattern in the area can effectively protect the natural environment in the area through scientific planning and management of the area through data [3]. Tang, Junmei analyzed and investigated the changes of spatiotemporal landscape pattern under the rapid urbanization. He believed that both the natural environment and the noisy city have their own landscape patterns, and this pattern would change with the development of the times. For this reason, he conducted a large amount of data survey and drew corresponding conclusions based on the data [4]. Through the review and understanding of the above literature, it is found that although this part of the literature has a clear description and explanation of the landscape pattern, it does not involve too much in the natural environment, just a few simple descriptions.

In view of this problem, in the aspect of literature review, people focus on the landscape pattern literature related to the natural environment. According to the relevant data, Fantinato, E proposed a concept of inland gradient pollination network. He believed that the landscape pattern of key plant species in the coastal natural environment could be revealed and analyzed through this pollination network, and the plant growth laws in such natural environment could be understood through data analysis [5]. Li, Zhen put forward a simulation theory based on CLUE-S model. He believed that through this model simulation, the natural environment landscape pattern of Sanjiang Plain can be effectively virtualized, and the natural environment of Sanjiang Plain can be planned according to the virtual model data, which greatly reduces the problem of long traditional landscape planning cycle [6]. Deng, Jing put forward the idea of combining landscape pattern with cloud computing, and established an interactive cloud platform for landscape pattern analysis, through which real-time data analysis of landscape pattern in any environment can be carried out [7]. Lu XiaoNing proposed an idea based on the Landsat image model. He believed that the image model could completely record the temporal and spatial changes of the wetland natural landscape pattern in the Yellow River Delta, and use the data generated by the model to plan the future development of the natural landscape in the Yellow River Delta [8]. According to the understanding of the literature on the landscape pattern of natural environment, it is found that although such literature is closely related to the natural landscape, there is no corresponding scientific conclusion data, and some of the literature is even too subjective, without scientific demonstration.

Based on the above literature, this paper analyzes and summarizes these literature, and decides to design a GIS-based dynamic analysis system for landscape pattern of natural environment protection areas. Through dynamic analysis of natural environment landscape pattern, the corresponding problems in traditional landscape pattern planning can be solved, and the quality and efficiency of natural environment landscape pattern planning can be improved.

2. Theoretical Method of Landscape Pattern Dynamic Analysis System

The landscape pattern of the natural environment protection area is the environmental landscape pattern in the final analysis, and the environmental landscape pattern is nothing more than the planning and layout of land, water, trees, buildings and other resources [9]. In view of the planning of the landscape pattern of the Natural Huajing Nature Reserve, this paper decided to use the method of Geographic Information System (GIS) technology as the main technology and RemoteSensing (RS) technology as the auxiliary to plan and deploy the landscape pattern. This paper makes use of the huge geographic information data of the geographic information system to plan a complete set of landscape pattern planning scheme of the natural environment protection area through simulation calculation. The work flow chart of the GIS landscape pattern dynamic analysis system in the natural environment protection area is shown in Figure 1:

