



Evaluation algorithm of alhagi sparsifolia desertification control under different irrigation amounts

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ABSTRACT

Desertification control is an important issue that must be considered in modern society. In order to effectively improve the accuracy and practicability of the evaluation algorithm of desertification control effect, the Alhagi sparsifolia index under different irrigation amount was taken as the research object, and the evaluation algorithm of desertification control effect was proposed. In the “vegetation-sandstorm-soil” index system, a number of indexes were selected according to the core environmental parameters of Alhagi sparsifolia and grassland desertification. And the analytic hierarchy process, remote sensing, geographic information system, and landscape technology were used to assign index weights of desertification control capacity, which were calculated by multiple discriminant matrices. Finally, the data regression analysis was performed based on remote sensing and computer image information screening and processing to determine the final evaluation results. The experimental data show that the true positive rate of the algorithm in this paper is between 160 and 200, which is within a large range of advantages, indicating that the overall evaluation accuracy of the algorithm is high and the evaluation effect is perfect.

Keywords: Irrigation amount; Alhagi sparsifolia; Desertification; Control; Regression analysis.

Algoritmo de evaluación para el control de la desertificación del alhagi sparsifolia bajo diferentes cantidades de riego

RESUMEN

El control de la desertificación es un tema importante que debe considerarse en la sociedad moderna. Con el fin de mejorar efectivamente la precisión y la viabilidad de un algoritmo de evaluación del efecto de control de la desertificación se tomó como objeto de investigación el índice del alhagi sparsifolia con diferentes cantidades de riego. En el sistema de índices “vegetación-tormenta de arena-suelo” se seleccionaron varios índices de acuerdo con los parámetros ambientales básicos del alhagi sparsifolia y la desertificación de los pastizales. Se utilizó el proceso de jerarquía analítica, la teledetección, el sistema de información geográfica y la tecnología del paisaje para asignar los índices de ponderación de la capacidad de control de la desertificación, los cuales se calcularon mediante matrices discriminantes múltiples. Finalmente, el análisis de regresión de datos se realizó con base en la detección y el procesamiento de información de imágenes de computadora y detección remota para determinar los resultados finales de la evaluación. Los datos experimentales muestran que la tasa de verdaderos positivos del algoritmo en este artículo está entre 160 y 200, lo que se encuentra dentro de una amplia gama de ventajas y que indica que la precisión de evaluación general del algoritmo es alta y el efecto de evaluación es perfecto.

Palabras clave: Cantidad de riego; alhagi sparsifolia; desertificación; análisis de regresión.

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Introduction

In 1977, the United Nations Conference on Desertification defined desertification as a situation in which the biological potential of the land is reduced or destructed and ultimately leads to a desert-like landscape. This definition has been widely accepted and applied over the past two decades (Lan et al., 2018). In 1991, aiming at the definition in 1997, the United Nations Environment Program did not mention the possible areas of desertification and their causes. According to the latest research results, desertification was redefined as a land degradation process caused by human adverse effects in arid, semi-arid, dry, and semi-humid areas. Throughout the definition and research of desertification in foreign countries, the concept of desertification is extensive (Qiang et al., 2018), including vegetation degradation, water erosion, salinization, reduction of soil organic matter, soil crusts, and tightening, and accumulation of toxic substances. These are the concepts of generalized desertification, which is essentially land degradation. From the reality of our country, the concept of desertification has also been proposed in China, only referring to the process of wind erosion in generalized desertification. There are three main definitions. The first is the definition proposed by Wu Zheng: in arid, semi-arid, and partially semi-humid areas, due to natural factors or human activities, the fragile balance of the natural ecosystem is destroyed. In this non-desert region, there are environmental changes in desert-like landscapes characterized by sandstorms, and desert environmental conditions in desert areas are strengthened and expanded. The second is the definition of Zhu Zhenda: On a certain sandy material basis and under the conditions of drought and strong winds, an environment or land degradation process with windstorm as the main symbol due to excessive human activities inconsistent with resource and environment. This definition of desertification aims at the period of human history. It mainly appears in arid, semi-arid and partially semi-humid areas and excessive economic activities are the main factors in the cause. Based on the concept of desertification in the United Nations, the third definition was proposed by Dong Yuxiang: A land degradation process characterized by windstorms in arid, semi-arid and semi-humid areas, and it is caused by climate change and human activities. This definition takes into account the human and natural factors (Zhao et al., 2019; Kang, 2018).

The most serious desertification in land resources is grassland. Grassland desertification is a special type of grassland degradation, which refers to land degradation caused by unbalanced human-land relationships in arid, semi-arid, and semi-humid grassland areas. It is one of the extreme manifestations of grassland ecosystem degradation. Grassland desertification, vegetation degradation, and surface exposure will intensify wind erosion and wind accumulation, which will cause continuous deterioration of the environment and a series of socio-economic problems. Therefore, the restoration and reconstruction of degraded grassland ecosystems have received increasing attention. Most of the grasslands in northern China are in arid and semi-arid climates, and the ecological environment has a very limited anti-interference ability. In the mid-1970s, the area of degraded grasslands in the country accounted for about 15% of the total grassland area. By the mid-1980s, it had increased to more than 30%. In the mid-1990s, it reached more than 50%, which had increased to 90% by the beginning of the 21st century. Grassland productivity is declining and the grassland ecological environment is rapidly deteriorating (Peng et al., 2018). Therefore, the continuous increase of desertification of grassland has seriously affected the ecological environment construction, social and economic development of grassland areas in China, and caused great harm. In order to effectively curb the trend of grassland desertification, the state has launched a series of grassland desertification control projects, aiming at increasing the vegetation coverage, preventing sand and stopping desertification, and improving the grassland environment. Especially since 2000, a series of large-scale grassland vegetation restoration and reconstruction ecological projects and scientific research (Wei, 2017) has been launched.

