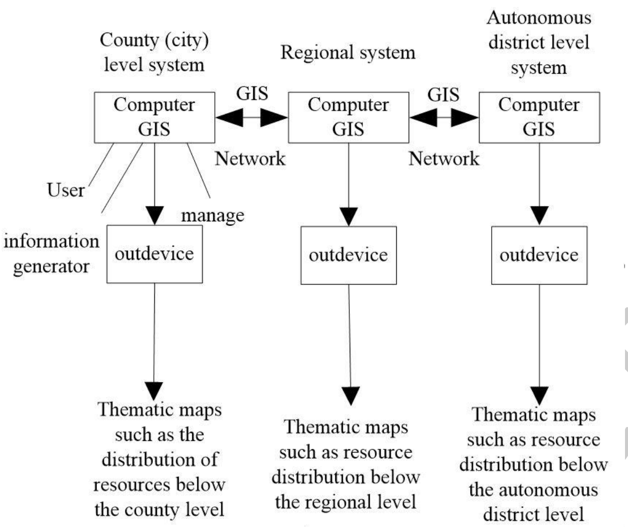
Global NEST Journal, Vol 22, No X, pp 1-10

Dynamic monitoring method of forest coverage based on GIS technology

Zhang Y.*
School of Information Science & Engineering, Changzhou University, Changzhou 213000, China
Received: 02/07/2020, Accepted: 04/08/2020, Available online: 22/10/2020
*to whom all correspondence should be addressed: e-mail: zhangyihan_zhang@126.com
https://doi.org/10.30955/gnj.003389

Graphical abstract



Abstract

When studying the dynamic monitoring method of forest coverage based on GIS technology, a dynamic monitoring system of forest coverage based on GIS technology was constructed, and forest coverage was dynamically monitored by means of the system. The system constructs attribute database and spatial database through RS data and topographic map, GPS measured data and GIS data, transfers data from the two databases to the quality supervision module for real-time query, early warning and evaluation of decision-making data quality, and transfers data that meets the quality requirements to the method management module and model in the data management module. In the model management module method, the management module uses geometric precise correction method to enhance remote sensing image, classifies and enhances remote sensing image by maximum likelihood method, calculates forest coverage by model management module according to classified remote sensing image on the basis of the method module, transmits the calculation results to the result database, updates the dynamic monitoring results in real time, and monitors them. The result is transmitted to the output module for output. The experimental results show that the average energy consumption for dynamic monitoring of forest cover is 324.09 J, and the monitoring results are consistent with the statistical results of the actual statistical yearbook.

Keywords: GIS technology, forest, coverage, dynamic monitoring, geometric precision correction, maximum likelihood method

