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Image Analysis of Spatial Differentiation Characteristics of Rural Areas Based on GIS Statistical Analysis

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Abstract: In rural geographic studies, the topic of multi-functions of rural regions has been gaining growing interest. Geographic areas with a complicated arrangement of activities of society and nature and the regional landscape noticeably articulate spatial differentiations. The image analysis and classification study of the spatial differentiation characteristics and patterns of rural regions are the basis of efficient governance and arrangements of village space, which play leading roles in rural revitalization and new-type urbanization policy. With rapid urban–rural transformation, rural development faces challenges under the progressive drive of accurate urban–rural integration development. Therefore, this paper proposes a spatial differentiation model based on a sociophysical information system and geographic information system, which is used to study rural development planning and land classification. The data are taken from the dataset of ucsd for analyzing the rural geographical data. The gis is a computer-aided system for analyzing, acquiring, displaying, and storing rural geographic information. This article discusses several noteworthy features of rural settlement distribution using a gis-based information processing approach and image analysis.

Keywords: economic development; land environment; landscape planning; rural economic revitalization; sociophysical information system

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1. Introduction

The lack of spatial data at the rural and regional levels is one of the significant issues for government officials, rural development experts, and local-level planners [1]. Sustainable economic growth in rural areas is recommended via water resource development and management strategies, soil and water conservation measures, and appropriate land use patterns [2]. However, rural regions constitute a complex system that incorporates the agricultural system, the natural ecology, and certain activities of the urban system [3]. Increasing attention is being paid to the roles that industrialization, environmental preservation, and social security in rural regions play in urban and rural change and development [4]. Therefore, the rural regional function is the key determinant of the differentiation of rural patterns and the identification of rural development status [5]. To identify the rural development pattern and put into action a distinct route of rural revitalization, it is essential to establish the spatial pattern of the rural, regional function at the parcel scale [6].

Spatial differentiation generally denotes the spatial depiction of uneven development across geographic space [7]. It directly represents the process of social division or the segregation of societal expectations [8]. The qualities of spatial differentiation characteristics are the products of natural and societal processes that have resulted in a disjointed, irregular, complicated, and unstable, yet articulated, Earth's surface [9]. The Earth's surface is like a kaleidoscope, which may be interpreted in various ways, such as gis, remote sensing, and satellite imagery [10]. gis is a computer system that examines and shows geographically referenced data and utilizes data attached to a rural area [11,12]. Combining gis data interpretation, exploration, and modeling with image analysis is the process of geospatial analysis [13]. Depending on the number of activities and their complexity, the resulting data undergo several levels of spatial analysis software-based computer processing [14]. Land and resource mapping, incorporating local and scientific spatial information, environmental management, community-based natural resource management, natural hazards, and area planning are some of the primary utilizations of gis in rural expansion [15]. Farmers can utilize geospatial tools such as geographic information systems (gis), global positioning systems, and land remote-sensing satellite images to assess variations in soil quality for planting crops [16]. Overall, geospatial technology is certain to play an ever-increasing role in developing infrastructure in rural areas to enable their development and to provide essential services to rural populations [17]. The image analysis supports analyzing and exploiting image and raster data in gis with a collection of commonly used display capabilities, processes, and measurement tools [18]. Pixels in a remotely sensed image must be assigned classes determined by the schema, which is a land cover and land use classification system. Classified images' raster results may generate customized themed maps [19]. High-resolution multispectral imaging sensors are among the newest advances in sensor technology for Earth observational remote sensing. The data these sensors provide are more comprehensive and specific to each image component. Since the data sources are improving, there are more elements to see in the images (classes) [20].

This paper constructs a spatial differentiation model based on gis, aiming to study and analyze the problems of rural development planning and classification. The performance indicators of the model are further tested and analyzed, mainly from their efficiency ratio, land use prediction ratio, classification accuracy, and rural spatial pattern recognition ratio. The test results show that the model can effectively analyze the data and information in rural development planning and landscape design, and monitor the change of rural land use and rural environments in real time, thus providing effective information guidance for rural development planning.

The introduction of this paper mainly summarizes the problems of rural development planning, and introduces the application of relevant technologies in rural spatial planning, economic development, land use, and other aspects. Related Works mainly introduce the research of other researchers on rural economic development, landscape planning, farm architecture, etc. The Materials and Methods section mainly focuses on the analysis of the spatial differentiation model assisted by a social–physical information system and geographic information system, and the relevant tests and analysis of the model from different aspects. Actual Application and Future Prospects of the Model mainly describes the specific application of the model and its role in the future of rural planning and development. The conclusion summarizes the main contents of the article and explains the role of the model.

2. Related Works

In recent years, the content of rural landscapes has attracted extensive attention from the academic community, and scholars have launched research on it. Dina Statuto's time evolution analysis based on gis was proposed by others for rural landscape analysis. Spatial analysis using open source gis tools was used to examine data spanning nearly two centuries, from 1829 to 2017, to determine land use changes in a representative rural environment in the Basilicata region (southern Italy). This multi-temporal survey determined the location of natural evolutions of a rural landscape by assessing land use change and using a technology to explore changes in landscape structure. Then, the authors used landscape measurement and spatial analysis technology to statistically evaluate the changes of the rural landscape to determine the location of natural changes in the environment without human intervention in the past 188 years [21]. Giuseppe Cillis's geospatial method was introduced to analyze local architecture and rural landscapes. gis geospatial analysis, including a range of disciplines and time scales, can be used to assess the success of management technologies aimed at protecting their rural characteristics. This study included a technique to check the accuracy of certain findings in the study area, which is characterized by a typical rural Mediterranean landscape. Recent scientific research shows that many farm buildings have greatly affected the maintenance, monitoring, management, and long-term viability of the rural environment. This paper confirms these findings. In particular, returning to traditional farming methods may help rural areas achieve sustainable development, reduce resource waste, prevent environmental degradation, and maintain a healthy ecosystem balance [22], according to Dina Statuto and team. In order to detect the land use change of the typical rural landscape in Basilicata (southern Italy), a free and open source gis tool was used for spatial analysis, including data from 1829 to 2017 for about two centuries. The purpose of this multi-time analysis was to investigate the change of a landscape structure by assessing land use change and implementing a method to determine the natural evolution area of the rural landscape. Then, the landscape measurement and spatial analysis tools were used to identify some areas of natural landscape evolution in the past 188 years without any human intervention, and the changes in rural landscape were quantitatively assessed. Through Pgis/Pgis method, Fagerholm Nora learned about the local realization of landscape services in three multi-functional rural landscapes in Tanzania, understood the potential of these methods to support participatory spatial planning, and pointed out that the most abundant landscape services are social gatherings and planting sites, in which the spatial mode of providing services is the realization of human benefits from biophysical landscape mode. In general, cultural landscape services show aggregation and small spatial scope [23]. However, these scholars' research on rural landscapes is not comprehensive enough, and further research on rural planning needs to be carried out in combination with other methods.