Alhagi sparsifolia belongs to Leguminosae sp, alhagi ganeb. It is a perennial semi-herb plant, mainly distributed in Xinjiang, Gansu, Inner Mongolia, China, and the former Soviet Union, Iran, Afghanistan, Pakistan, and India. Alhagi sparsifolia is one of the representative shrub vegetation species in the arid area of Xinjiang, China, with a total area of 1.7 million hectares. It is important for sand-fixing vegetation and plays an important role in maintaining the local ecological environment. At present, grassland desertification control

through alhagi sparsifolia is a common method in the world. In order to further study the effect of desert control, it is necessary to combine the natural characteristics of alhagi sparsifolia and construct an evaluation system of desertification control effect according to its natural growth ability under different irrigation amounts.

Material and Methods

Evaluation algorithm for desertification control of alhagi sparsifolia under different irrigation amount

In this paper, the index system of "Alhagi sparsifolia vegetation-sandstorm activity- Alhagi sparsifolia soil" was adopted. According to the difference of irrigation amount, the vegetation coverage, aboveground biomass, grass height, plant species, annual plant proportion, fixed sand proportion, fixed sand fragmentation, mobile sand proportion, mobile sand fragmentation, soil erosion modulus, soil organic matter, soil mechanical composition, soil crust and other indicators were selected with the analytic hierarchy process to construct the ecological benefit evaluation index system of grassland desertification control project (Meng et al., 2018).

Through the ground surveys, data on alhagi sparsifolia status and soil were obtained, and GPS handheld terminals were used as an aid to locate and measure ground survey points (Qiang et al., 2017). According to the meteorological data, the administrative zone map, the grassland type map, the topographic map of the study area, the knowledge of the Alhagi sparsifolia, and the images obtained by the Landsat 5 sensor and the Landsat 7 sensor, the vegetation coverage, the aboveground biomass, the vegetation height, the change of plant species number of the Alhagi sparsifolia are obtained inside and outside the project. In addition, the proportion of fixed and mobile sand, the change of fragmentation degree of fixed and mobile sand landscape before and after the implementation of the project can be analyzed to realize a quick and comprehensive evaluation of the ecological benefits of a grassland desertification control project. The overall process is as follows:

The ecological benefit evaluation system of alhagi sparsifolia desertification control

The grassland desertification control project mainly refers to the various measures in favor of the growth of Alhagi sparsifolia or adjusting the land use structure. Through the project, the vegetation on the desertification grassland gradually recovers, the sandstorm gradually disappears, the surface is stable, the crust is formed, and the soil is reconstructed after that. All these make great ecological and economic benefits. The ecological benefits of the grassland desertification control project refer to the protection and improvement of the natural environment, human life, and production environment after the implementation of the ecological environment construction projects. The eco-efficiency index is a kind of indicator that reflects the improvement of the environment, including indexes of improving the soil, preventing wind and sand, controlling soil erosion, regulating climate, conserving water sources, reducing disasters, and improving ecological environment conditions under the influence of Alhagi sparsifolia. In this paper, the irrigation amount was taken as the core variable, so the vegetation coverage growth rate, grassland productivity, plant species, desertification land area, and soil organic matter content changed with it. The basis of ecological benefit evaluation under the influence of different irrigation amounts is the evaluation index and its system. Even the national conditions, industry, and engineering construction properties are the determinants of the construction evaluation index system and evaluation index. At present, there is no uniform scope and standard at home and abroad. Therefore, it is necessary to establish a practical, reasonable, and operable ecological benefit evaluation index system for the grassland desertification control project (Yang et al., 2017).

Principles of index selection

(1) Principle of geographical regional differences

Grassland desertification in China is mainly distributed in sub-humid arid, semi-arid, and arid regions. There are significant differences in vegetation

