

Geospatial ecological economic planning based on water-energy-agritourism nexus, a case study of Jilin Province, China

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ABSTRACT

How to use geospatial technology to plan the ecological economy reasonably and promote the sustainable development of regional ecotourism has become an important issue faced by the current society. On the basis of the relationship between water and energy, this article took tourist areas as an example to analyze the geographical and spatial distribution characteristics of ecotourism attractions. A comparative analysis was conducted between the experimental group's tourist areas planned using GIS (geographic information system) and the control group's tourist areas planned using traditional planning. It was found that the average ecological and economic income of the experimental group within 1 year was about 1.2661 million yuan, which was higher than the average ecological and economic income of the control group within 1 year. This indicated that using GIS geospatial technology for reasonable planning of tourist areas is important for improving the overall ecological and economic income of tourist areas. This article used this research to explore the importance of rational planning of the ecological economy. Building a good ecological economic structure in tourism development plays an important role in reducing water and energy consumption to promote sustainable development of the tourism industry.

Key words: ecoeconomic planning, geographic space, tourist areas, water and energy relations

HIGHLIGHT

- This article analyzed the background and causes of ecotourism, studied the unreasonable factors of traditional tourism planning, and used the spatial analysis function of geographic information system on the basis of the relationship between water and energy to carry out the overall planning of tourism areas.

1. INTRODUCTION

Agritourism is a hybrid concept that integrates elements of two complex industries, agriculture and travel/tourism, to create and expand new profitable markets for agricultural products and farm services and travel experiences for tourists in a large regional market. Although there is no single definition of agritourism that is widely known, agritourism includes the interweaving of important concepts of marketing and economic development that are expanding today. Ecological economy is an economic way to achieve sustainable development that integrates regional economic development and environmental protection. Water resources are the fundamental resources for human survival and development (Li *et al.* 2020). They can also be converted into energy through various methods such as hydropower and steam power generation. However, due to regional differences, the distribution of water resources is uneven (Yuan *et al.* 2023a). Therefore, it is necessary to use geographic information system (GIS) technology in geographic space to digitize the ecological resources of the region, connect the data to the geographic map, and plan and utilize the ecological economy that can be developed in the tourism area reasonably based on the images and data information on the map. This article randomly selected six tourist cities as experimental objects, divided them into an experimental group and a control group, compared the number of tourists in the experimental group and control group in 1 year, and compared the level distribution of ecological environment quality and the ecological economic income in 1 year, so as to study the relationship of agro-tourism.

The geographical spatial ecological economic planning based on the relationship between water and energy is very meaningful (Yuan *et al.* 2023b). GIS can manage, analyze, and plot systems of all data types, making them suitable for any industry. Therefore, many experts have conducted a series of analyses on GIS (Xu *et al.* 2022a, 2022b). Feng *et al.* (2019) studied

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the impact of regional land use planning strategies and regional ecological economy based on remote sensing and GIS technology. [Xiong & Liu \(2019\)](#) focused on the analysis of ecological and economic systems, system models, ecological environment prediction, and ecological economy in geographical spatial regions through the combination of GIS. [Iortyom et al. \(2022\)](#) studied small-scale spatial optimization planning of physical geography area in an ecological environment in combination with the local actual situation, used GIS to accurately locate the ecological and geographical boundaries to be planned, determined different ecological areas, and improved the planning effect. [Jiang \(2020\)](#) established a database of various ecological issues; scientifically managed them using GIS and other means; effectively planned the overall land use, urban planning, and industrial layout planning; and effectively planned the ecological economy of tourist areas. [Guo et al. \(2023\)](#) believed that the era of ecological civilization construction emphasizes the comprehensive growth of ecological and economic benefits. In response to this demand and to enrich the natural ecological perspective of land space research, the ecological value evaluation and economic compensation of small watersheds were studied. [Huang et al. \(2022\)](#) analyzed that the agricultural landscape pattern in mountainous areas is crucial for clarifying the dynamic changes and development direction of agricultural landscapes, which also plays an important role in the rational planning and management of agricultural land. GIS has great advantages in the planning of ecological and economic systems in geographical spatial regions, as well as in the analysis of ecological environment and ecological economy. They have certain reference values for the ecological and economic development of the tourism industry.