1. Introduction

As the main body and important renewable resources of terrestrial ecosystem, forest plays an irreplaceable basic guarantee and support role in the history of human development. On the one hand, forests are the most complete natural resource pool, gene pool, storage reservoir, carbon pool and energy pool. They have the ecological value of maintaining the earth's living environment and improving human living space (Du *et al.*, 2018). On the other hand, as an indispensable and important natural resource for human development, forests have great strategic significance for the sustainable development of global society and economy (Ogbemudia *et al.*, 2019; Yassemi *et al.*, 2017). The basic measure of forest resources is area and accumulation. For a country and region, it can be measured by comprehensive index forest coverage. Forest coverage is an important indicator reflecting the abundance of forest resources and the state of ecological balance. Through the analysis and research on the change of forest cover, we can objectively evaluate the spatial distribution, characteristics and potential impact of forest resources on the environment in different periods, further understand the dynamic change trend of the quantity, quality and spatial distribution of forest resources, and provide information feedback for forest resource management. It provides advice on formulating forestry policy, formulating plan, guiding development and construction, and provides services for rational management, scientific management and sustainable development of forest resources (Jahdi *et al.*, 2018; Paramasiyam and Anbazhagan, 2020). Some foreign scholars have done a lot of research work in this field. For example, Knight uses aerial remote sensing data, geomorphological data and terrain elevation model in different periods as data layer for spatial overlay operation, and analyses the dynamics and changes of forest coverage in different geomorphological types and watersheds. The change of riverbank forest coverage was monitored by remote sensing combined with means. M.N. Siddiqui studied forest cover in Puerto Rico. Luis *et al.* investigated the relationship between climate change and forest cover. Overseas scholars have applied remote sensing technology to combine forest coverage and environmental change organically, with advanced means for in-depth research. During the Seventh Five-Year Plan and the Eighth Five-Year Plan period, China has successfully used Landsat data to conduct a comprehensive remote sensing survey of the "Three North" shelterbelt areas in China, and made a comprehensive evaluation of the dynamic changes of vegetation cover and the ecological benefits it produces. Many domestic scholars have also carried out research in the field of forest cover change from different areas and perspectives, and accumulated a lot of experience. Wang Xianying made a comparative analysis on the inventory data of the second type forest cover of Tuqiang Forestry Bureau of Daxing'an Mountains before and after the year's forest fire. Cui Yuexiang and others compared the annual forest coverage data of Inner Mongolia Alihe Forestry Bureau. Zhang Jixiang, Wang Dingsheng, Xu Chenghui and Jia Yingshe took Yongjia County, Lianyungang City, Huma County Forestry Bureau and Bila River Forestry Bureau of Zhejiang Province as objects, analyzed the change of forest coverage from the middle of last century to the beginning of this century, and analyzed the reasons for the change. The management suggestions were put forward, and the short-term study on the change of forest coverage in a small area was carried out with the city or forestry bureau or farm as the object. In the study of forest cover change in a large area at the provincial level, Lin Meizhen and others analyzed the dynamic changes of forest cover in Hainan in recent years. Song Yan listed the main data according to the results of the second-class annual survey in Hubei Province, summarized the current situation of forest coverage in the province, and compared with the second-class survey data, made a realistic analysis of the changes in forest area, forest volume, forest species, tree species structure and other aspects, with emphasis on its resource distribution, forest structure and stand. The quality and potential of forestry development were reviewed. However, most of the above studies are based on two types of survey data collected in the past two or three decades. In terms of content, only a simple comparison is made between the forest area and the amount of forest storage. The monitoring time is long and the monitoring accuracy is low. Therefore, a new method for dynamic monitoring of forest coverage should be explored.

Through actual investigation and analysis, it is found that with the rapid development of modern science and technology, it is possible to establish a dynamic monitoring system of forest coverage from the perspective of GIS technology. Firstly, the dynamic monitoring system of forest coverage is established based on computer technology and network technology. With the continuous development of computer technology, the popularization of computer knowledge and network application, and the emergence of mobile computers, with low price and superior performance, it has brought convenience to the collection of patch attribute data of forest resources, and it can quickly transfer the collected patch attribute data to the dynamic monitoring system and enter the attributes. The database and the update of attribute database create the precondition for establishing the dynamic monitoring system of forest coverage (Schroeder *et al.*, 2017). Secondly, with the rapid development of network technology, the whole region has basically formed an Internet network, which provides convenient conditions for the networking of forest resources dynamic monitoring systems at the upper and lower levels of the region, and also creates conditions for the transmission, sharing, access and output of forest information (Abishkar and Pragya, 2020; Zhang, 2018). Finally, with the rapid development of 3S technology, geographic information system (GIS) continues to develop and improve, especially the development of network GIS. At present, there are many kinds of geographic information software with complete functions. As an information platform, the attribute database and spatial database of forest resources (graphic database) can be established, which can query, update, analyze and export forest resources at any time. Its most remarkable feature is that it can scientifically manage and synthetically analyze spatial data, reflect the geographical distribution characteristics and the topological relationship between them, and has decision-making function. (Siyal *et al.*, 2017). It creates conditions for the establishment and use of forest resources dynamic monitoring system. Remote sensing is to determine, measure and analyze the nature of the target far away from the target and without direct contact with the target (Sachdeva *et al.*, 2018). The collected information is mainly the electromagnetic wave emitted or radiated by the target. As an important means of information acquisition, remote sensing has the characteristics of macro, dynamic, convenient and rich information. The development of remote sensing in the direction of hyperspectral and high resolution provides convenient conditions for fast, accurate and large-scale acquisition of spatial and attribute databases of forest resources, timely updating of GIS data, rapid development of global positioning system (GPS), and real-time acquisition of three-dimensional position and time data of positioning points (Ştefan *et al.*, 2018). With its global, all-weather, fast and accurate positioning function, GPS has been widely used in surveying, mapping, environment, engineering and other fields. Despite the limitation of SA or AS policy in the United States, the static accuracy of the system can reach centimeter level after calibration by reference station, and the accuracy of the real-time dynamic system can reach meter level after differential treatment. The accuracy of spatial positioning has been greatly improved, which provides an effective tool for collecting spatial database quickly and accurately. It can collect the geographical coordinates and track of forest resource patches at any time, transmit them to the dynamic monitoring system, enter the spatial database (graphics library), and update the spatial data (Zhang *et al.*, 2019). With the maturity of 3S technology and the expansion of its application field, its research and application begin to develop towards integration, forming 3S integrated system, and providing Geoscience Knowledge for intelligent data acquisition. That is, the development of science and technology, especially the rapid development of computer technology, network technology and 3S technology, is the research forest. Dynamic coverage monitoring methods create favorable conditions (Luo *et al.*, 2017; Rijal, 2019). Through the above analysis, it is found that the current GIS technology provides technical support for dynamic monitoring of forest coverage. Therefore, this paper constructs a dynamic monitoring system of forest coverage based on GIS technology, through which the dynamic monitoring of forest coverage can be realized.