Other scholars have also conducted some research on rural planning and other related issues. For example, Amanda Hoffman-Hall recommended mapping remote rural settlements with geospatial data fusion at a spatial resolution of 30 m. It is important to include the multi-temporal auxiliary information sensitive to human activity patterns in the region, such as the change of seasonal vegetation signals, the distance to water, and the distance to the latest active fire, for the detection of small settlements under the Landsat resolution. In this scenario, the innovative use of live fire provides a key parameter to improve the accuracy of the final map. On the basis of each pixel, the classification accuracy of the final dataset reached 86.5%, while the location recognition accuracy reached 93.1%. The population of Anzhen is more scattered and isolated than previously recorded, and several small communities have been found (in some cases, the scale is two–three buildings). This study shows that it is feasible to draw spatial vulnerable population maps using medium-resolution remote sensing data by incorporating relevant regional attributes [24]. Marija Drobnjakovi discussed the typological classification method of rural settlements. The author starts with an example of typology being used as a methodology, then discusses typology as a scientific field, and finally ends by showing how it can be used to help achieve appropriate research objectives and discoveries. This study examines the theoretical track and thematic methods of rural typology. At first, the characteristics of rural communities, such as population size and layout, were used for classification. However, the author concluded that, in view of the evolution of practice and the established need to monitor changes in rural areas and coordinate them with contemporary development trends, it is necessary to combine the above factors with other aspects of settlements in order to fully understand the areas under study. When it comes to application typology, a program has been developed. Under modern concepts and technologies, it is used to classify rural areas in Serbia and other places in a more detailed way [25]. Zhu, C. studied the spatial differentiation characteristics of the cost-distance weighted method and the geographical weighted regression model on the transport accessibility and multidimensional poverty of rural households in karst mountainous areas. The author analyzed how access to convenience affects many factors that lead to agricultural household poverty. Compared with restricted farmers, there are fewer samples to promote farmers to build houses. The promotion of villagers' groups is particularly concentrated in the northern half of the demonstration area, namely Wuli, Guxia, and Bashan villages. Mugong village, Taiping village, Yindongwan village, and Chaeryan village are all located in a fengcong depression, where most people live. The author has carried out a quantitative study on traffic accessibility, multi-dimensional poverty, and spatial heterogeneity to clarify the measurement methods of these concepts and how they differ geographically; this is of vital practical significance when formulating anti-poverty policies at the regional level [26].

To sum up, according to the research contents of the above different documents, we have carried out some comparative analyses on them, and the research comparison of different documents is shown in Table 1.

Table 1. Comparison of different literature studies.

Literature	Advantage	Shortcoming
[21]	Integrates multiple technologies for analysis	Only the rural environment of one region is selected, lacking contrast
[22]	Geospatial method is introduced to analyze local architecture and rural landscapes	The research object is limited to the Mediterranean region
[23]	Studies the local rural landscape services in combination with multi-functional rural landscapes	Lack of practical demonstration
[24]	The classification accuracy and location recognition accuracy of data sets have been improved	Not considered from multiple factors
[25]	Considering various factors, the research is relatively comprehensive	No empirical research
[26]	Quantitative research on transportation accessibility, multi-dimensional poverty, and spatial heterogeneity	Geographic location selection is too centralized

3. Materials and Methods

In order to better study the issues related to rural development and economic revitalization, this paper integrates gis and constructs a spatial differentiation model. The dataset collected is from GIS & Geospatial Technologies: Sorted by Geography, and the data in Land cover of Liberia were selected from the global database column. This model was used to analyze and process data sets, used rural environmental information, especially climate, temperature, and rainfall data, to discuss changes in land use and land classification (lulc) categories, and extracted relevant image information from satellite images.

This article explores how spatial planning might help stimulate growth and stability in rural economies. However, there has been limited successful integration between rural development theory and practice and rural spatial planning. Nevertheless, development and planning techniques share many of the same obstacles. They are supported by the same bases of policy-making, most notably the predominance of territorial approaches and community-based models. Furthermore, the environmental quality of rural areas appears to be increasingly linked to their economic fortunes (in terms of attracting capital and in-migrants), and the production of environmental goods offers a potential development pathway for some rural areas as producers of renewable energy or in regard to payments for ecosystem services. These viewpoints point to the need for more comprehensive descriptions of the rural situation and possible routes toward stronger, more resilient, and more sustainable rural communities. Planning for the built environment, and more specifically, the coordination of the spatial and territorial components of rural development, may play a significant role in creating resilient routes for the rural economy. However, discussions of the rural economy are typically separated from local plans for rural areas. The rural environment is given higher priority in planning policy, which prioritizes using regulatory tools to safeguard and preserve rural areas. More proactive methods of strengthening rural communities' lives and economies are investigated, whereas the conventional way of understanding rural planning is criticized. Therefore, this paper integrates a social–physical information system and geographic information system, applies these two systems to the spatial differentiation model, and analyzes the problems of rural economic development, land use prediction, rural landscape planning, and other aspects with the help of this model, so as to promote the overall development of the rural economy.