Improving the quality and stability of the ecosystem contributes to the sustainable development of the regional ecological economy, creating a series of economic, environmental, and resource wealth for the region ([Nie et al. 2023](#); [Yang et al. 2023](#)). Therefore, many experts have conducted a series of analyses in protecting the ecosystem and building the ecological environment ([Wu et al. 2023](#)). [Xu et al. \(2022a, 2022b\)](#) extracted the main artificial features of the Yangtze River Delta in 2000 and 2015, and analyzed their spatiotemporal characteristics using methods such as kernel density, average nearest neighbor, weighted analysis, and spatial autocorrelation analysis, providing a scientific basis and decision-making reference for wetland ecosystem protection in the region. [Wu et al. \(2022\)](#) and [Yin et al. \(2023\)](#) established an adaptive indicator system around policy-oriented inland lake areas, integrating multiple econometric and geographic methods, and proposed a framework for livelihood security analysis. [Ruan & He \(2022\)](#) studied that water resource security is a fundamental scientific issue that must be faced in ecological environment construction. He calculated the water resource security situation from 2010 to 2018 and used a fixed effect regression model to analyze the factors affecting the water resource system. [Yang & Meng \(2020\)](#) explored the impact of local residents' energy consumption on the coordination between ecology and economy, improved energy utilization efficiency, optimized residents' consumption structure, implemented differentiated policies for urban and rural residents' energy consumption, and established a spatial planning system and operational mechanism that integrates multiple regulations ([Tong et al. 2023](#)). [Shaheen \(2020\)](#) included data mining add-ons in the GIS interface and proposed an automated intelligent geographic decision support system to ensure the best energy development plan in the region to deal with the current energy crisis. [Liu et al. \(2022\)](#) have conducted extensive research on the synergy of ecosystem services, but the control field and driving mechanism of its synergy have not been fully understood. Ecological engineering is the key factor of coordination, and ecological restoration shall be given priority in the coordinated control area. By utilizing various modern information technologies for coordinated planning of ecology and economy, significant development of the regional ecological economy can be promoted, and the sustainable development of the local tourism industry can be promoted.

In recent years, the rapid development of tourism in various countries has played a certain promoting role in the development of the regional economy. At the same time, due to the unique geographical location and advantageous resources such as local customs, tourist areas have attracted a large number of tourists to travel and consume, and regional ecological tourism has been fully developed. This new type of tourism can to some extent improve the local environmental pollution problem and effectively promote the development of the local economy. When developing regional ecotourism, sustainable development should be the goal, and local natural resources and environment should be actively protected. When developing regional ecotourism, corresponding development models should be implemented based on the geographical characteristics and types of tourism resources of different regions. Therefore, it is necessary to use geographic information technology to plan the tourism ecological resources of the region reasonably and promote the stable development of the ecological economy.

2. ECOLOGICAL TOURISM ECONOMY

The ecotourism economy is a green economic model that promotes the sustainable development of local tourism through the interaction and connection between the ecological environment and the economic development (Hou 2021; Tian & Zhang 2023). Promoting the development of the ecotourism economy plays an important role in stabilizing the water resources and energy conservation and protection of the region. This tourism economic model has changed the original tourism model that sacrifices the ecological and natural environment, and would focus on protecting the ecological and natural environment. On this basis, some tourism projects would be developed.

2.1. Innovation of ecotourism models

Ecotourism is a tourism industry developed mainly on the basis of the ecological environment. It takes full advantage of the unique advantages of the physical geography environment in the region to carry out a series of play activities while maintaining the stability of the ecological environment. This is a benign concept of ecotourism development. While developing the natural tourism industry in the region, ecological environment protection is carried out, and on this basis, the sustainable development of the region's economy, culture, and other aspects is promoted. This is an economic model developed when the tourism industry reaches a certain stage, which plays an important role in promoting the sustainable development of the tourism area.

2.2. Background and reasons for the emergence of ecotourism

The emergence of ecotourism has profound practical reasons, which can be summarized as a series of problems caused by the traditional tourism industry to the ecological environment during the development process. After the ecological environment is destroyed, the economy of the tourist area is affected by a series of factors. It is recognized that protecting the ecological environment of the tourist area can promote the long-term development of the tourist area, and thus, it has emerged as a modern new type of ecotourism model.