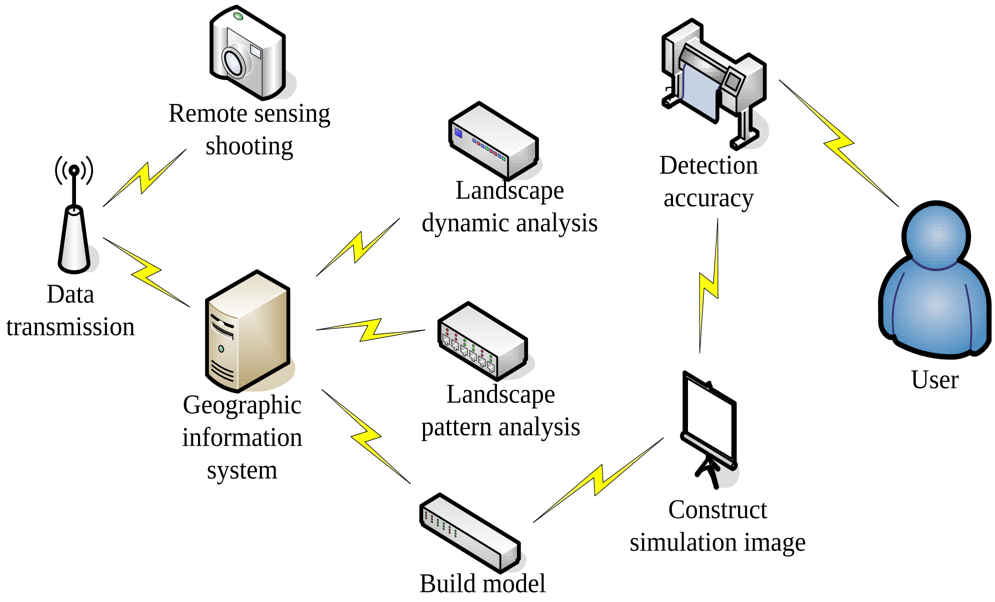

Figure 1. Working flow chart of GIS landscape pattern dynamic analysis system

The corresponding environmental image is taken by remote sensing technology, and the image data after shooting would be transferred to the geographic information system. The system would process the data and analyze the data dynamics and patterns of the natural landscape in the data. It can model the corresponding natural environment, then construct a complete virtual image scheme, and the system would finally test the accuracy of the scheme. When the accuracy meets the requirements, it would send the scheme to the user to complete the whole system workflow.

Some literatures pointed out in the regional agricultural landscape pattern that the classification of landscape pattern has a very important impact on the pattern planning [10]. In the selection of landscape pattern classification methods for natural environment protection areas, this paper selects the maximum likelihood classification method, which achieves the classification purpose by calculating the probability of each individual pixel's attribution to each category, and classifying the pixel into the category with the largest probability. The maximum likelihood classification method would form a discriminant function according to each landscape type. The discriminant function formula is as follows:

$$F_e(A) = \frac{(A-B_e)\sum_e^{-1}(A-B_e)-\ln P(C_e)+\ln|\sum e|}{2} \tag{1}$$

C_e represents the e-type landscape, $P(C_e)$ represents a prior probability, and A represents the pixel multi-spectral gray value vector. B_e represents the mean vector of gray value, and $|\sum e|$ represents the absolute value of covariance matrix. The data classification of landscape pattern can be basically completed through the above formula, and the next step is to consider the dynamic degree of landscape type. The dynamic degree of landscape type is mainly determined by the recognition of landscape pattern image, which can quantitatively reflect the change rate of various landscape types and produce relatively obvious differences according to the different types of landscape image [11-12]. The absolute dynamic degree of landscape type is the reflection of the area change of landscape type in a certain period of time, and its expression formula is as follows:

$$A_z = \frac{B_y - B_x}{B_x} \times \frac{1}{C} \times 100\% = \frac{\Delta B_{in} - \Delta B_{out}}{B_x} \times \frac{1}{C} \times 100\% \quad (2)$$

Among them, B_x and B_y represent the area of landscape type A in the early and late stages, and ΔB_{out} represents the sum of areas where A is transformed into other types. ΔB_{in} represents the sum of the areas from other landscapes to A, C represents the time period from the beginning to the end, and A_z represents the annual change rate of landscape types. The relative dynamic degree of landscape type is the specific reflection of the intensity of landscape change between the early and late stages of the landscape type. The relative dynamic degree model formula of landscape type is as follows:

$$C_z = \frac{\Delta B_{in} + \Delta B_{out}}{B_x} \times \frac{1}{C} \times 100\% \quad (3)$$

The variables in the formula are the same as those in (2). The overall planning and design of the landscape pattern of the natural environment protection area can be completed not only by considering the landscape type relative to the absolute dynamic degree, but also by considering more practical factors to supplement the planning. In the landscape pattern design and planning, in addition to the things that are easy to identify and distinguish, there are also some special things that are difficult to classify in the planning. Therefore, in the design and planning, people should combine landscape metrology and landscape pattern connectivity to establish a landscape index to ensure that special things can be planned in the design and planning [13-14]. The comprehensive dynamic degree of landscape type covers the use of landscape indicators. Through the comprehensive dynamic calculation of special things through landscape indicators, the purpose of dynamic analysis of the landscape pattern of special things is finally achieved. The calculation formula is as follows:

$$J = \frac{\sum_{i=1}^{n} |\Delta B_{xi} - \Delta B_{yi}|}{K} \times \frac{1}{C} \times 100\% \quad (4)$$

ΔB_{xi} and ΔB_{yi} represent the area of the initial and final stages of the landscape type, K represents the total area, C represents the period from the initial stage to the final stage, and J represents the annual change rate of the overall landscape. Through the cooperation of the above formulas, the design of the overall core framework of the GIS landscape pattern dynamic analysis system for natural environment reserves has been completed. After the completion of various auxiliary work, the GIS-based landscape pattern dynamic analysis system for natural environment reserves has been finally designed.