2. Materials and methods

2.1. Constructing a dynamic monitoring system of forest coverage based on GIS technology

In order to solve the shortcomings of the existing monitoring system in terms of human, material and financial resources consumption, and unable to provide timely data and distribution of forest coverage, it is necessary to gradually establish a dynamic monitoring system of forest coverage in order to provide timely and rapid data and distribution of forest coverage, timely and accurate decision-making basis for forestry construction and sustainable development (Cetinkaya *et al.*, 2018).

From a technical point of view, the basic idea of dynamic monitoring of forest coverage is to establish a dynamic monitoring system of forest coverage step by step, based on counties (cities), regions (cities, autonomous prefectures) and autonomous regions. Firstly, relying on modern computer technology and network technology, taking unified geographic information system (GIS) as the operating platform, remote sensing satellite images and scanned topographic maps as the main spatial information sources, the minimum patch attributes of the original forest resources survey after correction as the attribute information sources, and the global satellite positioning system as the spatial information sources (Yuan *et al.*, 2018). Collection tools, mobile computers as attribute information collection tools, the establishment of a county (city) level as a unit of dynamic monitoring system of forest resources, the system should be able to update patches at any time to the attribute database and spatial database (graphical database) and at any time output County (city) below all levels of forest resources data tables and forest resources points. On this basis, using modern network technology and GIS technology, all regions (municipalities, autonomous prefectures) networked the forest coverage dynamic monitoring system of their counties (cities), and established the regional (municipalities, autonomous prefectures) level forest coverage dynamic monitoring system. The autonomous region networked the forest coverage dynamic monitoring system of all regions (municipalities, autonomous prefectures). The relationship between the dynamic monitoring systems of forest cover at all levels is shown in Figure 1.

