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Assessment of the Current Status of Rural Ecological Protection and Construction of a Legal Protection System Based on GIS and Big Data

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Abstract This paper constructs GIS component environmental supervision system, uses wireless sensors and other hardware devices to collect rural ecological environment related data, and completes the conversion of geographic information to data information. The mathematical morphology of corrosion, expansion and other operations are introduced to pre-process the collected data. Adaptive filtering algorithm is integrated to enhance the features of remote sensing image, retain the edge details and improve the image processing effect. The results show that in the quantitative comparison and ablation experiments of “ideal” and “non-ideal” remote sensing datasets, the peak signal-to-noise ratios of this paper's method are greater than 40dB, and the structural similarity indices are greater than 0.9, which are better than the other nine image data processing methods. Methods. After processing the rural domestic waste images, the total amount of domestic waste in 15 counties can be projected, and the amount of compostable waste TN and TP generated in rural domestic waste is $30.3492*10^3$t and $6.0575*10^3$t, respectively. According to the results of the processing and analysis, corresponding optimization suggestions of the rural ecological environment and legal protection system are proposed.

Index Terms GIS component environmental regulation, mathematical morphology, adaptive filtering algorithm, rural ecological protection, legal optimization

I. Introduction

Rural development should first ensure ecological livability, give full play to the advantages of rural resources, and promote the innovation and improvement of the agricultural production system. Increase the strength of ecological environmental protection, to implement the principle of green ecological oriented development, to realize the further conversion of the traditional overconsumption of resources to the production mode, and actively practice the green sustainable development road [1], [2].

With the acceleration of urbanization, the urban-rural dual structure has become the main form of some areas, in order to meet the needs of economic development, the protection of industrial production and urban environment has become the focus of development, and lead to ecological environmental protection issues have been ignored, especially for some of the rural areas, it is more necessary to increase environmental protection efforts [3]-[5]. And the rapid development of industrialization and agricultural production in agricultural areas, providing an important driving force for the development of the rural economy, but the development of industrialization and the use of pesticides will lead to rural pollution problems continue to intensify, so that the salinization of rural land, hardening of the soil, water resources have been damaged, but also cause serious air pollution problems [6]-[9].

However, at present, rural ecological environment protection still exists in rural residents' weak legal awareness, relevant legislation is not perfect, weak law enforcement and other reasons, resulting in unclear land resource ownership, difficult to fully implement rural ecological environment protection and other problems, which restricts the healthy development of rural ecological environment [10]-[12]. In order to solve this dilemma, it is necessary to increase the strength of rural ecological environmental protection and environmental governance, and take measures to solve the existing legal problems one by one, so as to truly safeguard the rights and interests of farmers and realize the sustainable development of rural economy [13], [14]. The construction of ecological environmental legal protection system can increase the publicity of the rule of law, strengthen the farmers' awareness of ecological environmental protection, improve the masses' concept of the rule of law, improve the environmental regulatory system and environmental governance, and at the same time actively improve the legal system of ecological environmental protection, and increase the strength of law enforcement, so as to realize the ultimate goal of rural ecological environmental protection [15]-[17]. Therefore, the construction of the rule of law in rural ecological environment should be actively promoted and ecological environmental protection should be implemented.

The implementation of rural ecological protection will promote the development of green China. This paper proposes a technical framework for rural ecological monitoring that integrates GIS and mathematical morphology and adaptive filtering algorithm to realize the analysis and legal optimization of rural ecological protection problems. The GIS component environmental monitoring system is constructed to realize data collection and visualization display of rural ecological environment through wireless sensors and DEM model. Utilizing mathematical morphology to operate and process image data to improve image pre-processing ability. Combine the Gaussian filter and smoothing algorithm of adaptive filtering, etc., to deal with remote sensing image noise and enhance the image visualization effect. Aiming at the current situation of rural ecological protection, analyze the feasibility of optimizing the legal system with the support of GIS.