The main reasons for the emergence of ecotourism come from three aspects: the environment, tourists, and reasonable planning for sustainable ecotourism economic development. Environmental issues are the main issue, and the natural environment is the foundation for the development of tourism. Without unique natural environmental advantages and high ornamental value, there is no regional advantage in developing tourism. Since tourism can be developed, the region has its own unique ecological tourism value. Tourists are the main source of income in the tourism industry. The development of tourist areas is essential to improve the local economy, which will attract tourists to visit the unique scenery of the scenic area. When tourists enter the tourist area for sightseeing, they would consume in four aspects: clothing, food, housing, and transportation and then gather many industries to drive the local economic development. The reasonable planning of sustainable ecotourism economic development is to utilize the unique geographical environment advantages and plan the geographical environment reasonably. While developing the tourism industry, real-time maintenance of the ecological environment is carried out, forming a scientific, reasonable, and sustainable development approach to ecotourism development.

2.3. Traditional tourism operation mode

The traditional tourism operation mode has solidified its thinking and plans tourism projects at the cost of damaging the ecological environment, resulting in a series of problems such as sustained deterioration of the ecological environment, large financial investment in the later stage, and sustained reduction of tourist volume.

The operation of traditional ecotourism is mainly divided into three parts, namely, the development model of the regional tourism industry, the construction of tourism area content, and the surrounding supporting tourism facilities and industries. The development model of the regional tourism industry is mainly based on the three directions of setting up scenic spots for sightseeing, regional characteristics, and tourism marketing model, and exploring the characteristics of scenic spots for promotion. In terms of content construction of tourist areas, different tourism themes are set up every year within the tourist area, and based on this, activities and characteristic programs are carried out to attract tourists to travel. In terms of supporting tourism facilities and industries in the surrounding area, the construction of hotels facilitates tourists' accommodation and long-term stay. The construction of nearby snack streets meets the needs of tourists for unique cuisine, and the development of tourism-dedicated lines facilitates tourists' travel. From the overall content of the traditional tourism operation, a series of measures are aimed at developing the natural environment of the scenic area and constructing a series of activities to attract

tourists. There are no protective measures for the ecological environment, which is not conducive to the sustainable development of the ecological environment and thus affects the later development of the tourism industry in the region.

2.4. Problems in ecotourism economic planning

The main problem with the traditional tourism operation mode is the lack of reasonable planning for the ecological tourism economy. The problems in the ecological tourism economic planning mainly include five aspects. First, the economic planning of ecotourism is not standardized, such as not planning some amusement projects according to the requirements while ensuring the safety of tourists. Second, the theoretical system of ecological tourism economic planning is incomplete, and extensive management methods can easily lead to the repetitive development of tourism resources in the region. This is manifested in the following aspects: similar activity projects in tourist areas, lack of creative planning schemes, unsystematic market analysis, and poor operability. The third is inadequate supervision. After the completion of ecotourism planning, the management and management of tourism products and other regulatory work are not in place. The fourth is the low level of management, mainly due to the lack of systematic training for park staff. The knowledge reserve for management is not up to the standard, which in turn lowers the overall management level of the tourist area. Fifth, there is a mismatch between policies and regulations, mainly due to the lack of support from policies and regulations that match the booming development of the tourism industry. Therefore, it is necessary to use new technological means for reasonable planning of the ecological economy of tourist areas.

3. TOURISM AREA PLANNING UNDER WATER AND ENERGY

3.1. Relationship between water and energy in tourist areas

The tourism industry has made great contributions to the global economic development, with water and energy consumption closely related to the development of the tourism industry (Sofronov 2018; Marques *et al.* 2022). By analyzing the relationship between water footprint and energy footprint of a tourist area, it is found that tourism expenditure is the primary driving force for water and energy growth, and a good economic structure can effectively offset the increase of water and energy, as shown in Table 1.

As shown in Table 1, this table summarizes the data on the consumption of water and energy and changes in economic income in the city's tourist areas from 2009 to 2017. Table 1 shows that the consumption of water and energy in the city's tourist areas increased year by year from 2009 to 2017; the consumption of energy in the city's tourist areas increased year by year from 2012 to 2017; and the economic income of the city's tourist areas also increased year by year from 2009 to 2017. This indicates that the city consumes a significant amount of water and energy when developing its tourism industry. Therefore, new technologies are used to adjust the economic production structure of the tourism industry to reduce water and energy consumption.