A complex system called a social–physical information system is made up of physical systems, such as human social systems, and information systems that link the two. In order for "social+physical systems" to be "equivalently" mapped into information systems, it realizes the link between physical systems and information systems through sensor networks as well as the connection between social systems and information systems through social sensor networks. On this foundation, the control and application goals of the social–physical information system, such as safe, reliable, and efficient operation, can be gradually attained through mutual understanding, virtual and real interaction, and collective improvement of the information system and "social+physical system" in the social–physical information system.

Based on the idea of an information physical system, a social–physical information system expands the breadth of administration and control by including social and human variables into complex systems. The research field is expanded to include social systems via the social–physical information system. Through intelligent human–computer interaction, it realizes the natural integration of physical systems and personnel planning, and is anticipated to accomplish total administration and control of a variety of complex systems. It can play a supporting function in the building of rural information, rural information management, and other elements of rural development when it is applied in the spatial differentiation model. The sociophysical information system can gather and evaluate different information resources required for rural economic development and use them effectively to speed up both the planning and construction of new landscapes and rural economies.

Figure 1 shows the gis-sdm model. The paper uses rural environmental information, specifically climate, temperature, and rainfall data, to discuss land use and land classification (lulc) class changes, extract images from the input dataset [27], and process satellite images. There is a lot of noise in the image, such as electronic noise, optoelectronic noise, AC noise introduced by power supply, shot noise, etc. Preprocessing satellite images is essential before change detection and image classification since it removes chances of errors by the sensor, solar, atmospheric, and topographical factors. It is termed preprocessing when remotely sensed data undergoes radiometric and geometric correction. Image preprocessing in this study included various operations, such as geometric and radiometric correction, gap filling, atmospheric correction, enhancement, subsetting, and band selection. Image classification refers to labeling images with information about their particular topic. The method generates groups of pixels with similar digital values in the same data classes. Six different types of lulc are used: bare land, rural built-up area, agricultural land, forest land, waterbody, and herbaceous land. The current research uses a backpropagation classifier trained using a supervised classification strategy. Supervised classification is based on the notion that users may choose training samples (groups of pixels) from images representative of desired classes. Then, the image processing will use these samples as standards for classifying the other pixels. To train the classifier in this research, uniformly distributed regions of interest in the research region for all class categories are determined utilizing visual interpretation of Landsat imageries. To facilitate the differentiation of lulc classes in the image, true and false combinations have been used to enhance the feature display. Using the rural spatial analysis module, the data are aggregated, synthesized, and analyzed in gis to reveal spatial correlations. Planning for the long-term sustainability of rural areas requires a thorough and timely grasp of lulc, including its pace, trajectory, root causes, and knock-on effects. Providing accurate and up-to-date geographical data on lulc and analyzing modifications in a research area have been two primary uses of remote sensing and gis. RS images are valuable for collecting, evaluating, and modeling lulc information and changes because they accurately represent land use conditions. To monitor land usage and identify changes in the landscape, digital data must be collected, stored, displayed, and evaluated, and gis offers this flexible platform for rural areas' landscapes.

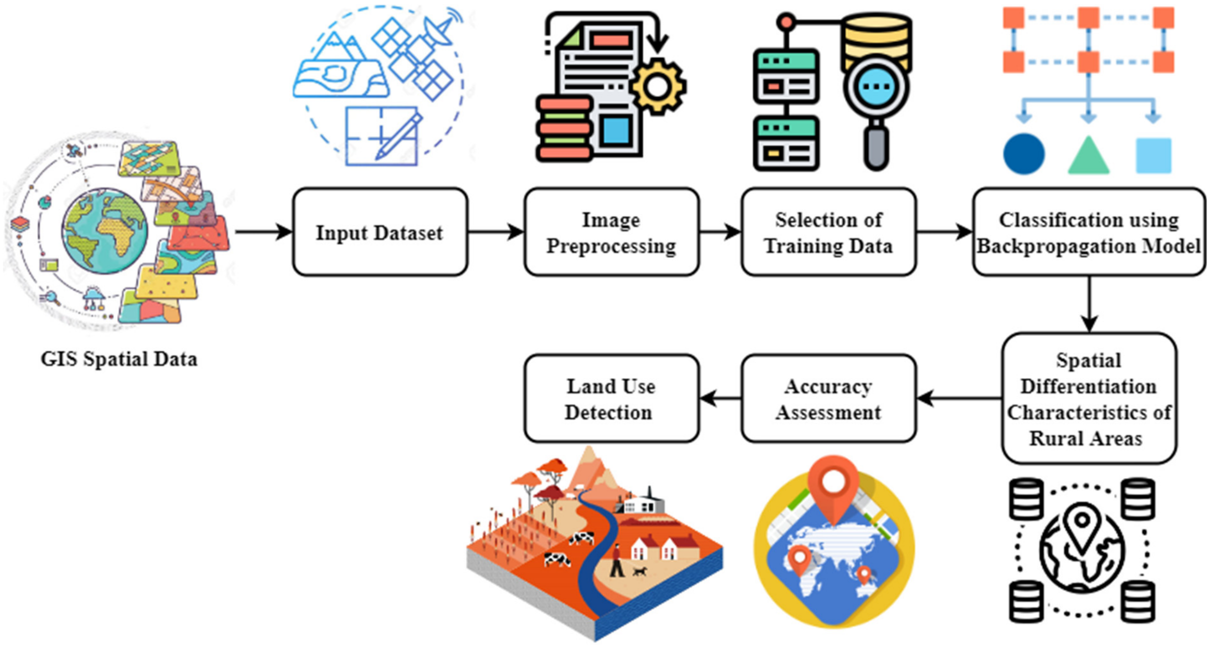

Figure 1. gis-sdm model.