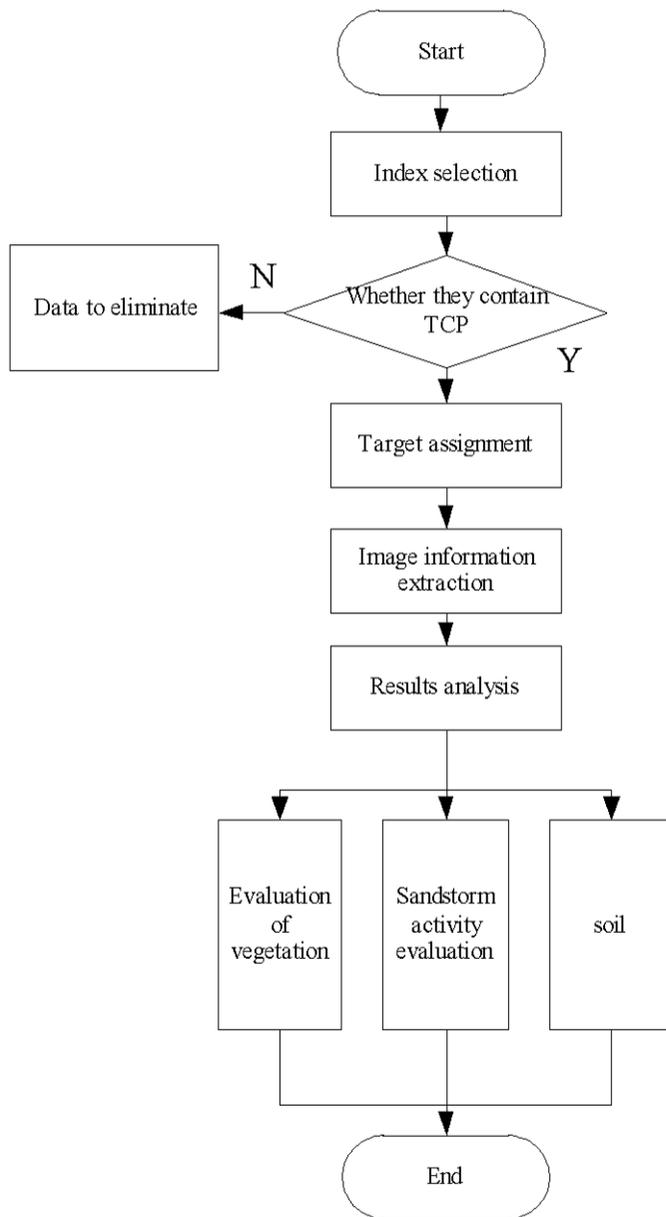


Figure 1. Process of control evaluation

types and structural characteristics in different regions. Due to the influence of the natural environment, climate, and natural vegetation growth, the project measures adopted have significant differences. There are also significant differences in vegetation restoration ability and natural vegetation coverage in different regions. Therefore, in order to reasonably evaluate the grassland desertification control project, the ecological benefit index should be determined according to the actual situation of the study area.

(2) Principle of dominant index

The purpose of the Alhagi sparsifolia grassland desertification control project is to control or reduce grassland desertification. Because there are many factors affecting the ecological benefit index of the grassland desertification control project, when determining the specific index, it is necessary to combine the actual situation and select the core factors that can express the degree of grassland desertification control as the dominant index. The so-called core factors refer to the ones that control the wind erosion on the grassland, the formation of sandstorms, and the surface exposure. According to the research results and actual application, the dominant factor is vegetation change.

(3) Principle of specific indicator operability

The ecological benefit index should reflect the environmental benefits brought by the grassland desertification control project in a comprehensive and systematic way. The indexes to be evaluated should be easy to obtain and to be processed. The original data should be easy to obtain through surveys, statistics, remote sensing, and other means, and be easy to be processed through quantitative calculation. They should also have clear realistic meaning.

(4) The irreplaceable principle of a specific index

There are many indexes for evaluating the ecological benefits of the grassland desertification control project. Most of the indexes have a certain correlation and mutual transmission. Therefore, when determining specific indexes, it is necessary to avoid the related indexes caused by the dominant factors. The determined indexes can make a scientific and reasonable evaluation of the construction effect of the project, and the indexes are irreplaceable (Zhang et al., 2018).

(5) Cross-scale principle

The development and application of remote sensing, geographic information systems, and GPS technology have greatly broadened the research horizons of people; on the other hand, it also poses certain challenges to conventional work programs based on ground surveys. Since there are differences between the ground survey and remote sensing, geographic information system, and GPS in workflow and requirements, it is likely that different research conclusions will occur. Researchers in the same area have found conflicting results only because different research methods are not expected. Therefore, when selecting evaluation indexes, cross-scale indexes that can be compatible with different research methods to avoid the above problems should be selected.

Evaluation indexes and their meanings

The grassland desertification control project can be similarly regarded as the reverse process of grassland degradation. The process is first reflected in the change of the composition of Alhagi sparsifolia vegetation, and then the change of soil properties. Alhagi sparsifolia vegetation restoration and soil restoration are interaction processes that reflect the nature of overall environment restoration. These two processes are sometimes consistent in time, and sometimes there is a certain hysteresis. That is, vegetation restoration and soil restoration occur simultaneously or vegetation is restored first, and soil restoration is only manifested after a certain period of time. An important factor associated with grassland degradation or restoration is sandstorms. According to the above principle of index selection, the ecological benefit evaluation of the grassland desertification control project is mainline. The three indicators, vegetation, soil, and sandstorms, that reflect the ecological benefits of the grassland desertification control project are selected as the criterion layers. The influencing factors related to project construction and ecological benefits are selected to form an index system. A comprehensive analysis is performed on the index system, compared with other ecological benefit evaluation index systems, and some indexes were removed according to the scientific, practical, and measurable requirements, and the ecological benefits they will bring. The ecological benefit evaluation index system of the grassland desertification control project was initially determined (Zhang et al., 2018). The framework of the ecological benefit evaluation index system is shown in Figure 2.