II. Technical support for monitoring the status of rural ecological protection

II. A. Construction of environmental monitoring system for GIS components

The analysis of rural ecological problems and their causes shows that the optimal solution to optimize and solve the rural ecological problems is to strengthen the supervision of the environment, however, the supervision will consume a lot of human, material and financial resources. Therefore, the environmental monitoring system can be built with the help of GIS components to solve this difficulty. Nowadays, digital technology has been widely used in various fields of society, and has become one of the powerful driving forces to promote high-quality economic development.

In order to promote rural ecological environmental protection, it is necessary to digitally empower with the advantages of artificial intelligence and big data in algorithms, and use advanced digital technology to innovate the traditional production and management methods and business and service modes, so as to drive the development of the economy in terms of production methods and other aspects. Based on GIS components, Visual Studio.Net development platform, SQL Server database and GPRS/CDMA broadband communication technology, utilizing the visualization of GIS and the powerful data management function of SQL Server, a comprehensive environmental supervision system that can conduct real-time and accurate online monitoring of pollution sources in rural environments is constructed, which can greatly improve the The efficiency and level of rural environmental management can be greatly improved.

II. A. 1) Environmental quality indicators are monitored

Using the wireless sensors in the GIS component, it is possible to monitor various environmental factors in a rural area, realize data collection, processing, storage, and transform geographic information into data information, and be able to do real-time monitoring of the flow rate of pollution sources at various places, the total amount of emissions and concentrations and other relevant data, and real-time control of the operation of the monitoring site equipment. Monitoring center can be graded in the environmental protection department, the main server for the Windows Server operating system, in the monitoring center, can be used GPRS/CDMA broadband communication technology, the establishment of point-to-point, one-to-many communication. In each monitoring point, a dedicated fiber optic connected to the telecommunication network can be used and equipped with a public IP.

II. A. 2) Visualization of monitored data

Using the DEM model in the GIS component to extract the terrain factor and carry out spatial simulation, the monitoring indicators such as water quality and soil are modeled through image processing and other steps, and according to the data provided by the modules of geographic information, monitoring source management, comprehensive query, analysis and statistics, data protection, real-time data and system management of the environmental monitoring system, it realizes the visual processing of the data, and in the monitoring center, the integrated The display platform carries out the display of each index.

II. B. Basic Theory of Mathematical Morphology in Image Processing

II. B. 1) Corrosion and expansion

Preliminary processing of remote sensing images obtained by GIS technology using mathematical morphology. Corrosion is one of the most basic operations of mathematical morphology. The corrosion of a structural element B on a target point set A is denoted as $A\Theta B$ and defined as:

$$Y = A\Theta B = \left\{ y \mid y + b \in A, \forall b \in B \right\} = \left\{ y \mid y = a - b, \forall b \in B, a \in A \right\} \tag{1}$$

It can be seen that $A\Theta B$ consists of all points y that translate B by y but are still contained within A. If B is viewed as a template, then $A\Theta B$ consists of the origin of all templates that can be filled inside A in the process of translating the template.

The expansion is the second fundamental operation of mathematical morphology. The expansion is the dual (inverse) of the erosion operation. The expansion of a structural element B into a target point set A is denoted as $A \oplus B$ and defined as:

$$Y = A \oplus B = \{y \mid y = a + b, Or\ a \in A, b \in B\} = \bigcup_{b \in B} Ab \tag{2}$$

It can be seen that $A \oplus B$ is the new image formed when the image A is translated with each point in B and rejoined.

II. B. 2) Open and closed operations

In the usual case, two different sets may produce the same corrosion result, therefore, the corrosion operation is not reversible. That is, the original image cannot be fully recovered from the result of corrosion. The same is true for the expansion operation, but a minimally recoverable image can be determined. The methods are either erosion followed by expansion, or expansion followed by erosion. We define the former as an open operation and the latter as a closed operation, notated as $A \circ B$ and $A \cdot B$, respectively. The open and closed operations are also pairs of dyadic operations. To wit:

$$A^{\circ} B = (A\Theta B) \oplus B \tag{3}$$

$$A \cdot B = (A \oplus B)\Theta B \tag{4}$$

II. B. 3) Hit-and-miss transformations

In image analysis, detecting both the interior and exterior of an image, rather than limiting oneself to detecting only the interior or exterior of an image, often yields good results for investigating the relationship between objects and the background in an image. This can be achieved by the hit-and-miss transform. The hit-and-miss transform has proved to be a very effective method in solving problems similar to target recognition, refinement, and so on.