3. System Performance Test and Data Comparison

3.1. System Performance Test

The completion of the design of the dynamic analysis system for the landscape pattern of the GIS natural environment reserve is only a theoretical success in the final analysis. Whether it can be used normally in practice is still unknown. In order to detect whether the system is abnormal, this paper decides to carry out corresponding performance tests on the system. The test items mainly include the error rate of GIS landscape pattern dynamic analysis system and the success rate of data analysis. The data table of system error rate and data analysis success rate is shown in Table 1:

Table 1. Data table of system error rate and data analysis success rate

Unit(%)	Error rate		Unit(%)	Success rate	
	Group 1	Group 2		Group 1	Group 2
Data 1	0%	0%	Data 1	100%	100%
Data 2	0%	0%	Data 2	100%	100%
Data 3	0%	0%	Data 3	100%	100%
Data 4	100%	0%	Data 4	0%	100%
Data 5	100%	100%	Data 5	0%	0%
Mean	40%	20%	Mean	60%	80%

According to the data in the system error reporting rate and data analysis success rate data table, there are corresponding problems in both the system error reporting rate and data analysis success rate. Among the system error reporting rate data, data 4, 5 in the first group of data and data 5 in the second group of data all have an error reporting rate of 100%, which indicates that there is an exception in the operation of the system, resulting in the system calculation being unable to proceed. The system reported errors, which also led to abnormal data analysis success rate, so the analysis success rate of these data is shown as 0%. In order to understand whether the system has design defects or data anomalies that cause the system to report errors, the tester carefully examined and analyzed the test data, and finally found that the data is incomplete, which caused the system data operation to fail, and the system sent an error alarm. After the corresponding improvement and adjustment of the error reporting data, the error reporting rate of the system was re-detected. The error reporting rate of the data with exception was 0% this time, and the success rate of data analysis was 100%. This means that after the repair of the test data, the system normally did not detect the exception and sent an error report, and the data operation also ran perfectly. Through the test of system error rate and data analysis success rate, the final conclusion is that the GIS landscape pattern dynamic analysis system designed in this paper is really feasible and effective in practical use, and there is no abnormality.

3.2. Comparative Analysis of System Image Recognition Rate and Data Classification Success Rate Data

The traditional landscape pattern system is applied in a wide range of fields, both in the natural environment and in the urban-rural fringe, and the methods used are mostly in the form of evolution simulation [15]. Although the traditional landscape pattern system has a wide range of applications, its mode and output data have certain fluctuations and differences, and it is not very accurate to simulate the landscape pattern, resulting in a certain discrepancy between the landscape pattern planning scheme and the actual situation. In order to intuitively understand the performance of the GIS landscape pattern dynamic analysis system (GIS system for short) designed in this paper, the performance of the modified system is compared with that of the traditional system. Through comprehensive comparative analysis of various values generated by the system performance, it is judged whether the system is superior to the system designed by the predecessors. First of all, the system image recognition rate and data classification success rate are compared. The data comparison and analysis diagram of the system image recognition rate and data classification success rate is shown in Figure 2: (a is the data comparison and analysis diagram of the system image recognition rate, and b is the data comparison and analysis diagram of the data classification success rate)