The role of alhagi sparsifolia vegetation is the most important. Alhagi sparsifolia vegetation is not only a comprehensive reflection of the quality of the project land, but also the most ideal protector of the soil, and also the main body of the ecosystem. The vegetation index mainly refers to the ones describing the shape and productivity of alhagi sparsifolia, such as the community composition, life form, biomass, and its coverage. Undoubtedly, most camel thorn vegetation indexes can be obtained through ground surveys. However, some indexes that characterize vegetation productivity, such as alhagi sparsifolia coverage and biomass, have been quantitatively extracted by remote sensing data. Although there are some differences in the data obtained at different scales, these indexes are clearly cross-scale. This paper selects four vegetation indexes that are operable and can directly reflect the ecological benefits of Alhagi sparsifolia in the desertification control project. They are the

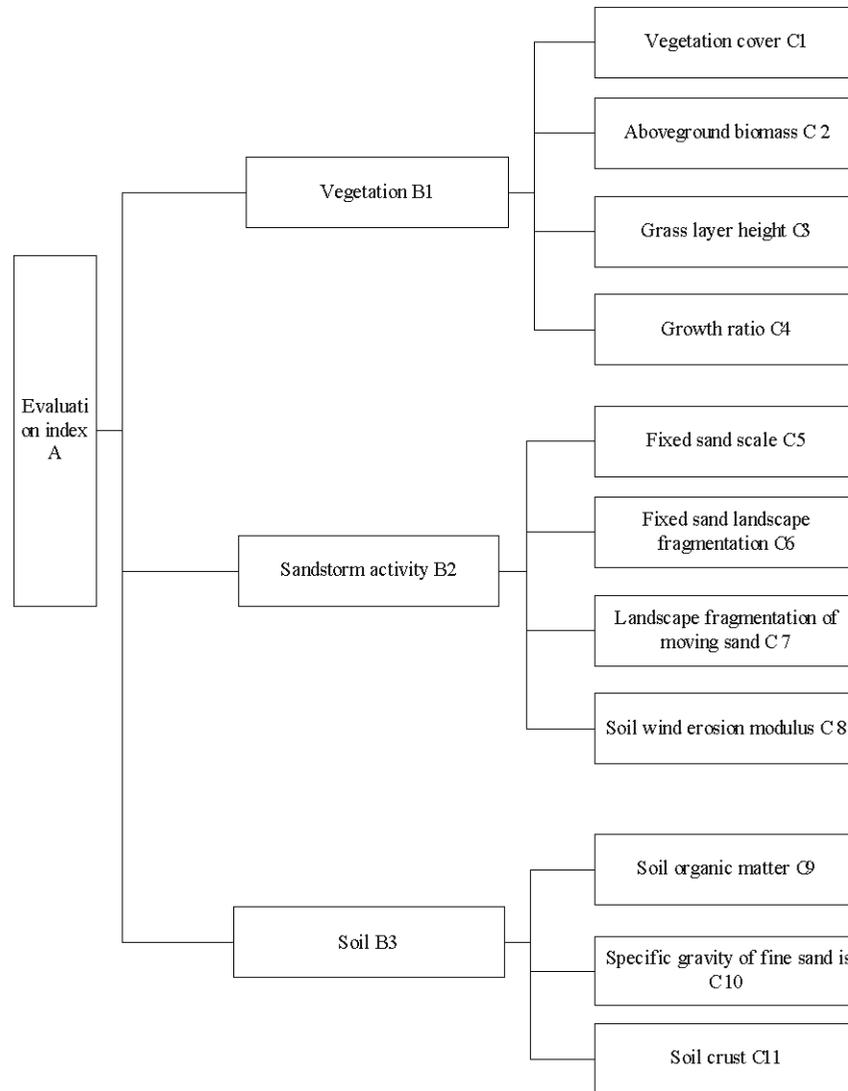


Figure 2. Index system

coverage of the *Alhagi sparsifolia*, the aboveground biomass, the height of the grass layer, and the proportion of annual plants (Guan et al., 2018).

(1) *Alhagi sparsifolia* vegetation coverage refers to the ratio percentage of the vertical projection area to the sampling area of the total *Alhagi sparsifolia* community. Coverage is the most critical factor in vegetation, and it reflects the degree of vegetation and the size of the photosynthesis area. It is also the main factor affecting soil erosion, which is of great significance for environmental change and monitoring research in the control area.

(2) Aboveground biomass: The total weight (fresh or dry weight) of one aboveground plant (or all plants) per unit area, which is the quantitative index of forage growth. Aboveground biomass indicates the growth rate and regenerative capacity of pasture. In general, for the same plant community, the amount of above-ground biomass can indicate the size of the coverage and leaf area, and can also indicate the ability of photosynthesis.

(3) Grass height: The grass height in nature can reflect the production status of the pasture, and has a great relationship with the utilization mode. The natural state of the grassland plants was maintained during the measurement, and the average height of the grass layer was measured (Ajaj et al., 2017).

(4) Proportion of annual plants: The percentage of annual plant coverage of total plant coverage. The proportion of annual plants can reflect the stability of plant communities. When the proportion of annual plants is small, the stability of the community is good; otherwise, the community is unstable. Wind erosion

is the loss process of surface materials under the action of wind. It is the beginning of the sandstorm and desertification process. The sub-processes in the desertification process are directly or indirectly generated by wind erosion. Wind erosion is one of the most important causes of grassland desertification. After desertification, the grassland is dominated by bare sand, and the floating sand, semi-fixed sand, and fixed sand are randomly distributed among them. Therefore, the proportion of fixed sand, mobile sand, and the size of wind erosion modulus are significant indicators for evaluating the effects of grassland desertification control projects. In addition, this paper introduces the landscape fragmentation, a landscape analysis index, to quantitatively study the dynamic characteristics of mobile sand and fixed sand in the study area.