Figure 2 shows the geographic data management. The aim is to create a supportive environment where geographical data can be managed and accessed for further study and experimentation with cutting-edge data analysis methods, as well as for the processing and analysis of geographical images and information (in particular, statistics). The whole system is made up of a flexible framework that is always changing and improving. Each geographical information object is logically organized as a table data structure, with suitable key data fields connecting it to related tables (data subsets). This structure is based on the relational database concept. With the help of proper key identifiers, the system can track down a given set of coordinates, a description of a map's region, a list of local governments, and much more in the vast universe of geographical information. With a bottom-up approach to database architecture, tables are organized into categories based on geographic data (such as the thematic and reference map, demographic information, etc.) and their relationship to other aspects. The database is usually filled with quantitative and qualitative data on fundamental features (populations, rural regions, etc.), with a handful of relative environmental impacts and variables considered. The system generally has a high computing power for tasks such as image processing and data analysis. In this regard, image processing, including and not limited to spatial illustration, bit-level processing, color processing, inverse, median filter processing, contrast modification, edge detection, and sharpening, is crucial. Statistical mean, population distribution, percentage deviation, standard deviation, geometric image transfer and transformation, classification, aggregations, regression, and so on are all examples of statistical processing. The interface has numerous options for managing geographical image files, including importing and showing imageries from a default directory and capturing new images whenever suitable tools are utilized (e.g., local storage mainframe, ccds camera). The many tasks involved in processing an image are classified into several groups according to their specific tasks.

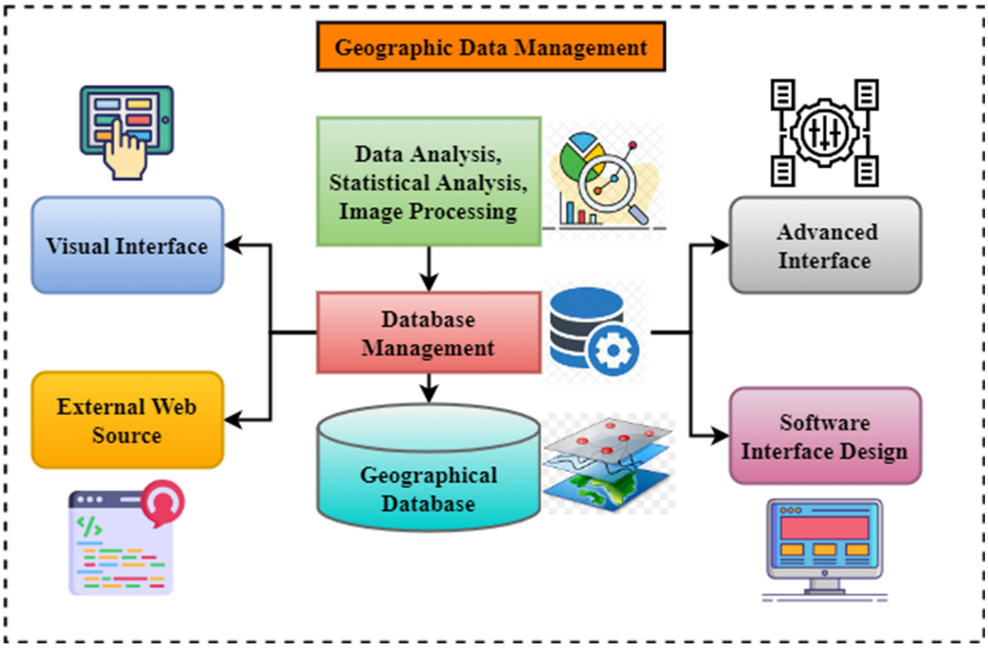

Figure 2. Geographic data management.

3.1. Preposition 1: Spatial Analysis

Settlements in rural areas serve as the spatial carriers of people's daily lives, their economic and cultural activities, and the legacy of previous generations. One of the primary focuses of rural geography, an important subfield in studying human–nature interactions, is the pattern of human settlements and how they are structured. It is essential to comprehend a rural area's structure, functional restructuring, optimization, and renewal. To better establish the policy of rural revitalization and development, it is vital to illustrate the rural settlements and comprehend their roles in the socio–environmental interactive model. This article aims to achieve such a study utilizing spatial analyses such as spatial autocorrelation and kernel density and modeling methodologies. Kernel density is a nonparametric technique to measure the likelihood density of random variables, it is utilized to examine spatial distribution patterns of rural settlements by computing the unit density within the definite neighborhoods, and the outcome produces smooth surfaces with a huge median and minor peripheral value. It can be articulated by:

$$f(y,x) = \frac{1}{mg^2 \sum_{j=1}^{m} L\left(\frac{d_j}{g}\right)} \tag{1}$$

As shown in Equation (1), where $f(y,x)$ denotes the density estimation at locations (y,x), m indicates the number of rural settlements, g denotes kernel size, L is the size of land regions, i.e., kernel functions, and d_j is the distance between the location of jth rural settlements and locations (y,x). Spatial autocorrelation analysis measures whether one observation in space is associated with its adjacent, involving SA and outlier and cluster analysis.

In remote sensing images, the spectral features are the spectral distribution and grayscale of target objects or the brightness ratio between bands. To decrease the amount of data calculation and enhance the calculation speed, it is necessary to fully use the spectral characteristics of images. Based on information entropy, the concept of an equilibrium degree is established to measure the homogeneity and equilibrium of land use distribution, and the expression of equilibrium degree is shown in expression (2):

$$I = \frac{G}{G_{max}} = -\sum_{j=1}^{m} q_j \ln(q_j)/\ln(m) \tag{2}$$

which shows the degree to which one or several dominant land types dominate the land types in the rural region.

Patch density denotes the number of patches per unit region, and the computation is as follows:

$$P = M/A \quad (3)$$

As denoted in Equation (3), M indicates the overall number of patches in the rural study area and A denotes the overall area of the study area in km^2.