3.2. Evaluation of the current situation of tourist areas

The tourist areas of three cities, Nanchang, Changsha, and Wuhan, were recorded as the experimental objects. This article analyzed the tourist resources and the income of each industry in the tourist areas of these three cities, calculated the ecological capacity of the tourist areas through formulas, and used the spatial analysis technology of GIS to carry out the reasonable planning of the ecotourism economy of the tourist areas on the basis of these data.

3.2.1. Tourism resources in tourist areas

Analysis and statistics were conducted on the overall tourism resources of the three cities to comprehensively grasp the focus of the city's tourism development, as shown in Table 2.

Table 1 | Analysis of water and energy environment expansion in a tourism area from 2009 to 2017

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Water consumption (hundred millioncubic/m ³)	1.56	1.84	2.26	2.34	2.59	2.67	2.75	2.86	2.96
Energy consumption (ten thousand tons)	318.39	332.26	359.48	378.36	397.26	410.47	435.27	457.34	496.64
Economic income (hundred millioncubic/yuan)	102.14	109.24	112.35	118.62	121.39	126.74	132.45	137.59	141.26

Table 2 | Statistical tables of tourist resources of various categories of scenic spots in the three cities

	Nanchang	Changsha	Wuhan
Scenic spot	8	4	5
Nature reserve	10	3	6
History and culture	7	5	8
Museum	11	7	9
Cultural scenic spot	9	5	7
Total amount	45	24	35

As shown in [Table 2](#), among the three cities, Nanchang had the most tourism resources, with a total of 45, and Changsha had the least tourism resources, with a total of 24. [Table 2](#) shows that there are significant differences in the total amount of tourism resources among the three cities, indicating that some regions have more tourism resources and are relatively suitable for developing the tourism industry, while others have relatively fewer tourism resources. Therefore, innovative ideas are needed when developing the tourism industry.

3.2.2. Industrial income of tourist areas

By conducting statistical analysis on the industrial income of the tourism areas in three cities, it can be inferred from the data that which industries play an important role in promoting economic development, as shown in [Table 3](#).

As shown in [Table 3](#), the income of Nanchang's tourism area has been increasing year by year from 2010 to 2017, indicating that the city's tourism industry has developed well and frequent updates of tourism projects were carried out within the tourism area, which has continued to increase its attractiveness to tourists. Therefore, Nanchang's tourism industry has great development prospects. The income of the tourism area in Changsha has been increasing year by year from 2010 to 2014, but the income of the tourism industry has shown a downward trend since 2015. This indicates that Changsha had a good development prospect at the beginning of the tourism industry, but did not pay attention to protecting the ecological environment during this period and did not manage the scenic spots properly. The fixed nature of tourism projects has led to a low attractiveness of the tourism industry to tourists in the area, which in turn has led to a downward trend in the income of the tourism industry in the later stage. The income of the tourist area in Wuhan has been increasing year by year from 2010 to 2013, but since 2014, the income of the tourism industry has shown a downward trend. This indicates that Wuhan has not paid attention to the protection of the ecological environment when developing the tourism industry, which has caused great damage to the ecological environment of the tourist area and reduced its attractiveness to tourists, leading to a downward trend in the income of the tourism industry in Wuhan.

3.2.3. Measurement of ecological environment capacity

If an ecotourism area wants to be in a virtuous cycle, it is necessary to control tourists within the range that the ecological environment can withstand. This can effectively protect the ecological environment of the tourism area and promote the

Table 3 | Revenue of tourist areas from 2010 to 2017

	Nanchang (millions)	Changsha (millions)	Wuhan (millions)
2010	2,498	1,358	3,235
2011	2,634	1,524	3,512
2012	3,235	2,624	3,624
2013	3,512	2,748	3,861
2014	3,624	2,935	3,717
2015	3,761	2,225	3,625
2016	4,017	1,446	3,421
2017	4,325	1,234	2,765

sustainable development of the tourism industry. The measurement formula for the regional ecological environment capacity is as follows:

$$G = \frac{\sum_{o=1}^n D_o Y_o + \sum_{o=1}^n W_o}{\sum_{o=1}^n A_o} \quad (1)$$

where G is the daily capacity of natural tourism resources, Y_o is the natural purification time of various pollutants, and W_o is the amount of the o -th-type pollutant that workers dispose of every day.