(1) Proportion of fixed sand: The percentage of fixed sand area in the total project land area. The larger the proportion of fixed sand, the better the recovery of the project area.

(2) Proportion of mobile sand land: The percentage of mobile sand area in the total project land area. The smaller the proportion of mobile sand, the better the recovery of the project area.

(3) Soil wind erosion modulus: the amount of wind erosion per square kilometer per year, and its common unit is $T/KM2*A$. The soil wind erosion modulus value visually reflects the degree of wind erosion in the soil.

(4) Fragmentation: Landscape fragmentation refers to the process of landscape plaques from simple to complex due to disturbances of natural or human factors, that is, the process of the landscape from single homogeneous to

complex heterogeneity. The total number of plaques, the number of plaques per unit area, the plaque area per unit area, and the boundary density are commonly used indicators to reflect the characteristics of landscape fragmentation. Landscape fragmentation indicates that the landscape shape is fragmented, enhances the edge effect of the landscape, and reduces the total area of a certain type of landscape and the core area of each plaque. The soil is composed of four parts: minerals, organic matter, soil moisture, and soil air (Tang et al. 2018). Soil indexes are mainly indexes that describe the physical, chemical, and biological characteristics of the soil, such as soil thickness, soil texture, mechanical composition, structure, nutritional status, organic matter content, profile characteristics, salt content, salt type, soil microbial status. These indexes are mostly ground surveys or analytical assay indexes. Although quantitative data on soil indexes through microwave remote sensing can be achieved in scientific research, it is costly and far from reaching the application stage.

Soil is one of the necessary conditions for vegetation growth. Three main indexes that reflect the environmental characteristics of vegetation were selected to characterize the effect of the grassland desertification control project to restore the soil. They are soil organic matter, soil mechanical composition, and soil crust.

(1) Soil organic matter: Soil organic matter content is one of the most important indicators of soil properties. It indicates various nutrients contents in the soil, especially nitrogen and phosphorus, and represents the potential capacity and stability of soil fertility. It is the key factor in the health of the soil. The soil sample was taken back to the laboratory for analysis to determine the organic matter content (g/kg) in the soil.

The content of soil organic matter is an important index of soil fertility. Organic matter also plays an important role in the physical and chemical properties of the soil. For example, soil organic matter can improve the physical structure and chemical properties of the soil, which is conducive to the formation of soil aggregate structure, promotion of nutrient absorption, and growth of plants.

(2) Soil mechanical composition: Soil is composed of different sizes of soil particles in different proportions. These different grain sizes are mixed together to characterize the soil thickness, which is called soil mechanical composition or soil texture. It affects the soil moisture, air, and heat movement, and also affects the conversion of nutrients and the type of soil structure. The mechanical component is a stable natural property of soil, which determines the behavior and use of soil to a large extent, and is one of the basic materials necessary for studying soil wind erosion. The aluminum box was used to take the surface sand sample for indoor analysis, and the fine sand proportion is one evaluation index.

(3) Soil crust: The crust is a thin layer formed along with the fixation of sandy land, the accumulation of organic matter on the surface of the soil, and the growth of lower plants. Soil crust is an important indicator of surface wind erosion and stationary status (Dai et al., 2017).

A clear indicator of the restoration of sandy vegetation communities is the degree of surface fixation. The better the restoration of sandy vegetation, the higher the degree of sandy land fixation. The visual index reflecting the degree of surface fixation is the thickness of the surface crust of sandy land. According to research, the crust material is mainly a mixture of fine particles (fine sand and ultrafine sand accounted for 93), salts, and amorphous silicon gel. It has strong wind erosion resistance and can resist wind with a speed of 30 m/s. However, if the crust is too thick, it will also inhibit the growth of sandy plants. For some regular fixed sands, the crust is too thick, affecting water infiltration, and the soil moisture condition is deteriorated, which will lead to poor plant regeneration.

Index weight calculation

The weight determination of each evaluation index plays an important role in the comprehensive evaluation of the control effect of Alhagi sparsifolia. The weight of the evaluation is very important for the final evaluation result, which reflects the relative importance of each index. In the vertical direction, it reflects the effect of index variety on the change of comprehensive ecological benefit. In the horizontal direction, it indicates the position of the index in the same evaluation index level. Whether the weight is determined reasonably will directly affect the judgment results (Sherratt & Synodinos, 2017). The analytic hierarchy process was used to construct an analytic model and determine the

index weights. As a basic evaluation method, the Analytic Hierarchy Process (AHP) plays an extremely important role in multi-objective decision-making problems. It also has extremely high using frequency. To analyze problems with AHP, the problems should be organized and leveled first to construct a structural model of hierarchical analysis. The hierarchical analysis structure model usually consists of three layers. There is only one element in the highest layer, which is generally the target or ideal result of the analysis problem, so it is also called the target layer. The middle layer includes the intermediate links to achieve the goal. It can be composed of several layers, including the rule and sub-rule that need to be considered, so it is also referred to as the rule layer. The index layer is below the rule layer (Rosen et al., 2019).