To compare the differences and changing trends of dissimilar land use types, this research quotes the dynamic outlook of land use to quantitatively reflect the changing rate of land use types through the dynamic attitude of single land use types. The dynamic perspective of land use refers to the change rate of a certain type of land area in a period and its expression:

$$Q_j = \frac{V_b - V_a}{V_a \times T} \quad (4)$$

In expression (4), Q_j denotes the gis's dynamic attitudes of land use types in t time. V_b and V_a indicate the regions of specific land use types at the creation and end of the research and gis's efficiency ratio. T indicates the research periods, which is the annual change ratio of land use types when expressed in years.

3.2. Preposition 2: Backpropagation Model

Using multispectral satellite images, elements such as land use may be identified using an RS application called land cover classification. The goal of land cover classification from remote sensing imageries is to assign every pixel in the image to one of many land cover classifications. This study employs the backpropagation model to train and fine-tune weights for supervised classification. Due to its effectiveness, this model is perhaps the most popular one used in research on artificial neural networks. The network begins with the intended output and works backward to the inputs, modifying the relative importance of its connections along the process. Expression (5) defines the error vector as the variance between the network's output and response.

$$E = \frac{1}{2}\sum(l_t - l_0)^2 \quad (5)$$

As shown in Equation (5), E denotes the square of errors between anticipated outputs and the original output and l_0 and l_t specify the real and anticipated output of networks, respectively.

Class confusion and statistics matrices were computed after classification, and majority analysis was applied to the final map result. By assigning incorrect pixels from a large class to a smaller one, majority analysis lowers the background noise in the categorized map. A universal need in image classification is an evaluation of the accuracy of maps derived from any remotely sensed product; this serves multiple purposes, including self-evaluation; quantitative comparison of different methods, algorithms, and analysts; and increased confidence in the reliability of the derived map. This research evaluates the classification accuracy using metrics derived from Equation (5) and the error matrix. Most experts agree that the error matrix is the best technique to depict the accuracy with which remotely sensed data may be classified. In other words, it compares the predicted and actual values to prove how close the prediction is to reality.

Figure 3 shows the impact factors of village spatial structure. The traditional agricultural economy and the landscape both have a role in the spatial distribution of rural areas. Large-scale towns really cannot develop because of inadequate transportation and services. As the rural population has a certain degree of dispersion, the distribution of rural environmental land is also relatively scattered, showing a dotted distribution that is mainly affected by traffic, terrain, economy, culture, and other factors. There is an unusual spatial structure to villages because of the poor connections between the many communities in the area. Rural areas have an internal structure defined by the arrangement of its constituent parts inside the community's physical boundaries. This seriously restricts the economic activities between villages. With its complicated topographical setting, slow social and economic growth, and pervasive traditional cultural impact, the spatial layout of rural villages is at the center of this discussion. Affected by terrain and traffic, rural areas are in a relatively closed environment, which seriously restricts economic and cultural exchanges between rural areas and the outside world. Spatial features are the outward manifestation of culturally and climatically informed patterns of space development. In rural distributed populations, farming and planting are the major sources of food production. This area's rural landscape, mountains, and abundant water supply contribute to a unique pattern of rural development.

Figure 3. The impact factors of village spatial structure.

The following ideas can be used as a starting point for improving the integrity and systematicity of the spatial distribution and protection of traditional villages: traditional villages should thoroughly explore their distinctive culture and landscape genes, update the expression form of landscape genes, incorporate "local" and "national" cultural elements into the creation of their street space, preserve their spatial memory of the original ecology, and make the most of their geographic location. Break free from the "one thousand villages" conundrum in the current, explosive growth of tourism. In order to improve the integrity and intelligence of the overall spatial network of the streets and alleys from the perspective of spatial integrity, we should pay attention to the authenticity protection of the materials, workmanship, decoration, etc., used in the important node buildings, strengthen the excavation of the overall characteristics of the landscape corridors, and improve the integrity and intelligence of the overall area.

Figure 4 shows rural sustainability based on land use structure in rural regions. Focusing only on how environmental quality affects human health is essential to the ecosystem function-based approach. Such products and services may encapsulate all sorts of land use patterns (e.g., industrial and commercial lands, housing lands, recreation, service lands, etc.). In this way, residential land use systems' capacity to denote the supply of residential land function may be seen in the dynamic interplay of internal land use type (land use structures). Four primary functions (production, living, environmental, and potential functions) and six secondary functions (public service, residential, commercial, industrial production, and tourist) make up the categorization of multilevel rural residential land functions. Housing land, public service land (for example, places to work, study, recreate, and take public transit), and public infrastructure land all contribute to living functions, which is the primary and fundamental function in the rural residential land use model, providing residence and associated services for rural residents (village roads and street land). In particular, residential functions are the primary use for land zoned for housing. Land used for public services and the infrastructure that supports them expose the many public-sector organizations that work behind the scenes to maintain and improve our quality of life in every way possible. Producing products allows locals to work mostly in the manufacturing and agricultural industries.