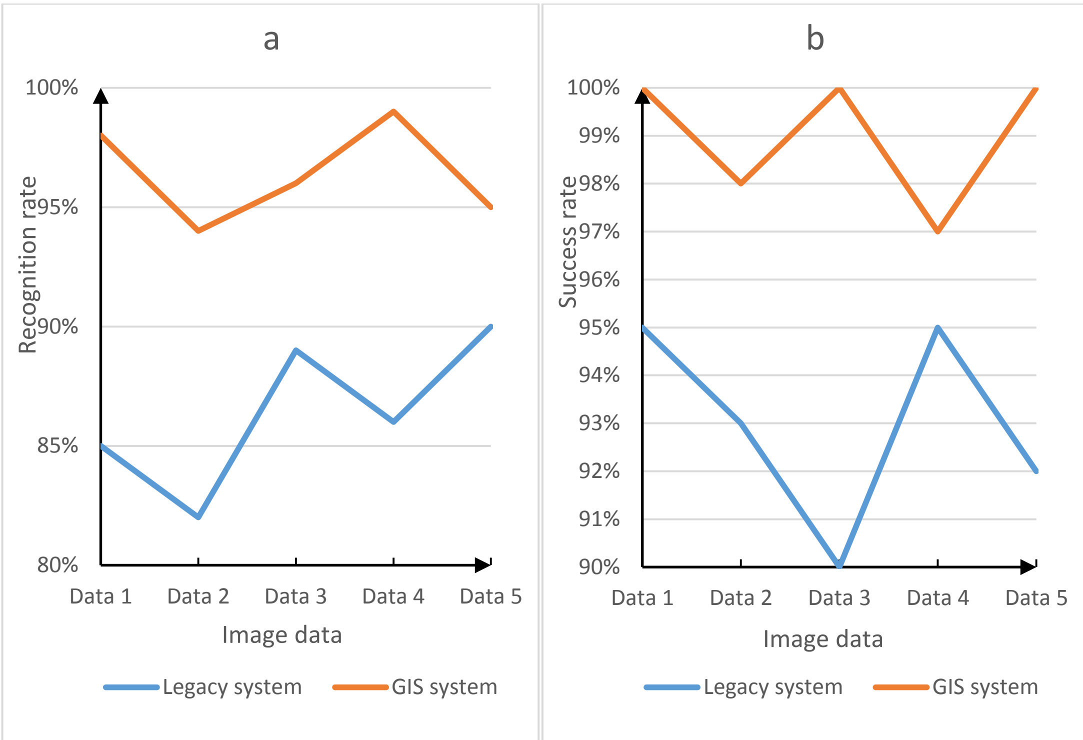

Figure 2. Comparative analysis of system image recognition rate and data classification success rate data

According to the data in the comparative analysis chart of the system image recognition rate data, it can be seen that the image recognition rate of the traditional method fluctuates roughly between 80% and 90%, which is considerable for the image recognition rate of the traditional system. The minimum recognition rate is 82%, the maximum recognition rate is 90%, and the difference between the two recognition rates is 8%. According to the existing system recognition rate on the market, it belongs to the standard. The reason for this situation is that the traditional system uses camera and other equipment to shoot images, and a series of factors such as angle and hardware may lead to blurred images. The lowest value of image definition of GIS system is 94%, the highest value is 99%, and the difference is 5%. GIS system uses aerial photography of RS technology, so it is naturally better than traditional system in terms of angle and hardware. The improvement of image definition also leads to the rise of image recognition rate. After the image is recognized, its data would be classified and processed by the system. In terms of data classification, the success rate of data classification of the traditional system is 90% at the lowest and 95% at the highest. The success rate of data classification of GIS system is 97% at the lowest and 100% at the highest. Although the difference between the success rates of data classification of the two systems is small, it is obvious that the success rate of data classification of GIS system is higher than that of traditional system. According to the results of data comparison and analysis, the performance of GIS system is slightly better than that of traditional system in terms of image recognition rate and data classification success rate.

3.3. Comparative Analysis of Data on the Scientificity and Completeness of the System Landscape Pattern Planning

After completing the comparative analysis of the system image recognition rate and data classification success rate data, the next step is to carry out a detailed data comparative analysis of the scientific nature of the system landscape pattern planning and the integrity of the scheme. The scientificity of landscape pattern planning and the integrity of formed schemes are the core indicators of landscape pattern system. In this regard, both traditional systems and GIS systems have formulated strict performance standards. The data standard of the traditional system in these two aspects is more than 90%, and the preliminary data standard of the GIS system designed in this paper is also set at more than 90% according to the traditional system standard. The test team randomly selected several groups of data to compare the performance data of the two systems. The comparative analysis chart of the scientific planning of the system landscape pattern and the scheme integrity data is shown in Figure 3: (a is the comparative analysis chart of the scientific planning data, and b is the comparative analysis chart of the scheme integrity data)