The hit-miss transformation captures both internal and external markers in a single operation. Let A^c be the complement of the image A to be processed, and the structure element B consist of two disjoint parts B_1 and B_2, i.e., $B = B_1 \cup B_2$ and $B_1 \cap B_2 = \varnothing$ ($\varnothing$ denotes the empty set). B_1 and B_2 are used to detect the interior and exterior of the image in the hit-and-miss transform, respectively. Then the hit-and-miss transform (denoted as $A * B$) is defined as:

$$A * B = (A\Theta B_1) \cap (A^c \Theta B_2) = (A\Theta B_1) - (A \oplus B_2^v) \tag{5}$$

II. C. Adaptive Filtering Processing

II. C. 1) Fundamentals of adaptive filtering

In order to improve the recognition accuracy of remote sensing images, adaptive filtering is introduced to process them to enhance the image features while preserving the image edges. The most commonly used filter for image smoothing is Gaussian filter. The basic idea of Gaussian filtering is to convolve the Gaussian kernel function $Gs(x, y, \sigma)$ with the original image $f_0(x, y)$ and finally get a smooth image $f_1(x, y)$.

$$f_1(x, y) = f_0(x, y) \cdot Gs(x, y, \sigma) \tag{6}$$

in equation (6):

$$Gs(x, y, s) = \frac{1}{2\pi\sigma^2} \exp\left[-\frac{1}{2\sigma^2}(x^2 + y^2)\right] \tag{7}$$

In Eq. (7): σ : Gaussian standard deviation, x : horizontal coordinate variable of the original image point, y : vertical coordinate variable of the original image point

The Gaussian filter has the desirable property that the smoothing effect of the filter can be controlled by σ, i.e., the degree of smoothing of the image can be adjusted by changing the value of the Gaussian standard deviation σ. In addition, the Gaussian filter can be obtained by convolving a series of finite-window mean filters, e.g., by using local filters with equal weights, and for a one-dimensional signal, this smoothing process can be expressed as

$$f^{(t+1)}(x)=\frac{1}{N}\sum_{i=-1}^{+1} f^{(t)}(x+i)W^{(t+1)}(x+i) \tag{8}$$

where: $f^{(0)}(x)$ - the original signal before smoothing

$f^{(t+1)}(x)$ - the signal after smoothing at the $t+1$th step iteration;

$N=\sum_{i=-1}^{+1} W^{(t)}(x+i)$ - $W^{(t)}(x)=1.0$ for any t and x.

This filter smoothes the gray values of all pixels in the image (including where the pixel gray values mutate), and does not purposely preserve the gray values of pixels where mutations occur, so the edges of the image are also smoothed out. In order to better preserve the edges of the image, we set the corresponding weight coefficients of the template $W^{(t)}(x)$ to 0.0 at the locations where the pixel gray values mutate, which avoids smoothing the pixel points at the mutation. Since the length of the filter window is finite, an appropriate choice of the filter window length will keep the two different regions separated by the mutation from being averaged. In addition, for the pixels at the mutation, the smoothing process will attribute them to their neighboring regions, and therefore, the edges of the image will be enhanced after the smoothing filter.

However, in practice, we do not know where the mutations in the gray values of the image pixels occur, and the steepness of the mutations occurring is not the same, we can not simply use a hard verdict (0.0, 1.0) to determine the weights of any point. To solve this problem, we use the calculation of discontinuities in the gray value of each pixel point in the original image to adaptively adjust the weight coefficients of the filter, i.e.

$$w^{(k)}(x)=\ddot{O}(d^{(k)}(x)) \tag{9}$$

In Eq. (9): $d^{(k)}(x)$ is a measure of discontinuity in pixel gray values

$\ddot{O}(d^{(k)}(x))$ is a monotonically decreasing function

such that $\ddot{O}(1)=0$ and $\ddot{O}(d^{(k)}(x))\to 0.0$ as $d^{(k)}(x)$ increases. Here the gradient of the pixel gray value is taken as the valuation of $d^{(k)}(x)$.