Table 1. The ecological benefit evaluation system of Alhagi sparsifolia in the desertification control project

A target layer	Rule layer B	Index layer C
Ecological benefits	vegetation	Vegetation coverage
		Aboveground biomass
		Grass layer height
		Growth rate
	Sandstorm activities	Fixed sand scale
		Fixed sand landscape broken
		Moving sand landscape broken
	soil	Soil wind erosion modulus
		Soil organic matter
		The proportion of fine sand
Soil crust		

According to the current data in Table 1, a hierarchical judgment matrix was constructed. The judgment matrix indicates the relative importance of the elements in this hierarchy to elements in the previous one. A comparison judgment matrix was constructed by comparing the relative importance of the element in two neighboring hierarchies. Based on the scale of 1-9 and its reciprocity as the measurement scale, Saaty proposed the corresponding judgment matrix. The scale is shown in Table 2.

Table 2. The scale of judgment matrix factor

scale	meaning
1	Meaning that the two factors are equally important
3	Represents two factors, the former is slightly more important than the latter
5	Compared with the two factors, the former is significantly more important than the latter
7	Indicating that the former is more important than the latter in terms of the two factors
9	Represents two factors, the former is more important than the latter
2468	Represents the middle digit of the adjacent judgment of 1, 3, 5, 7 and 9
The derivative of the above value	Indicates the degree to which two factors are more important than the latter

According to the scale standard in Table 2, the corresponding matrix is formed, and the judgment matrix of the ecological benefit evaluation factor of the grassland desertification control project is compiled as follows:

$$A-B = \begin{bmatrix} 1 & 3 & 5 \\ \frac{1}{3} & 1 & 3 \\ \frac{1}{5} & \frac{1}{3} & 1 \end{bmatrix} \quad (1)$$

$$B_1-C = \begin{bmatrix} 1 & 2 & 3 & 2 & 2 \\ \frac{1}{2} & 1 & 2 & 2 & 2 \\ \frac{1}{3} & \frac{1}{3} & 1 & \frac{1}{3} & \frac{1}{3} \\ \frac{1}{2} & \frac{1}{2} & 2 & 1 & 1 \\ \frac{1}{2} & \frac{1}{2} & 2 & 1 & 1 \end{bmatrix} \quad (2)$$

$$B_2-C = \begin{bmatrix} 1 & 3 & 2 & 3 & 3 \\ \frac{1}{3} & 1 & \frac{1}{2} & 1 & 1 \\ \frac{1}{2} & \frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{3} & 1 & 2 & 1 & 1 \\ 1 & \frac{1}{2} & 2 & 1 & 1 \end{bmatrix} \quad (3)$$

$$B_3-C = \begin{bmatrix} 1 & 3 & 2 \\ \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{2} & 2 & 1 \end{bmatrix} \quad (4)$$

There are three kinds of judgment matrix calculation methods: arithmetic mean method, geometric mean method, and maximum eigenvalue method. The geometric mean method was used in this paper. For example, the relative importance coefficient for problem A is estimated based on the A-B judgment matrix. Calculate the square root of the product of all elements in each row of the judgment matrix.

$$\bar{W}_i = n \sqrt[n]{\prod_{j=1}^n \alpha_{ij}} \quad (5)$$

\bar{W}_i can be normalized according to formula (5) to obtain normalized weight.

Because the judgment matrix needs to be fuzzy quantized based on empirical data, it is impossible to achieve complete consistency. A concept of random consistency ratio was proposed based on this, and its unit is CR. When the CR is less than 0.1, the consistency is considered to be satisfied; otherwise, the matrix needs to be re-adjusted. The CR calculating formula is as follows:

$$CR = \frac{CI}{RI} \quad (6)$$

Where C indicates the consistency index, RI is the proportional coefficient, which is related to the order of the judgment matrix n .

In this situation, CI can be expressed as:

$$CI = \frac{(\lambda_{\max} - n)}{n - 1} \quad (7)$$

Table 3. Random consistency proportion coefficient

Order number	1	2	3	4	5	6	7	8	9
The values	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Where λ_{\max} represents the maximum eigenvalue of the matrix, and the judgment results are as follows:

Table 4. A-B evaluation matrix

A	B1	B2	B3	\bar{W}_i	W_i
B1	1	3	5	2.466	0.673
B2	$\frac{1}{3}$	1	3	1	0.258
B3	$\frac{1}{5}$	$\frac{1}{3}$	1	0.405	0.105
Σ					1

Table 5. B1-C judgment matrix

B1	C1	C2	C3	C4	C5	\bar{W}_i	W_i
C1	1	2	3	2	2	1.888	0.345
C2	$\frac{1}{2}$	1	3	2	2	1.458	0.258
C3	$\frac{1}{3}$	$\frac{1}{3}$	1	$\frac{1}{2}$	$\frac{1}{2}$	0.858	0.087
C4	$\frac{1}{3}$	$\frac{1}{3}$	1	$\frac{1}{2}$	$\frac{1}{2}$	0.455	0.157
C5	$\frac{1}{2}$	$\frac{1}{2}$	2	1	1	0.870	0.157
Σ							1

Table 6. B2-C judgment matrix

B2	C6	C7	C8	C9	C10	\bar{W}_i	W_i
C6	1	2	3	2	2	1.888	0.345
C7	$\frac{1}{3}$	1	3	2	2	1.458	0.258
C8	$\frac{1}{2}$	$\frac{1}{3}$	1	$\frac{1}{2}$	2	0.858	0.087
C9	$\frac{1}{2}$	$\frac{1}{3}$	1	$\frac{1}{2}$	2	0.455	0.157
C10	$\frac{1}{2}$	$\frac{1}{2}$	2	$\frac{1}{2}$	1	0.870	0.157
Σ							1

Using the results of a single ranking of all hierarchies, the relative importance weights of all elements in this hierarchy were calculated compared to the previous one, which is the total ranking of hierarchies. The calculation needs to be performed hierarchy by hierarchy from top to bottom. For the second hierarchy below the highest one, the hierarchical single order is the total order. According to the consistency test, the CR values of the hierarchical single order and the hierarchical total order are both less than 0.10.