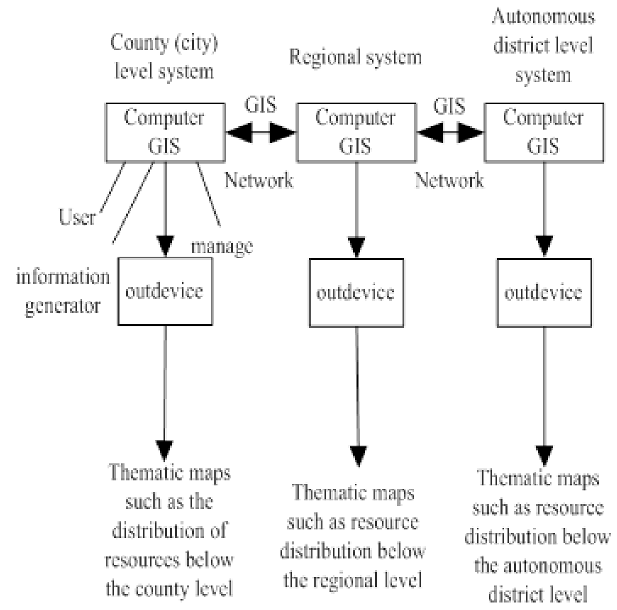


Figure 1. Connection framework between systems based on GIS

From Figure 1, we can see that county (city) level system, district level system and autonomous region level system are closely linked by network and GIS. Users can transmit their own data to each level system through network, and get the final output resource distribution and other thematic maps through output equipment. In order to build and share resources, a unified forest cover monitoring system (Gaji *et al.*, 2019; Shen *et al.*, 2017) needs to be built at each level in Figure 1. After the above analysis, it is found that the main operation of the dynamic forest cover monitoring system is the unified geographical information system (GIS). The main spatial information sources are remote sensing satellite images and scanned topographic maps. Therefore, this paper constructs a dynamic forest coverage monitoring system based on GIS technology, and constructs the overall framework of the dynamic monitoring system as shown in Figure 2.

As can be seen from Figure 2, the dynamic forest coverage monitoring system based on GIS technology mainly constructs spatial database and attribute database according to RS data and topographic map, GPS measured data and GIS data, transfers data from the two databases to the quality supervision module, real-time queries, early warning and evaluation through the quality supervision module. The quality of data information in price decision database is transmitted to the data management module which meets the quality requirements. The data in the two databases are managed by the data management module (Hector *et al.*, 2020; Kim, 2018). In the method management module, the corresponding methods are used to enhance the effect of remote sensing images, classify remote sensing images, and obtain more clear and intuitive remote sensing images. Based on clear remote sensing images, overlay analysis, network analysis and buffer analysis are carried out. The model management module establishes remote sensing information and environmental change models according to the classified remote sensing images. At the same time, the forest coverage is calculated by the observed and classified remote sensing images. The results are transmitted to the results database, and the results database is updated in real time. The updated dynamic monitoring situation is output through the output module (Khalile *et al.*, 2018).

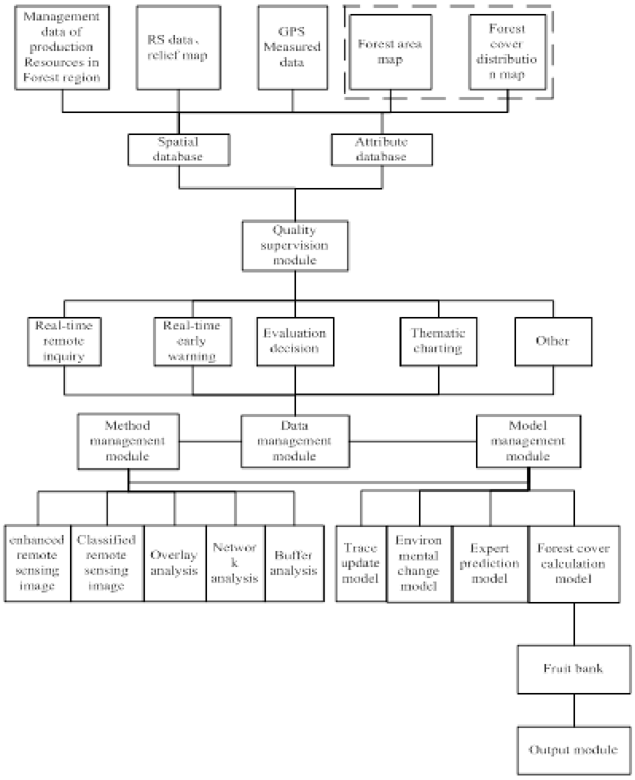


Figure 2. Overall frameworks of forest cover testing and management information system

2.1.1. Management module

The management module mainly includes the management module of the dynamic monitoring system of forest coverage based on GIS technology and the management module of the whole system. Firstly, the management module is the guarantee of the dynamic monitoring system of forest coverage based on GIS technology. In order to maintain the normal operation of the dynamic monitoring system of forest coverage, it is necessary to manage the data in the management module and the model management module management system through the method of the management module. Secondly, full-time personnel should be deployed in the whole dynamic forest coverage monitoring system. Forest coverage monitoring and management organizations should be set up within the competent forestry departments at or above the county (city) level. They are responsible for the maintenance, data updating, data query, data tables at lower levels and the output of various materials of the dynamic forest coverage monitoring system (Liu and Baghban, 2017). A patch information collector was set up in the township forestry station, and the system of reward and salary increase was adopted. The patch information was collected in time and transmitted to the county (city) forest coverage monitoring organization. Then it was input into the forest coverage monitoring system based on GIS technology, and updated in time with the internal data of the system (Palmate *et al.*, 2017).