Thus $w^{(k)}(x)$ can be expressed as

$$w^{(k)}(x)=\ddot{O}(f'^{(k)}(x))=\exp\left[-\frac{|f'(x)|^2}{2h^2}\right] \tag{10}$$

In Eq. (10): $f'^{(k)}(x)$ is the first order derivative of the image gray value $f^{(k)}(x)$.

h is a constant parameter that determines the magnitude of the edges that can be preserved during the smoothing process.

When the image gray value is represented by a two-dimensional signal $f^{(k)}(x,y)$, $d^{(k)}(x,y)$ is defined as the gradient of $f^{(k)}(x,y)$ (for ease of computation, make the filter window size 3.0 × 3.0)

$$\left[\frac{\partial f^{(k)}(x,y)}{\partial x},\frac{\partial f^{(k)}(x,y)}{\partial y}\right]^T=(G_x,G_y) \tag{11}$$

Therefore, the weight coefficient $w^{(k)}(m,n)$, which reflects the continuity of the gray values of the image pixels, can be expressed as

$$w^{(k)}(x,y)=y[w^{(k)}(x,y)]=\exp\left[-\frac{(d^{(k)}(x,y))^2}{2h^2}\right] \tag{12}$$

In equation (12): $d^{(k)}(x,y)=\sqrt{G_x^2+G_y^2}$

The smooth signal $f^{(k)}(x,y)$ at the point (x,y) is defined as

$$f^{(k+1)}(x,y)=\frac{1}{N^{(k)}}\sum_{i=-1}^{+1}\sum_{j=-1}^{+1}f^{(k)}(x+i,y+j)w^{(k)}(x+i,y+j) \tag{13}$$

In equation (13): $N^{(k)}=\sum_{i=-1}^{+1}\sum_{j=-1}^{+1}w^{(k)}(x+i,y+j)$.

II. C. 2) Smoothing algorithm for adaptive filtering

Step 1: Make $k=0.0$, iteration number $K=5.0$, and set the value of parameter h ;

Step 2: Calculate the gradient $G_x(x,y)$ and $G_y(x,y)$

$$\begin{cases} G_x(x,y)=\frac{1}{2}(f(x+1,y)-f(x-1,y)) \\ G_y(x,y)=\frac{1}{2}(f(x,y+1)-f(x,y-1)) \end{cases} \tag{14}$$

Step 3: Calculate the continuity factor

$$W_y(x,y)=\exp\left(-\frac{G_x^2(x,y)+G_y^2(x,y)}{2h^2}\right) \tag{15}$$

Step 4: Perform a weighted average of $f^t(x,y)$

$$f^t(x,y)=\frac{\sum_{i=-1}^{+1}\sum_{j=-1}^{+1}f^{(t)}(x+i,y+i)W^{(t)}(x+i,y+i)}{\sum_{i=-1}^{+1}\sum_{j=-1}^{+1}W^{(t)}(x+i,y+i)} \tag{16}$$

Step 5: Is k equal to K ? If $k=K$, end the iteration; otherwise $k=k+1.0$, go to Step 2.

III. Effectiveness of rural ecological environment monitoring based on GIS and big data technology

III. A. Performance Comparison and Analysis

III. A. 1) Quantitative comparison experiments

The image processing method of the mathematical morphology adaptive filtering algorithm in this paper is compared with the image processing effect of the same type of remote sensing image processing method. In order to judge the applicability of different methods, the "ideal" remote sensing dataset and the "non-ideal" remote sensing dataset monitored by GIS were selected as experimental data, among which the monitoring data quality of the "ideal" remote sensing dataset was high, while the monitoring data quality of the "non-ideal" remote sensing dataset was low.