The specific formulas for measuring the spatial environmental capacity of ecotourism are as follows:

$$Y = \sum_{o=1}^z F_o + \sum_{o=1}^q T_o + V \quad (2)$$

$$F_o = \sum_{o=1}^m D_o \quad (3)$$

where Y is the environmental capacity of ecotourism space; z is the total number of scenic spots; m is the number of scenic spots; and q is the coefficient of the roads within the scenic spot.

3.3. Ecological economic planning under GIS

3.3.1. GIS geographic spatial evaluation technology

With the development of tourism, the survey method, evaluation system, analysis system, and tourism planning and management method of traditional tourism resources can no longer meet the tourism needs of tourists, so it is necessary to introduce new GIS technology (Pencarelli 2020; Shang *et al.* 2020). GIS establishes coordinates on a unified geographical area, gathers the data to form a spatial database, and uses geospatial modeling to transform the data in the spatial database into a three-dimensional spatial geographic model. Through the model, spatial analysis, and management of the environment, water and energy resources of the tourism region can be carried out, and GIS technology can be used to detect and dynamically analyze the geographical information of the tourism region in different periods, providing timely and reasonable data information for the tourism industry.

3.3.2. GIS geographical spatial evaluation function advantages

GIS has many advantages in regional ecotourism planning. These advantages analyze the geographical environment and tourism resources of the tourism area in detail, and use the analyzed data to scientifically and reasonably plan the resources in the tourism area, promoting the sustainable development of the ecotourism industry, driving the local economy, and promoting the comprehensive development of the region.

Accuracy and efficiency: The GIS geographical spatial analysis function can accurately extract the terrain data of the tourist area and accurately process the spatial terrain data. It ensures the accuracy of information and can store data not only utilizing the processing of spatial information in tourist areas but also improving the efficiency of extracting spatial data in tourist areas.

Scientific rationality: GIS geographical spatial analysis function can integrate various influencing factors of the tourist area, carry out scientific and reasonable planning, reduce the impact of human factors, ensure the rationality of planning results, promote the reform of economic structure, and reduce water and energy consumption.

Visibility: The GIS geographical spatial analysis function can overlay geographical images on layers, display the spatial distribution of planned tourism resources and some information characteristics through three-dimensional models, and display the planning content in an intuitive and visual way.

3.3.3. Application of GIS spatial evaluation technology in tourism

The development and application of each technology have demonstrated its unique advantages in practice. GIS technology has shown its unique value advantages in multiple fields, and its advantages in the tourism industry are more obvious, as shown in Table 4.

Table 4 | Classification of advantages and characteristics of GIS in planning tourism

Classification	Function	Advantage
Collect data	Data collection will be carried out on maps, geographical landforms, photos and videos in tourist areas.	Can use a variety of ways to quickly collect a variety of tourist area information.
Manage and maintain data	Manage and maintain the data collected from the tourism geographic database.	Ensure data security and facilitate personnel to manage data.
Update data	Update and supplement the data of various tourist areas in real time to the geographic database.	It can be compatible with other information systems and realize data exchange.
Multimedia query	The data in the database are processed and the multimedia query window is built.	Convenient for visitors to inquire at any time the tourist area information.
Chart generation	The data of the analyzed tourist areas will be displayed in the form of charts.	Convenient for tourists to grasp the information of tourist areas in a timely and simple manner.
Mapping	By analyzing and processing the data of the region, the data are drawn into a special map.	According to the needs of users to map, it is convenient for tourists to travel and travel.

Jilin Province is located in the center of northeast China, 121°38′–131°19′ east longitude, 40°50′–46°19′ north latitude, the longest east-west about 750 km, the widest about 600 km from north to south, with a total area of 187,400 km², accounting for about 2% of the country's total land area, ranking 14th in China. GIS geographical spatial analysis technology shows its unique advantages in the application of tourism. The main advantages are that it can reasonably plan the regional tourism resources according to the geographical spatial distribution characteristics, change the original tourism economic structure, plan the economic structure suitable for the development of the regional tourism industry, and reduce the excessive consumption of water resources and ecological resources. The construction and development of the urban system in Jilin Province would promote its development, and its urban system study is very important. Spatial structure is the inevitable result of the spatial location choice of human long-term activity. Therefore, the spatial distribution characteristics of the urban system in Jilin Province would inevitably change in a certain time and space.