2.1.2. Quality supervision module

The advantage and disadvantage of dynamic monitoring quality of forest coverage monitoring system based on GIS technology lies in the supervision of data quality in the database. Data in the database is the core of GIS and the key investment point. The dynamic monitoring status of forest coverage should be supervised by the quality monitoring module. At the same time, the forest coverage of leading cadres should be checked by this module. Establishment of dynamic monitoring system for forest coverage, GIS data, GPS data and RS data and topographic map are the basic information sources in the system. The quality of the whole system depends on the accuracy of data information. If it is not accurate, it will lead to chain reaction. The resulting data tables and forest coverage distribution maps are also included. It will be inaccurate. It can be seen that the focus of the quality supervision system is to supervise the original acquired data information and the updated data information. Quality supervision can be carried out by means of sampling survey of data quality. Level-by-level control and strict control: the county (city) level should check the original data information one by one, and extract part of the data to check on the spot. The inconsistent and demanded data should be re-investigated and the data information should be resolutely not input into the system. After the system is completed, the competent departments at all levels should deal with the original data information and updated data every year. The information is checked by spot check. The purpose of spot checking of the original data information is to check whether there exists the phenomenon that the data should be updated but not updated or that the updated data information is inaccurate. In addition, in order to prevent the accumulation of data errors and the omission of new patches, it is necessary to compare the latest remote sensing satellite image with the image database in the system at intervals of a certain year (5-10 years). When discrepancies are found, timely research should be carried out to find out the causes and correct them in time.

2.2. Processing techniques of dynamic monitoring system

2.2.1. Enhanced remote sensing images

Remote sensing images represent the information of land objects by their spectral characteristics, radiation characteristics, geometric characteristics and temporal changes. It is difficult to accurately interpret all forest types from the perspective of satellite images' color, texture, structure and location. In addition to using geo-correlation analysis method to determine the types of objects by synthesizing the features of image such as hue, brightness, saturation, shape, texture and structure, and combining existing data and field investigation, image data should also be processed by spatial enhancement and radiation enhancement, so as to enhance feature extraction and vision interpretation ability (Han *et al.*, 2017; Randhawa *et al.*, 2019). Geometric correction is used to enhance remote sensing images. Geometric correction is to correct the geometric distortion of remote sensing images with various random factors by using ground control points. In the process of geometric precise correction, there are always two aspects: geometric position transformation and image gray level resampling. For geometric position transformation, the second-order polynomial in polynomial transformation is used to transform geometric position.

$$\begin{cases} X = F_x(u,v) = \sum_{i=0}^{n}\sum_{j=0}^{n-1} a_{ij}u^i v^j \\ Y = F_y(u,v) = \sum_{i=0}^{n}\sum_{j=0}^{n-1} b_{ij}u^i v^j \end{cases} \quad (1)$$

In the formula, (X,Y) is the coordinates of the pixels on the image to be corrected, F_x and F_y are the resampling correction distortion functions, (u,v) is the position of each pixel to be output in the corrected image space, a_{ij} and b_{ij} are the undetermined coefficients, and the undetermined coefficients are the coordinates of the image to be corrected using the ground control points and the coordinates in the reference coordinate system (such as those in the topographic map). The polynomial coefficients solved by the least square method are the order of the polynomial and the second order polynomial equation is the order of the polynomial. In the actual calibration process, the bilinear interpolation method is usually used to resample the brightness of the image and put the image into the center and process the image. In this paper, the ground control points are used for precise correction and transfer to the projection needed. The Gauss-Kruger projection is used in this study area. Fixed-point measurement in the field was used to obtain the coordinates of control points (Liu *et al.*, 2016). The polynomial transformation matrix provided by remote sensing image graphics processing software is used to correct the ground control points, which must be accurate because it directly affects the accuracy of geometric precision correction. Therefore, the ground control points are generally selected in the study area, which are easy to locate, have obvious geographical characteristics, stable, and can be clearly reflected in the two images, such as river intersection, road intersection and so on. In addition, the distribution of ground control points should be uniform, and the number of points should reach a certain number, but not too many. The control points are evenly distributed throughout the image, and enough points are selected to control the mean square deviation of the conversion results within a single pixel to ensure the accuracy of the geographic coordinates of the corrected image (Qin *et al.*, 2017).