Table 7. B3-C judgment matrix

B3	C11	C12	C13	\bar{w}_i	w_i
C11	1	3	2	1.888	0.345
C12	$\frac{1}{3}$	1	2	1.458	0.258
C13	$\frac{1}{2}$	2	2	0.858	0.087
Σ			2	0.858	0.087

Camelthorn index extraction and treatment evaluation

Analysis of information source data

The ecological benefit evaluation system of Alhagi sparsifolia desertification control and calculation results of its index weights were processed through the ArcGIS9.0 software. The software made a project distribution map by introducing surface attributes to the inflection point coordinates of the project and defining projections. The processing of remote sensing data was mainly performed in ERDAS IMAGE8.7 remote sensing image processing software, which realized image preprocessing, including the geometric correction and excavation of remote sensing images. The software can also realize enhanced processing of remote sensing information, extraction of point attributes, classification, and classification accuracy verification.

The field GPS data were spatialized and projected by ArcGIS 9.0 software to obtain a shapefile vector file. The correlation between ground survey data and remote sensing data was analyzed by mathematical-statistical analysis software SPSS to establish a regression model.

Remote sensing image processing

During the imaging process of satellite remote sensing, radiation errors and geometric distortions may occur due to the attenuation of the sensor function, the influence of the atmosphere, and the flight mode of the satellite. Therefore, the image should be subjected to radiation correction and geometric correction before information can be extracted. The remote sensing image used in this paper had been subjected to standard atmospheric radiation correction and scatter correction at the satellite ground station before purchasing, and the geometric correction of the system had been carried out according to the parameters of the sensor, which eliminated the geometric distortion caused by the earth rotation, satellite mode changes, and sensor aging.

The real positions of a series of pixels that were distributed uniformly in the remote sensing image were obtained by GPS. These positions are usually called ground control points (GCP). Because the research area is mainly sandy land and transportation there is inconvenient, GCP cannot be obtained in some areas. Therefore, the two remote sensing images were combined, and the previously corrected TM remote sensing image was taken as a correction reference. Finally, the standard error of the correction model (Root Means Squared Error, RMSe) was controlled within 0.5 pixels.

Evaluation of control effect

According to the control weights obtained by the above analytic hierarchy process, combined with the experimental data under different irrigation amounts, the vegetation index was obtained. The general process of extracting vegetation index using ERDAS remote sensing image processing software is below:

Step1: Open the remote sensing image using ERDAS remote sensing processing software.

Step2: According to the vegetation index formula, the band calculation was performed on different bands of the image in the modeling tool.

Step3: Obtain image files of vegetation index under different irrigation amounts.

The regression statistical analysis table based on the current index is as follows:

Table 8. The regression statistical analysis table

Sources of variance	Sum of squares	Degrees of freedom	The mean square	statistic
Return to the residual	72133.845	1	72133.852	62.179
The sum of the	25525.38	23	1107.287	
The correlation coefficient	67957.602	24		
fitting	0.859			
The slope	0.738			
intercept	1035.5			
	21.352			

It can be seen from Table 8 that the correlation coefficient between the index and the aboveground biomass is 0.859. After the regression significance test, the regression effect reaches a significant level. The vegetation index and the model of aboveground biomass were obtained:

$$Y = 1035X + 31.278 \tag{8}$$

Where Y is the biomass of alhagi sparsifolia under different irrigation amounts, X is the vegetation index.

The grassland estimation model was established by the Model module in the ERDAS software, and the biomass of each pixel on the image can be obtained to form a spatial distribution map of the aboveground biomass. Then the aboveground biomass data in different project areas were summarized to get the final evaluation results.

Results

The vegetation data obtained from the ground surveys and remote sensing image processing are taken as the basis. In the same period, the adjacent area, the enclosed development area, and the free grazing area outside the control project area were taken as the horizontal comparison, and the condition before the implementation of the project was taken as the vertical comparison. A comprehensive analysis was performed on the evaluation indexes of each vegetation index to see whether each index develops in a favorable direction, and thus draws the overall evaluation conclusion. The correctness of the conclusion is tested through experiment. In order to determine whether the evaluation algorithm of the control effect in this paper can effectively evaluate the control data and improve the evaluation accuracy, evaluation indexes usually select the cross-data samples, which are commonly used in the effect evaluation model. The area under the characteristic curve of alhagi sparsifolia was used to evaluate the comprehensive performance of the current evaluation method. The abscissa is the false positive rate (FPR) of the ROC curve and the ordinate is the true positive rate (TPR). The area under the curve was used to determine whether the evaluation method has a fitting phenomenon and a larger area indicates a better evaluation effect.