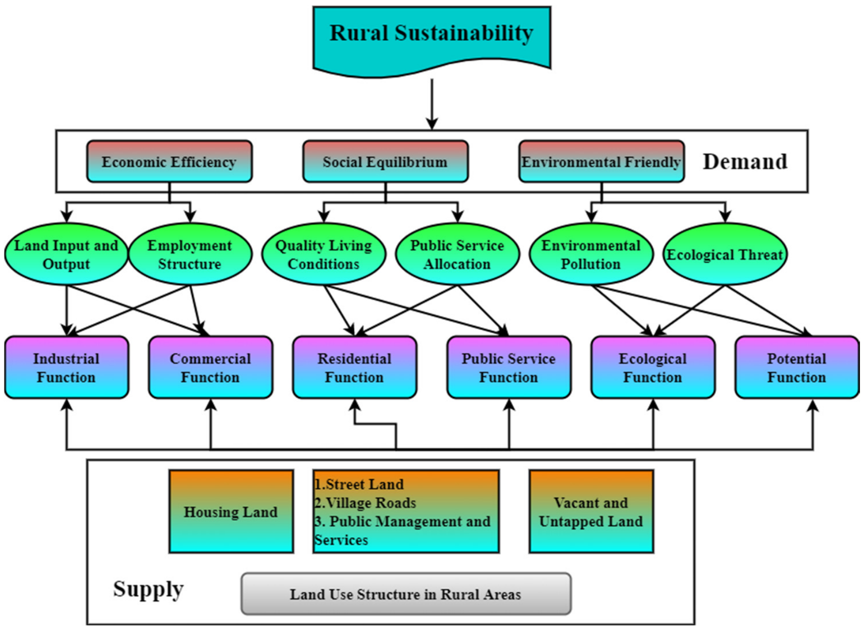

Figure 4. Rural sustainability based on land use structure in rural regions.

Land function refers to the function of land that can meet the needs of human production, life, and other aspects. The land has the function of breeding, providing the environment for plants to survive, and humans can also carry out agricultural planting activities on the land to provide crops for humans to achieve land use. The space bearing function of land provides a stable space for human activities and production, enabling human beings to carry out various production activities and service activities within the scope of land space bearing, and also provides a place for human habitation.

As a result of the poor profit margins associated with agriculturally producing land, its primary purpose is to provide the nutritional needs of the surrounding community (subsistence agriculture pattern). Therefore, it is distinct from the land supply. The non-agricultural production functions are what rural residential lands are most often understood to relate to in terms of their role as a place to live (e.g., industrial and commercial functions). Villages' industrial activity is supported by land set aside for manufacturing and storage. The commercial function consists mostly of the service and travel industries. The primary activities of those who live and work on rural residential property are those of living and producing. Living in a way that does not diminish the local economy, environment, or community is the goal of sustainable rural development. Sustainability in rural areas may largely depend on maintaining social stability, maximizing economic productivity, and minimizing negative environmental impacts. The two groups have contrasting needs concerning how rural residential land is used. Supporting people's day-to-day activities, which is essential and fundamental for residents from an agricultural society, is a key part of the living functions of rural residential lands and is integral to social equilibrium. The fundamental need for land functions might be seen as the condition of social equilibrium.

4. Experimental Results and Discussion

This study proposes a geographic information system-assisted spatial differentiation model (gis-sdm) for rural development and revitalization. The data are taken from the dataset of GIS & Geospatial Technologies: Sorted by Geography [28]. This study discusses the performance metrics of the proposed gis-sdm model, such as efficiency ratio, land use prediction ratio, classification accuracy ratio, and rural spatial pattern identification ratio.

(*i*) *Classification accuracy ratio*

The key to ecological and environmental protection and the foundation for rural land space governance and optimization is a thorough understanding of the spatial differentiation features of rural ecological land in many dimensions [29]. This research uses the backpropagation model to classify rural ecological land into four categories based on the traditional land use classification system: water body, woodland, grassland, and cultivated lands. This classification does not consider every land use type's environmental attributes and ecological function. Second, the paper investigates the spatial differentiation features of rural ecological landforms along a multi-dimensional gradient. Geographic information system (gis) spatial analysis was used to examine data on gross agricultural production density and rural settlements, and rural settlement area per capita. Compared with field study data, which can only cover a small number of rural communities, and the inaccuracy of recognizing land types using remote sensing information, the approach utilized here provides a more comprehensive and accurate image. Figure 5 illustrates the classification accuracy ratio. From the data in the Figure, it can be seen that the classification accuracy of this model for land types is far higher than the test results of other models. When the number of geographic data reaches 100, the classification accuracy is close to 100%. It can be seen that this model can effectively improve the classification accuracy of land types.

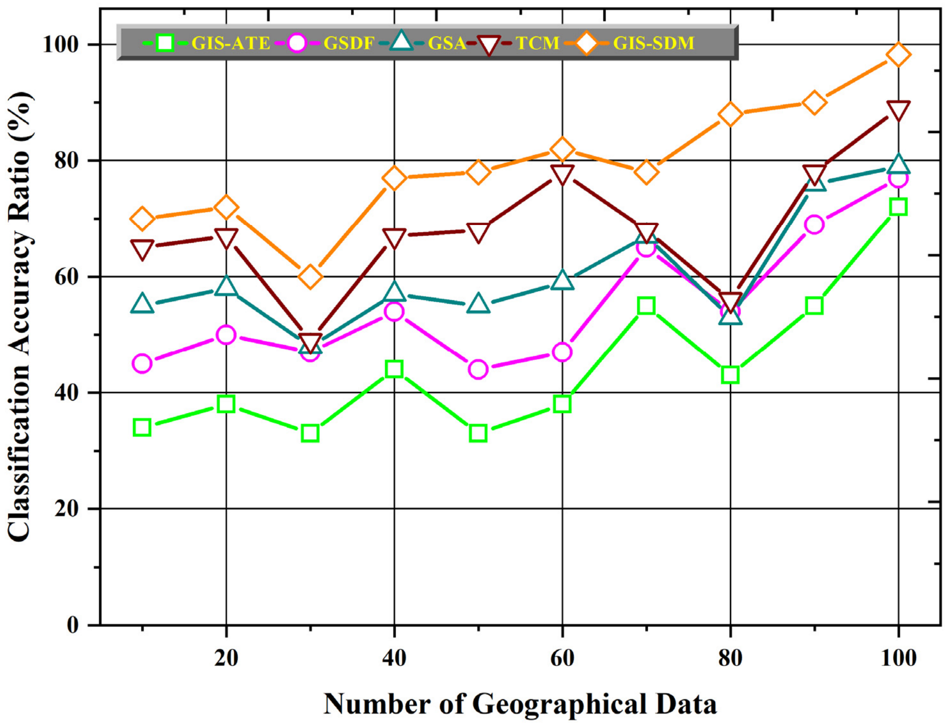

Figure 5. Classification accuracy ratio.