4. COMPARATIVE EVALUATION OF TOURISM AREA PLANNING BEFORE AND AFTER

4.1. Data sources

Six tourism cities were randomly selected as the experimental objects. The tourism resources and tourism income of the six tourist cities were roughly similar. The six tourism cities were Hangzhou, Xiamen, Xining, Guiyang, Guilin, and Dalian. The six tourism cities were divided into two groups: Hangzhou, Xiamen, and Xining were the experimental group, and Guiyang, Guilin, and Dalian were the control group. The experimental group used GIS geographical spatial analysis technology to plan the tourist area, while the control group used traditional planning methods to plan the tourist area. The experimental time was 1 year. During this period, the number of tourists, environmental quality, and tourism income data were recorded, and the results were analyzed.

4.2. Data evaluation

4.2.1. Number of tourists

Analyzing the changes in the number of tourists within a year, the more tourists there are, the more reasonable the tourism area planning is. The fewer tourists there are, the more unreasonable the tourism area planning is, as shown in [Figure 1](#).

The tourism industry was divided into off season and peak season. Generally, the peak season of tourism was from May to October, while the other months were off season, as shown in [Figure 1](#). It was obvious from the figure that the number of tourists in the experimental group after the tourism area planning by GIS geographical spatial analysis technology was more than that in the control group of tourism areas planned by traditional planning methods. The number of tourists in the tourist areas of the experimental group showed a continuous upward trend in the peak season from May to October, while the number of tourists in the tourist areas of the control group increased in the peak season from May to October compared with the off season, but the effect was not obvious. It shows that after the planning of the tourist area through GIS geographical spatial analysis technology, the attraction to tourists is increasing, and the number of tourists is increasing gradually.

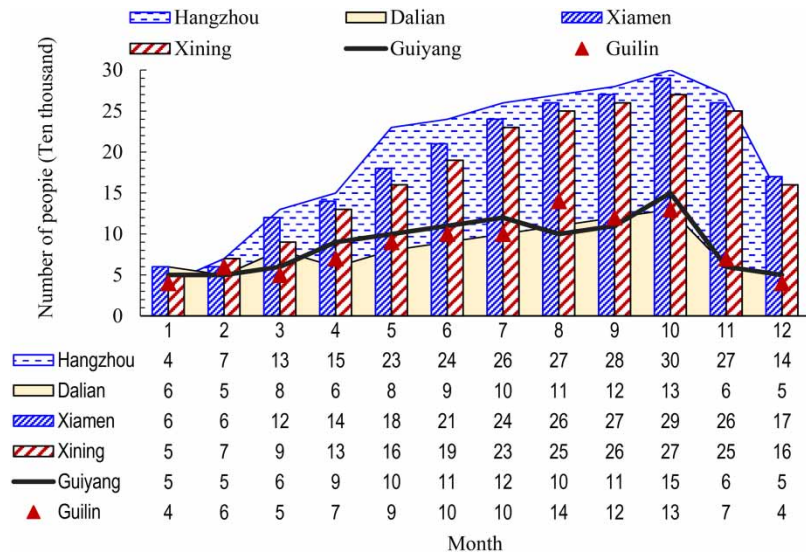


Figure 1 | Comparison of the number of tourists in the experimental group and the control group in 1 year.

4.2.2. Environmental quality

After a year of experimentation, the ecological environment quality in the tourist area was graded and divided into five levels, ranging from 1 to 5. Among them, the ecological environment quality at level 1 was the worst, while the ecological environment quality at level 5 was the best. The proportion of ecological environment quality levels between the experimental group and the control group was observed, and the experimental results were recorded and analyzed. The specific results are shown in Figure 2.

In Figure 2, the abscissa represents the ecological environment quality grade, ranging from 1 to 5, and the larger the number, the better the environment. The height of the rectangle represents the proportion of the ecological environment quality level.