Table 1 shows the quantitative results of different methods on the “ideal” remote sensing dataset scale factor X3. In the comparison of the processing performance of the five datasets, the peak signal-to-noise ratios (PSNR) of this method are 49.78, 49.69, 49.75, 49.58, 49.62dB, respectively, which are the highest among the 10 methods. , indicating that the image processing quality of this paper's method is better and less noisy. Meanwhile, the structural similarity index (SSIM) of this paper's method is 0.9132, 0.9285, 0.9204, 0.9263, 0.9318, respectively, which is the only method greater than 0.9 among 10 methods. This indicates that the processed image is closer to the original image and has better quality. In the “ideal” remote sensing dataset scale factor X3, this method has better remote sensing image processing effect.

Table 1: The quantitative results on the IDEAL remote sensing dataset

Method	Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5
	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM
Bicubic	40.36/0.8585	40.55/0.8500	44.50/0.8306	40.54/0.8853	40.48/0.8540
SRCNN	43.54/0.8883	43.03/0.8805	46.04/0.8485	44.85/0.8348	44.04/0.8038
FSRCNN	43.80/0.8005	43.38/0.8846	46.45/0.8530	44.38/0.8388	44.35/0.8060
EDSR	44.50/0.8083	44.05/0.8050	45.54/0.8553	45.60/0.8480	44.86/0.8340

SRMD	44.45/0.8064	43.50/0.8008	45.40/0.8554	45.08/0.8445	44.55/0.8300
RDN	44.50/0.8088	44.08/0.8060	45.54/0.8555	45.65/0.8405	44.85/0.8348
RCAN	44.68/0.8005	44.43/0.8080	48.00/0.8583	46.04/0.8436	44.06/0.8356
SAN	44.53/0.8005	44.48/0.8085	48.08/0.8588	46.00/0.8434	44.45/0.8386
CS-NL	44.68/0.8005	44.40/0.8056	45.88/0.8588	46.06/0.8438	44.04/0.8353
Ours	49.78/0.9132	49.69/0.9285	49.75/0.9204	49.58/0.9263	49.62/0.9318

Table 2 shows the quantitative results of different methods on the scale factor X3 for the “non-ideal” remote sensing dataset. The “non-ideal” remote sensing datasets also have similar results as in the previous paper. The peak signal-to-noise ratios of this paper's method in five datasets are 40.17, 41.29, 40.61, 41.53, and 40.67 dB, which are the only ones that exceed 40 dB among the ten methods. Meanwhile, the structural similarity index of this method reaches 0.9631, 0.9483, 0.9327, 0.9152, 0.9246, which is closer to 1.0000 than the other methods, and this method also has better processing effect in the “non-ideal” remote sensing data sets.

Table 2: Quantitative results on Non-ideal remote sensing datasets

Method	Dataset 1-blur	Dataset 2-blur	Dataset 3-blur	Dataset 4-blur	Dataset 5-blur
	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM	PSNR(dB)/SSIM
Bicubic	30.24/0.7483	31.25/0.8446	30.40/0.7304	31.43/0.7843	32.35/0.6436
SRCNN	31.03/0.8713	32.41/0.8514	32.12/0.6384	35.84/0.6338	31.06/0.7038
FSRCNN	32.71/0.6012	33.71/0.7836	33.34/0.7430	33.38/0.7388	33.35/0.7042
EDSR	31.37/0.7283	32.05/0.6246	32.10/0.8643	34.40/0.8370	37.81/0.7330
SRMD	32.29/0.7162	30.61/0.8718	33.12/0.8843	34.08/0.8325	33.36/0.7301
RDN	32.32/0.7009	32.41/0.8240	33.40/0.8344	35.44/0.8206	32.71/0.6338
RCAN	32.68/0.7325	31.56/0.6680	38.01/0.8283	34.01/0.8332	30.44/0.8344
SAN	33.46/0.8207	32.71/0.6084	38.78/0.8768	35.01/0.8334	32.64/0.7384
CS-NL	33.25/0.8804	36.37/0.7045	35.89/0.8480	37.04/0.8346	33.23/0.8343
Ours	40.17/0.9631	41.29/0.9483	40.61/0.9327	41.53/0.9152	40.67/0.9246