(*ii*) *Land use prediction ratio*

Rural communities often use landscape ecology and kernel density analysis, while gis technology is employed to study different kinds of landscapes and land use patterns. Due to rural development, some of the most noticeable land use changes and consequences on agriculture and other environmental services have occurred in rural and agricultural landscapes. Predicting land use in a given location is as essential as knowing where the relative likelihoods and densities of alteration are for assessing future environmental consequences or conservation initiatives. The prediction ratio of land use in this paper is determined by the total area of land and the usable area of land. The proportion of the usable area of land to the total area of land is the prediction ratio of land use. The larger the usable area of land, the higher the prediction ratio of land use. Using spatial land use forecasting models, users may create land use maps that illustrate the connection between risk evaluation and ecological influence models. Figure 6 signifies the land use prediction ratio. From the data in the figure, it can be seen that the land use prediction ratio of this method is higher than that of other methods, and the maximum land use prediction ratio can reach more than 90%. It can be seen that this method has certain advantages for land use prediction.

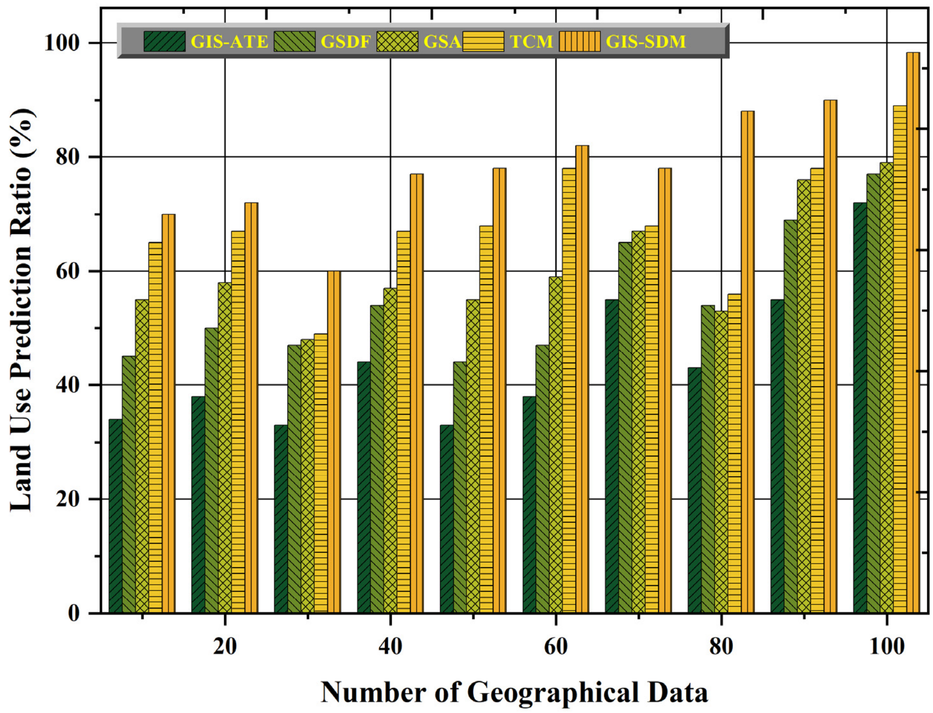

Figure 6. Land use prediction ratio.

(*iii*) *Rural spatial pattern identification ratio*

Spatial analysis is a technique for examining spatial data and differentiation characteristics in rural areas. Geospatial data serve as the engine, and various statistical procedures emphasize information discovery in the spatial domain. It may be used to address real-world geospatial challenges by calculating the connections between geographic features and providing a quantitative description of the resulting spatial pattern. By looking at where people are leaving their homes and what circumstances are causing them to leave, humans may better understand the dynamics of rural population loss. The spatial pattern of rural development may be evaluated with high classification and prediction accuracy using the suggested gis-sdm and backpropagation models. This model can be an experimental reference for further digitalizing rural planning's spatial pattern. Figure 7 demonstrates the rural spatial pattern identification ratio. It can be seen from the Figure that, compared with other methods, the rural spatial pattern recognition rate of the model in this paper is significantly higher, and the overall recognition rate remains above 88%, of which the highest recognition rate can reach 98%. It can be seen that the model can effectively improve the rural spatial pattern recognition rate.

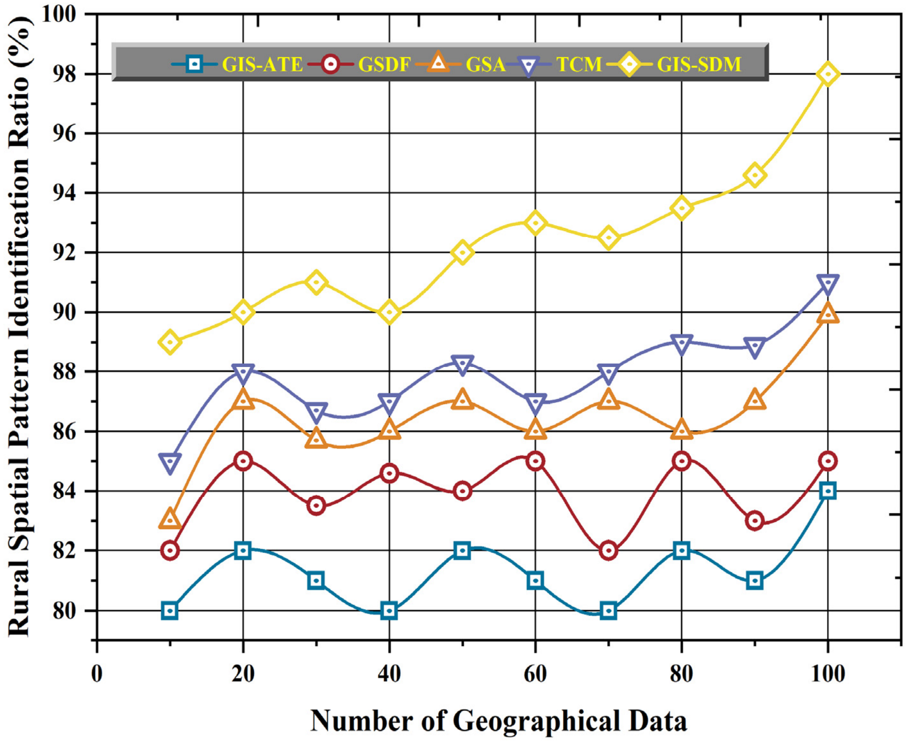

Figure 7. Rural spatial pattern identification ratio.