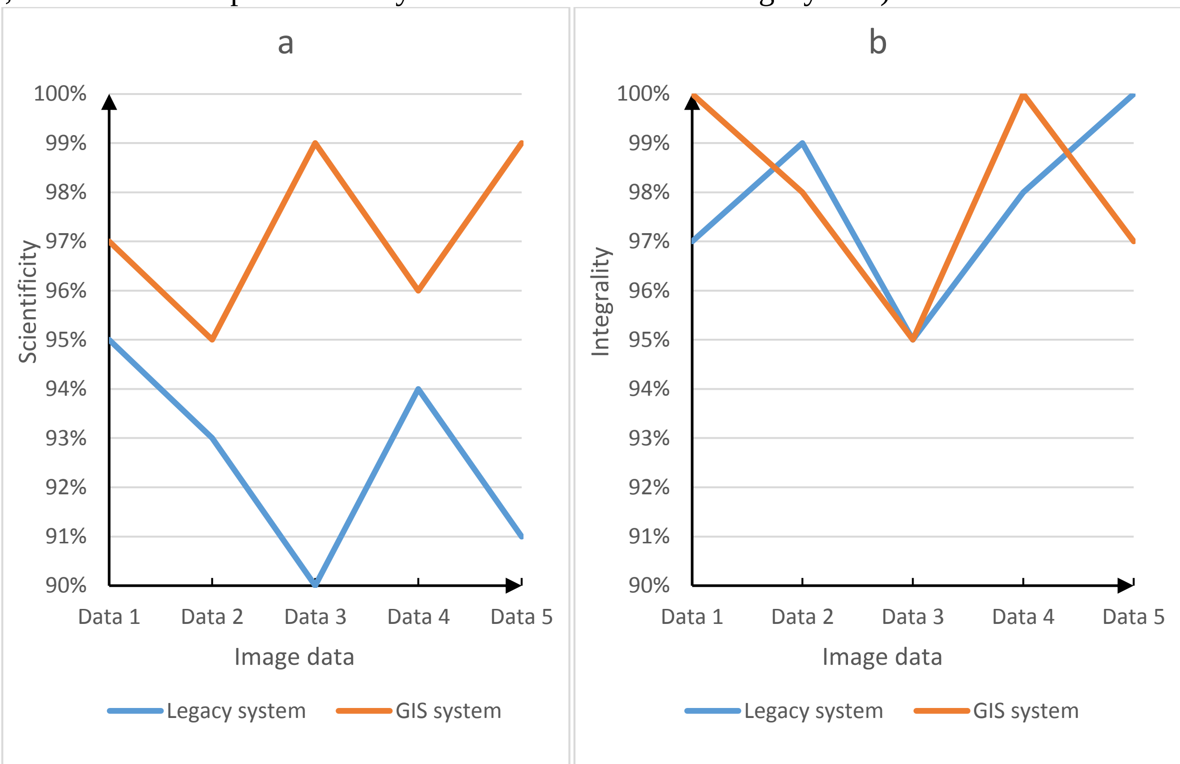

Figure 3. Comparative analysis of the scientific and scheme integrity data of the system landscape pattern planning

From the perspective of the data trend in the comparative analysis chart of the scientific planning and scheme integrity data of the system landscape pattern, the fluctuation range has not changed much. The GIS system and the traditional system have both stabilized at more than 90% in the scientific planning data, while both have reached the minimum integrity data of 95% in the scheme integrity. If it is necessary to compare the two systems, the average value of GIS system in planning science is 97.2%, and the average value of traditional system is 92.4%. Obviously, GIS system is better in planning science. In terms of scheme integrity, the average scheme integrity value of the traditional system is 97.8%, and the average scheme integrity value of the GIS system is 98%. The average difference between the two is only 0.2%, which is almost negligible.

3.4. System Use Survey Data

Through the comparative analysis of the data of GIS system and traditional system, it is found that although the data of the two systems are not different, the overall performance of GIS system is better. However, as a system, its excellent performance is not enough to show that it can be accepted by people. The purpose of this design system is to improve the quality and efficiency of the landscape pattern, and the quality and efficiency need to be judged by people. Therefore, in order to understand whether the GIS system meets the needs of people, this paper randomly selected 1000 users and divided them into GIS system users and traditional system users, with 5 groups in each category and 100 people in each group. The comparative analysis chart of system use satisfaction and use intention survey data is shown in Figure 4 through the survey of system use satisfaction and use intention survey data: (a is the comparative analysis chart of system satisfaction data, b is the comparative analysis chart of use intention survey data)