III. A. 2) Ablation experiments

In order to verify the data preprocessing advantages of the adaptive filter processing module proposed in this paper, we replaced the adaptive filter processing module with the traditional data processing module and conducted experiments on Dataset 1, Dataset 2, Dataset 1-blur, and Dataset 2-blur datasets and compared them quantitatively with mathematical morphology. Table 3 shows the results of the experiments. The peak signal-to-noise ratios of the proposed adaptive filtering processing module are all over 40 dB and the structural similarity indices are all over 0.9 on the 2 types of datasets. In contrast, the peak signal-to-noise ratio of the traditional data processing model is between 30-40 dB, with a maximum of 36.77 dB, and the structural similarity index is between 0.6-0.9, with a maximum of 0.8761. From the 2 evaluation indexes, compared with the traditional data processing module, the proposed adaptive filtering and processing module is more conducive to the learning of the internal features of the remotely sensed image, improves the resolution of the remotely sensed image, and It can provide more accurate visualization images for the subsequent environmental regulation.

Table 3: Quantitative comparison results

Method	Proportion	Dataset 1	Dataset 2	Dataset 1-blur	Dataset 2-blur
		PSNR(dB)/ SSIM	PSNR(dB)/ SSIM	PSNR(dB)/ SSIM	PSNR(dB)/ SSIM
+AF	X3	41.36/0.9712	42.64/0.9213	40.45/0.9547	41.87/0.9254
+Traditional data processing	X3	33.46/0.7402	33.23/0.8761	34.46/0.8364	36.56/0.7612
+AF	X6	40.86/0.9035	41.43/0.9783	42.26/0.9156	41.33/0.9038
+Traditional data processing	X6	36.77/0.7127	36.63/0.6231	36.36/0.7764	36.44/0.6149

III. B. Monitoring of rural ecosystems

III. B. 1) Summary of rural household waste surveys

The method of this paper is applied to the monitoring of rural domestic waste in 10 counties of city A. The current status of rural domestic waste is obtained through GIS components, and the image processing is realized by using adaptive filtering processing methods, etc. Except for a few villages with simple centralized garbage collection and treatment (landfill and incineration) for the implementation of the new rural construction in the region of city A, the majority of the villages in the remaining area have no garbage treatment facilities, and the domestic waste is discharged everywhere and directly discharged as much as produced. The majority of villages have no garbage treatment facilities, and domestic garbage is discharged everywhere, directly discharging as much as it generates. Table 4 shows the amount of domestic garbage generated and discharged in the rural areas of City A. The emission coefficients of domestic garbage in the rural areas of City A range from 0.601 to 0.894 Kg/d per capita, and the average emission coefficient is 0.691 Kg/d per capita, which is a large amount of emission and requires external environmental supervision.

Table 4: The amount of rural domestic waste generated in City A

County	Rural population (ten thousand)	Amount of domestic waste generated (Kg/ person · day)	Domestic waste discharge volume (Kg/ person · day)	Total amount of domestic waste generated (tons/year)
County A	97.757	0.894	0.894	31349
County B	71.321	0.601	0.601	15502
County C	75.084	0.718	0.718	19419
County D	33.270	0.644	0.644	7645
County E	16.293	0.667	0.667	3836
County F	22.686	0.683	0.683	5701
County G	29.712	0.736	0.736	8290
County H	24.823	0.738	0.738	6681
County I	73.874	0.661	0.661	18056
County J	96.426	0.855	0.855	29799
Total	521.42	6.91	6.91	151477

III. B. 2) Domestic waste generation and emissions

The average value of rural domestic waste generation coefficients of 10 counties and districts in A city obtained by GIS monitoring can be used to project the rural domestic waste generation of the remaining 5 counties and districts in the lake area of A city according to the existing data after image processing, so as to get the total amount of domestic waste generation in A city and the lake area in 2024. Figure 1 shows the 2024 domestic waste generation emissions in City A. The total amount of domestic waste generated in City A and the lake area is 15.1477×10^4t and 4.5876×10^4t, respectively (all of the above excludes the amount of construction waste in towns and cities, etc., that is transferred to the countryside). Considering that the proportion of rural resident population is 75%, it is estimated that the actual amount of rural domestic waste generated may be lower. Generally, households with a high standard of living have a relatively high amount of domestic waste, but the correlation between the two is not obvious. Targeted analyses will be required for the actual monitoring process.