(*iv*) *Efficiency ratio*

Integration of local and scientific spatial information, land and resource mapping, area planning, community-based natural resource management, natural hazards, and environmental management are some of the primary applications of gis in rural growth. gis can measure the quality of rural area soil and identify whether it can be used for mining purposes or not. gis helps the government recognize the problems of rural areas, such as improper sanitation conditions, no electricity, etc., so the government can use gis to track animal and human migration patterns. Using gis's efficient mapping capabilities and scientific planning and management methodologies, recent research on rural planning illustrated that gis's robust spatial analysis could be effectively applied to rural areas. Proper and efficient use of gis enhanced the new rural planning's scientific, practical, normative, and accurate performance. Figure 8 displays the efficiency ratio of the recommended gis-sdm model. It can be seen that the efficiency ratio of the model in this paper is much higher than the test results of other models. The efficiency ratio can reach up to 97%, which has obvious advantages.

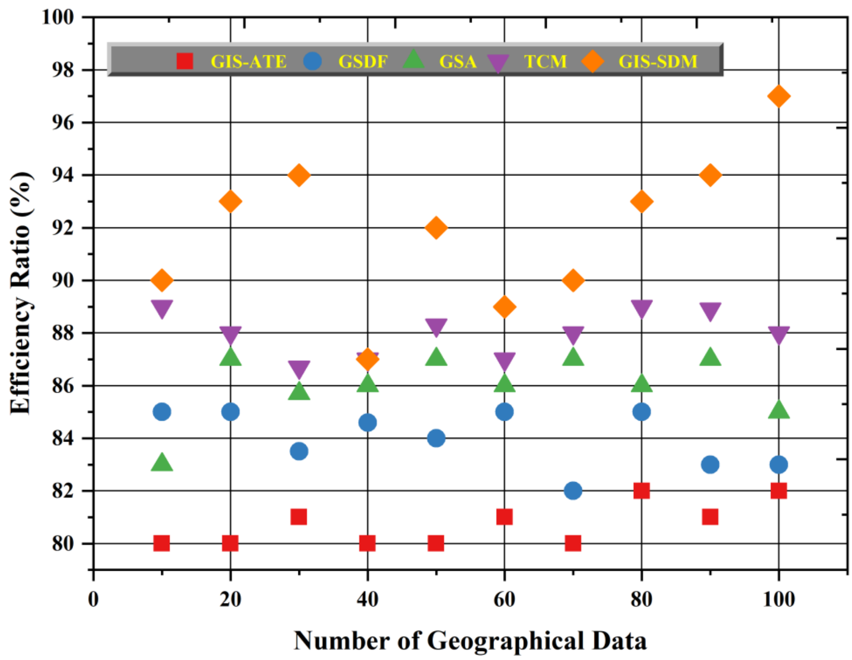

Figure 8. Efficiency ratio of proposed gis-sdm model.

5. Actual Application and Future Prospects of the Model

On the basis of a sociophysical information system and geographic information system, it has good application effect to analyze rural landscape planning and development with the help of a spatial differentiation model. The application of social–physical information systems in rural development is mainly reflected in the management of rural personnel and rural information construction, as well as the effective management and control of complex systems. The application of gis in rural development is reflected in the management of natural resources, natural disasters, and environmental management of communities. It is used to measure soil quality and determine the type of soil used in the area. The application of spatial differentiation models in rural landscape planning is reflected in the detection of land use, identification, and optimization of landscape changes. In future rural development planning, it is also necessary to further study the correlation and mechanism between rural landscape multi-function and rural landscape system. It is also necessary to optimize the performance of spatial differentiation models in combination with other emerging technologies. At the same time, it is also necessary to conduct dynamic monitoring and trend simulation of rural landscape construction to clarify the thinking and path of balancing rural landscape multi-function, so as to guide the sustainable development of the rural economy. The spatial differentiation model assisted by gis will continue to play a very important role in providing more accurate data analysis and service functions for rural spatial development and landscape planning.

6. Conclusions

The rural landscape has changed dramatically due to social and economic changes and the implementation of new agricultural and environmental policies. In this paper, a spatial differentiation model is built by integrating a sociophysical information system and geographic information system to study rural development planning and land prediction and classification. This article proposes the geographic information system-assisted spatial differentiation model (gis-sdm) for rural development planning and classification. Suitable strategies for representing the dynamics of rural land modification may be aided by the geographical tools presented here, which can be utilized for rural landscape planning. This paper also further carried out relevant experimental research on the spatial differentiation model. The experimental results show that the classification accuracy of rural land types has been significantly improved under this method, including the land use prediction rate, rural spatial pattern recognition rate and efficiency rate, which have been improved to varying degrees. It can be seen that this method can effectively optimize rural land classification and planning issues. It has been shown that the primary elements affecting the quality of life in rural areas and the intensity with which they are experienced vary considerably between evaluation units. Economic incentives, locational externalities, and geological factors all have a role in shaping land use patterns. Our results and land use forecasts prove that spatial models may be utilized to develop conservation and development plans that mitigate unique environmental impacts in different geographic locations.

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