As shown in Figure 2, there was a significant difference in the experimental results between the experimental group and the control group. The experimental group had the highest proportion of areas with an ecological environment quality level of 5, while the proportion of areas with an ecological environment quality level of 1 was the lowest. This indicated that the overall

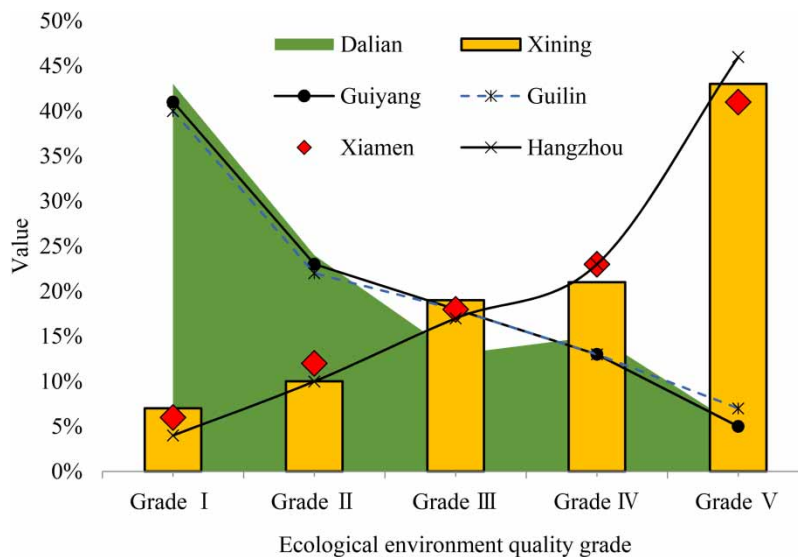


Figure 2 | Comparison of eco-environmental quality grade distribution between the experimental group and the control group 1 year later.

ecological environment quality of the experimental group was at a high level, and the ecological environment protection was good. In the control group, the regions with the ecological environment quality grade of 5 accounted for the least, and the regions with the ecological environment quality grade of I accounted for the most. It showed that the ecological environment quality of the control group was at a low level as a whole, and the protection of the ecological environment was not in place, which proved that the use of GIS geographical spatial analysis technology for planning can not only continuously attract tourists but also protect the ecological environment.

4.2.3. Ecological economic income

The ecological economic income of the tourism area is the most reflective of the development of tourism. The higher the ecological economic income, the more reasonable the distribution of environmental resources in the ecological zone. The lower ecological economy indicates that the distribution of ecological resources is not reasonable and hinders the development of tourism, as shown in Figure 3.

From the data in Figure 3, it can be seen that the average ecological and economic income of Hangzhou Tourist Area within a year was about 2.9492 million yuan; the average ecological and economic income of Xiamen Tourist Area within a year was about 3.1508 million yuan; the average ecological and economic income of Xining Tourist Area within a year was about 2.9858 million yuan; the average ecological and economic income of Guiyang Tourist Area within a year was about 1.8017 million yuan; the average ecological and economic income of Guilin Tourist Area within a year was about 1.7542 million yuan; the average ecological and economic income of Dalian Tourist Area within 1 year was about 1.7317 million yuan. The average ecological and economic income of the experimental group within 1 year was about 3.0286 million yuan, while the average ecological and economic income of the control group within 1 year was about 1.7625 million yuan. The average ecological and economic income of the experimental group within 1 year was about 1.2661 million yuan higher than the average ecological and economic income of the control group within 1 year, indicating that the overall ecological and economic income of the experimental group's tourism area has improved. Figure 4 shows the distribution of geographical spatial state in Jilin Province, China.

As shown in Figure 4, it can be clearly seen that the ecological and economic income of the six urban tourism areas was similar in January and February. However, starting from March, the ecological and economic income of the experimental group was higher than that of the control group and showed a continuous upward trend during the peak season from May to October. Moreover, during the off season of tourism in November and December, the ecological and economic income was also over 2 million yuan. The ecological and economic income of the three tourist areas in the control group in January and February was not significantly different from that of the experimental group. However, during the peak