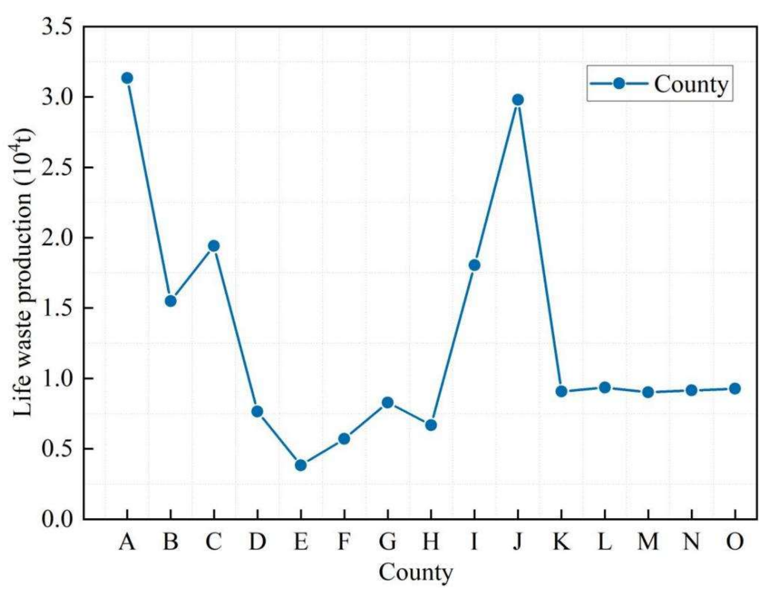

Figure 1: Amount of domestic waste generated in City A in 2024

III. B. 3) Compostable waste N and P generation content

Based on the results of image data processing, the pollutant content of rural domestic waste was analyzed. Figure 2 shows the rural compostable waste TN and TP generation in A. More than 50% of compostable waste (i.e., organic waste) in the domestic waste in A. 80% of the N amount and P content of the contributable domestic waste is equal to other waste, based on which, the generation of compostable waste N and P can be measured for each county and district of A. In 2024, the generation of compostable waste TN and TP in the rural domestic waste in A is respectively 30.3492*10^3t and 6.0575*10^3t, of which, the largest amount of generation is in county B. From this, it can be judged that the monitoring of the current situation of rural ecological environment can be accomplished by using GIS technology and data processing techniques such as adaptive filtering.