It can be seen from the data in Figure 3 that the area under the overall characteristic line of this state evaluation method is significantly higher than the conventional method used for comparison. Its true positive rate is between 160 and 200, which is within a large advantage range, indicating that the overall evaluation is accurate and its effect is perfect. This is because the algorithm in this paper first constructed a “vegetation-sandstorm-soil” index system, selected a number of indexes, and calculated their index weights. According to the calculation results, the analytic hierarchy process was used, with the help of remote sensing, geographic information system, and landscape technology, to assign weights to the grassland control indexes. Finally, remote sensing, computer image information screening, and processing were used to perform data regression analysis and obtain the final evaluation results, which effectively improved the accuracy of the evaluation results.

The flow of the test evaluation algorithm:

Table 9. The analysis process of test evaluation algorithm data

Input: evaluation information data point set $X, G \times G$ grid, $(G+1) \times (G+1)$ grid	
Output: sample for each data point	
process	
Step1	Enter each data point x_i
Step2	Distribution point x_i , Go to the corresponding indicator network
Step3	Define an empty set of governance metrics and collect cluster examples
Step4	Take each datagiPut it into the corresponding grid
Step5	Construct similarity matrix S_1 and S_2 Put them into the corresponding matrix
Step6	Merge the sample to perform the third AP
Step7	For the current no matrix, construct a similar matrix S
Step8	The above formula is used to calculate the similarity
Step9	Compute the governance data preference
Step10	Distribution of x_i ; Corresponding example
Step11	end

Organized experimental data is as follows:

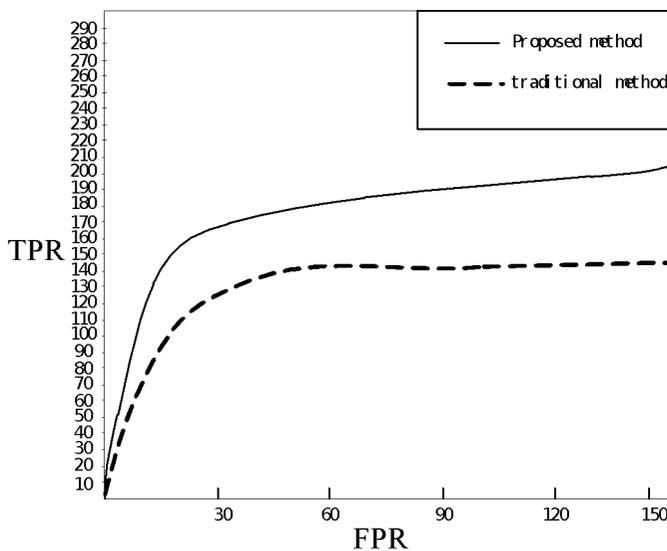


Figure 3. Comparison of evaluation results of different methods

Discussion

Desertification is one of the most important environmental and socio-economic problems in modern society, threatening the survival and development of mankind. China is one of the countries seriously affected by desertification in the world. Desertification has attracted much attention because of its development speed and impact on the social economy. According to statistics, in terms of its development rate, in the 1950s-1960s, desertification land in China expanded to 1,560 km². The desertification land in the 1970s-1980s expanded to 2,100 km² and reached 3,600 km² in the 1990s. The area of desertification land has increased by 46.74 million km² from 1987 to 2000 and reached 385,700 km² by the year 2000. Compared with the monitoring results in 1987, the area of desertification land has decreased after more than ten years of control, and the desertification degree has been reduced. However, the overall development of desertification is greater than the reversal. Especially in the past ten years, there has been a significant increase.

Under this background, this paper proposes an evaluation algorithm for the effect of *Alhagi sparsifolia* desertification control under different irrigation amounts. The experimental results show that compared with the traditional methods, the algorithm in this paper has higher prediction accuracy and better prediction effect, which fully verified its effectiveness and feasibility. On the basis of obtained accurate assessment results, it helps relevant departments to propose environmental management programs in a targeted manner, which is conducive to the improvement of environmental problems and has practical significance.

Conclusion

By reviewing the literature, summarizing the previous research and evaluation theory of desertification control and consulting experts, this paper adopted the *Alhagi sparsifolia* vegetation, sandstorm, soil, and other indexes as a system, and selected the vegetation coverage, aboveground biomass, grass height, plant species, annual plant proportion, fixed sand proportion, fixed sand fragmentation, mobile sand proportion, mobile sand fragmentation, soil erosion modulus, soil organic matter, soil mechanical composition, soil crust and other indexes. These indexes almost cover the main ecological and environmental impact factors brought by the *Alhagi sparsifolia* project and accurately and comprehensively reflect the ecological benefits of the project under different irrigation amounts. In addition, the paper uses the analytic hierarchy process to determine the index weights. The outstanding advantage of the analytic hierarchy process is that it can minimize the influence of subjective factors, as well as express and treat human subjective judgments in quantitative form. Moreover, the mathematical principle of the AHP is rigorous, simple, and easy to implement, and the factors of complex problems are organized by dividing the order of interconnection. AHP also gives objective judgment and quantitative expression of the relative importance of each evaluation index in each hierarchy, which provides an effective technical method to solve the weight distribution in the evaluation of ecological benefits. According to the experiment data, it can be known that the evaluation algorithm in this paper has numerous reasonable results and application advantages.

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