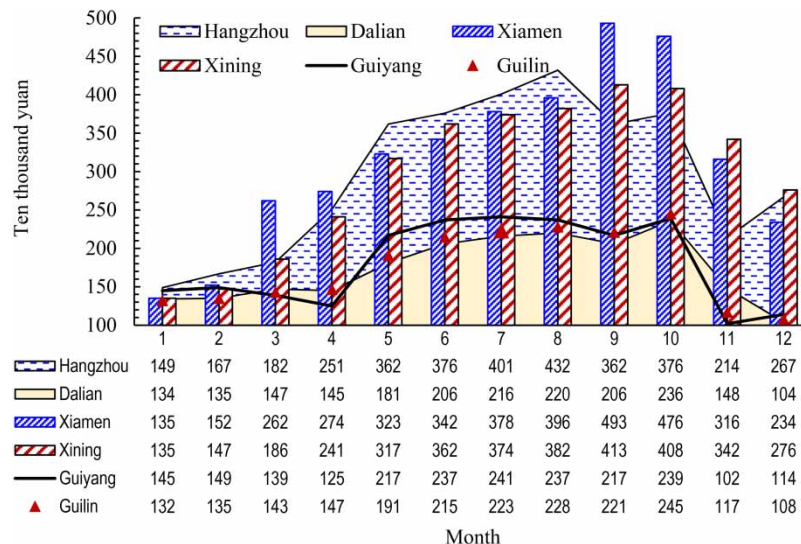


Figure 3 | Comparison of ecoeconomic income between the experimental group and the control group in 1 year.

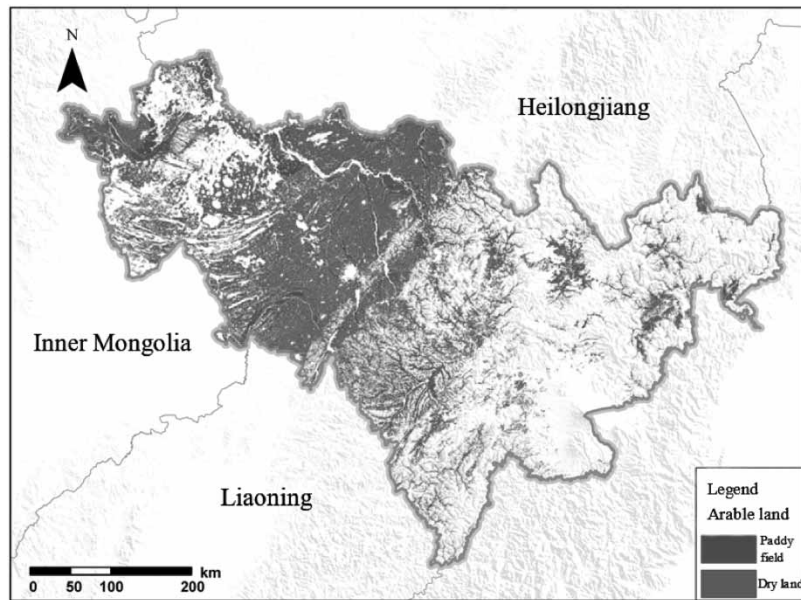


Figure 4 | Ecological distribution of paddy field and dry land in Jilin Province, China.

season from May to October, although the ecological and economic income increased slightly compared to the off season, the increase was not significant. The overall ecological and economic income was below 2.5 million, indicating that the use of GIS geospatial technology for reasonable planning of tourist areas is of great help in improving the overall ecological and economic income of tourist areas.

5. CONCLUSIONS

With the development of the economy, the tourism industry has flourished in recent years, which indirectly indicates the improvement of residents' living standards and has a great promoting effect on the development of regional ecotourism. The development of the regional economy can reduce the significant consumption of water and energy. The reasonable planning of tourist areas is of great significance for the resource utilization and ecological environment protection of tourist areas. The traditional planning methods and development models of tourist areas are no longer suitable for the high demand of tourists' gradual development. It is meaningful to use new technologies to re-plan tourist areas in a reasonable manner. This article analyzed the traditional ecotourism model, summarized the problems of why tourism is not attractive, and analyzed the advantages of GIS geographical spatial analysis technology in the close relationship between water and energy and tourism. By using GIS geographical spatial analysis technology, the ecotourism area was re-planned on the basis of protecting the ecological environment, and the tourism projects that adapt to the natural environment were constructed to promote the development of ecotourism, which not only improved the overall ecological economic income of the tourism area but also protected the ecological environment and ecological resources.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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First received 14 May 2023; accepted in revised form 7 September 2023. Available online 26 September 2023