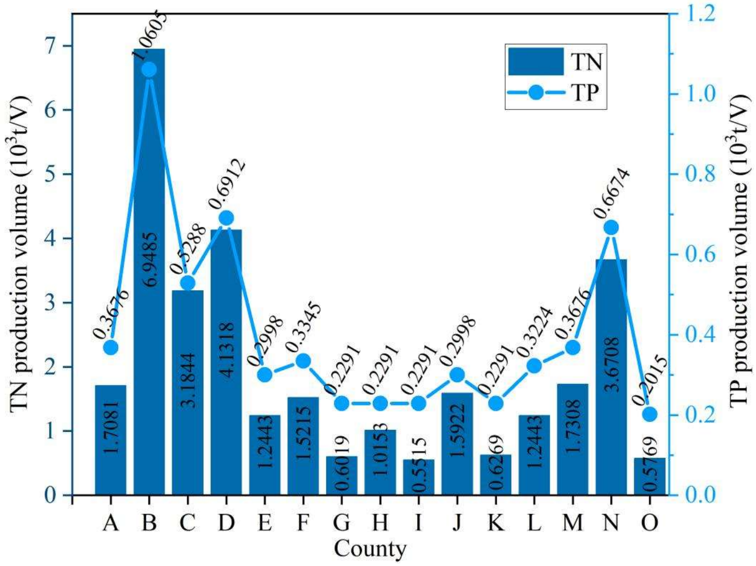

Figure 2: Generation volume of TN and TP compostable waste in rural areas

IV. Optimization of rural ecological environment legal system construction with GIS technical support

Geographic Information System (GIS) can analyze and process the whole or part of the spatial information, and provide technical support for the ecological environment construction work in environmental management, environmental monitoring, environmental planning and other aspects. Based on GIS and big data technology, this paper analyzes the current situation of rural ecological environmental protection in A city, and gives optimization suggestions on the current situation and problems of rural ecological environmental protection in A city from the legal perspective.

(1) Formulate a multi-local integrated environmental protection plan, and extend the ecological and environmental legal system of A city area to the neighboring areas. From the previous GIS analysis, it can be seen that A city area covers an extremely wide area, and some regions with water and soil resource problems will eventually affect the whole A city area due to ecological and meteorological factors. Therefore, relying solely on the local government to formulate a perfect and comprehensive system of laws and regulations is obviously not able to fully safeguard the rural ecological environment from the perspective of City A as a whole.

(2) Give full play to and implement the mandatory constraints of laws and regulations: the environmental protection infrastructure in the rural areas of City A is very weak, and the lack of a legal regulatory system around the rural ecological environment in City A is also very common; to optimize the legal system for the rural ecological environment in City A, it is necessary to give full play to and implement the mandatory constraints of ecological environmental laws and regulations in City A, so as to provide a more feasible legal system in Based on the synergistic development of local agriculture and other industries in A city, the low-cost and high-efficiency ecological environment management model of rural areas in A city will be implemented.

(3) Grasp the opportunity of national financial policy to increase the subsidy for environmental protection in rural areas of A city. Organic agriculture, sustainable agriculture and other industries that are conducive to the construction of ecological environment should be subsidized through laws, regulations and other measures in the

agricultural industry of A city. By cooperating with the national fiscal policy on eco-agriculture construction, increase the investment in the field of eco-environmental protection in the provinces of A city. For example, improve the subsidies for reducing the agricultural use of chemical fertilizers, the sustainable recycling of straw and poultry manure, and other regulations and policies as well as subsidy measures, and optimize the assessment mechanism for rural ecological environmental protection in A city area.

(4) Strengthen the role of rural residents in ecological environmental protection in City A, and implement a bottom-up supervision system. The right to participate in environmental protection is an important guarantee for rural residents to participate in ecological environmental protection. In the development of ecological environmental protection and the implementation of laws and regulations in A city area, the recognition and support of local rural residents for environmental protection policies is the key to determining whether environmental protection laws and regulations can be implemented in place. Therefore, in the future legal system of ecological environmental protection for rural residents in City A, the role of local farmers as the main body of ecological environmental protection should be continuously strengthened, and farmers should be the most basic implementers and supervisors of environmental protection policies, so as to promote the democratization of ecological environment protection in City A.

V. Conclusion

This paper monitors the current status of rural ecological protection through GIS and data technologies such as mathematical morphology and adaptive filtering algorithms, and proposes suggestions for optimizing the safeguard system of environmental laws. The peak signal-to-noise ratios of this paper's method in the “ideal” remote sensing dataset are 49.78, 49.69, 49.75, 49.58, 49.62 dB, and the structural similarity indices are 0.9132, 0.9285, 0.9204, 0.9263, 0.9318, respectively. The peak signal-to-noise ratio of this paper's method is also greater than 40 dB and the structural similarity index is close to 1, which is better than that of the comparison method in the “non-ideal” remote sensing dataset and the ablation experiments. Combining the methods of this paper, it can be found that the generation of compostable waste TN and TP in rural domestic waste reaches $30.3492*10^3$t and $6.0575*10^3$t in 2024, and according to this, four optimization suggestions of rural ecological environment and legal system are given. In the future, it is necessary to further optimize the remote sensing image processing capability of the adaptive filtering algorithm to improve the refinement level of monitoring.

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