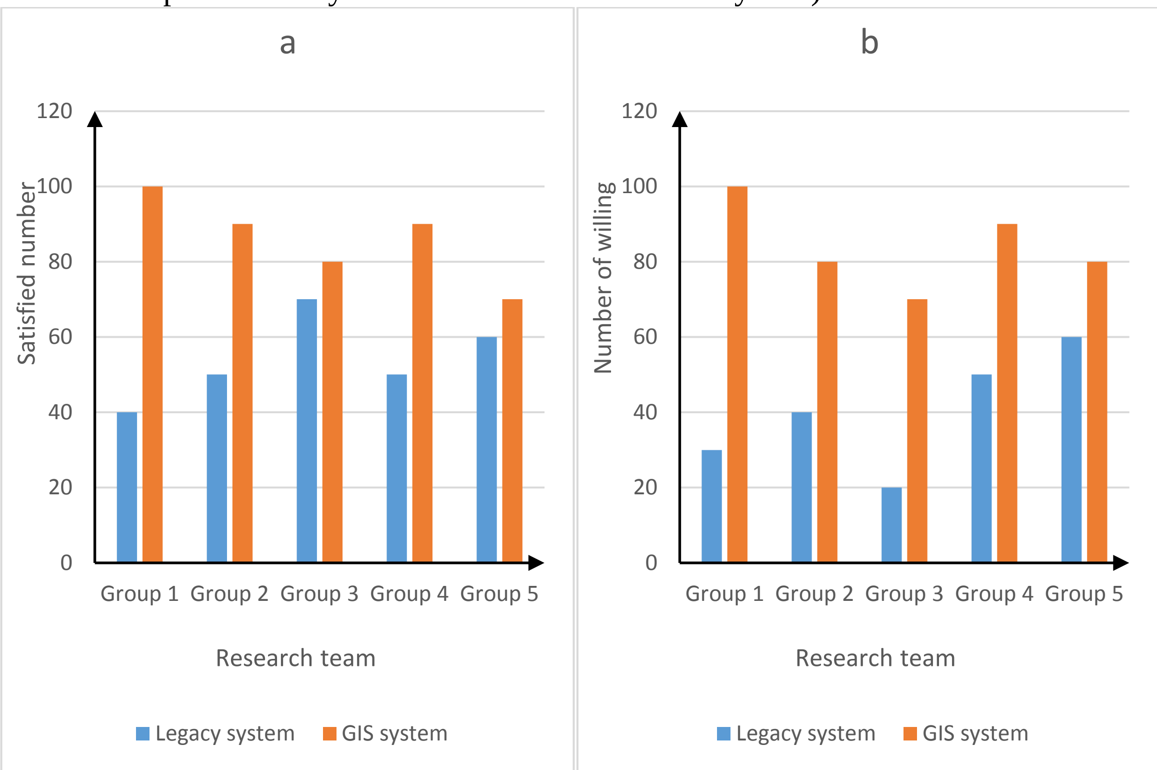

Figure 4. Comparative analysis of survey data of system use satisfaction and use intention

According to the survey data table in Figure 4, it is intuitively felt that most people are more inclined to GIS system, and the proportion of people is higher than that of traditional system in terms of satisfaction and willingness to use. In the survey of satisfaction data, the comprehensive satisfaction rate of the GIS system is 86%, and the comprehensive satisfaction rate of the traditional system is 270, and the comprehensive satisfaction rate is 54%. On the difference of satisfaction, the comprehensive satisfaction of GIS system is 32% higher than that of traditional system. The degree of satisfaction would directly affect the survey data of the willingness to use the system. According to the data, the total number of people willing to continue using the traditional system is 200, with a comprehensive willingness rate of 40%. The total number of people willing to continue using the GIS system is 420, with a comprehensive willingness rate of 84%. Compared with the difference of satisfaction, the difference of willingness to use rate is even greater, and the data difference of comprehensive willingness rate is 44%. Such a huge difference is enough to show that the GIS system is superior to the traditional system in both performance and operability in actual use.

4. Conclusion

Through the design, test and comparative analysis of GIS system, the final conclusion is that the GIS-based dynamic analysis system of landscape pattern in natural environment protection areas is indeed stronger than the traditional landscape pattern system in the field of landscape pattern analysis. In system design, GIS system combines RS technology. In terms of hardware use, GIS system adopts relatively advanced aerial photography equipment. Although the GIS system is not very different from the traditional system, and even some parts are completely consistent with the traditional system, it is each part that has made a small improvement, which has improved the overall performance, and also achieved the design intention of improving the quality and efficiency of the natural environment landscape pattern planning. Although GIS system still has some common problems like traditional systems, it is believed that as long as people make unremitting efforts and carry out in-depth research on small areas, all problems would be solved one day.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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