2.2.2. Classified remote sensing images

After obtaining the enhanced remote sensing image by geometric precise correction method, it is necessary to classify the remote sensing image by appropriate method. The forest coverage position can be obtained by classifying the remote sensing image, and the forest coverage rate can be calculated. After investigation and analysis, it is found that the main method of classifying remote sensing images is supervised classification. Supervised classification can selectively determine the classification category according to the application purpose and region, avoid some unnecessary categories, precisely control the selection of training samples, and decide whether training samples are or not by checking training samples. It can be classified accurately to avoid serious errors in classification and to avoid the re-classification of spectral cluster groups by unsupervised classification. There are many supervised classification methods, among which the maximum likelihood method is a widely used classifier (Li, 2017; Rana *et al.*, 2020), which can consider more than two bands and categories quantitatively at the same time and is sensitive to variance changes. Therefore, this paper uses maximum likelihood method to classify remote sensing information. The basic mathematical formula of maximum likelihood method is based on the hypothesis of normal distribution. The formula is as follows:

$$L_k = P(k \mid x) = \frac{P(k) \times P(x \mid k)}{\sum P(i) \times P(x \mid i)} \quad (2)$$

In the formula, i denotes the i gray level of remote sensing image, x is the abscissa of ground control points in the original image, k denotes the existence of k gray level in remote sensing image, and when a remote sensing image is understood as a two-dimensional information field, the k gray level denotes k information. The classification system based on maximum likelihood method should fully consider the scale, accuracy, remote sensing data differentiability, regional characteristics and systematicness. According to the practical and concise principle, combined with the actual needs of dynamic monitoring of forest cover, the classification system is constructed as shown in Table 1.

From Table 1, we can see that forest cover and land use are divided into two levels by maximum likelihood method. The first level classification divides remote sensing images into five levels: forest land, farmland and water area. The second level classification supplements the first level classification. The second level classification divides forest land into coniferous forest, broad-leaved forest and shrub forest. The farmland is divided into paddy field and dry field. All the information of forest cover in remote sensing images can be obtained by the above classification, and the forest cover image after classification (Cao *et al.*, 2018) can be obtained. On this basis, the artificial interpretation of remote sensing images and the addition of topography and geomorphology can better remove the grassland around hilly land and further improve the classification accuracy.

2.2.3. Method for calculating forest coverage rate

It is more important to calculate forest coverage in the dynamic monitoring system of forest coverage based on

GIS technology. According to the regulations for the Implementation of the Forest Law, the formula for calculating forest cover is as follows:

$$F_g = \frac{s_q + s_l + s_g + s_{nl} + s_f}{s_t} \times 100\% \quad (3)$$

In the formula, F_g denotes the forest coverage, s_q denotes the area of trees, s_l denotes the area of bamboo forests, s_g denotes the area of shrubs, s_{nl} denotes the area of farmland forest network, s_f denotes the area of forest coverage around, and s_t denotes the total area of land. Article 24 of the Regulation stipulates that the forest coverage rate referred to in the Forest Law refers to the percentage of forest area and land area per unit of administrative area. Forest area includes arbor forest area and bamboo forest area with a canopy density of more than 0.2, shrub forest area specially stipulated by the state, farmland forest network and the coverage area of trees beside villages, roads, waterside and houses (Nan *et al.*, 2018).

Table 1. Classification system

I Grade classification	II Grade classification
Forest land	Coniferous forest
	Broad-leaved forest
	Shrub forest
	Garden plot
	Urban green space
Farmland	Paddy field
	Upland field
Waters	Waters
Resident land use	Town building land
	Rural residential areas
Bare area	Bare area

3. Results

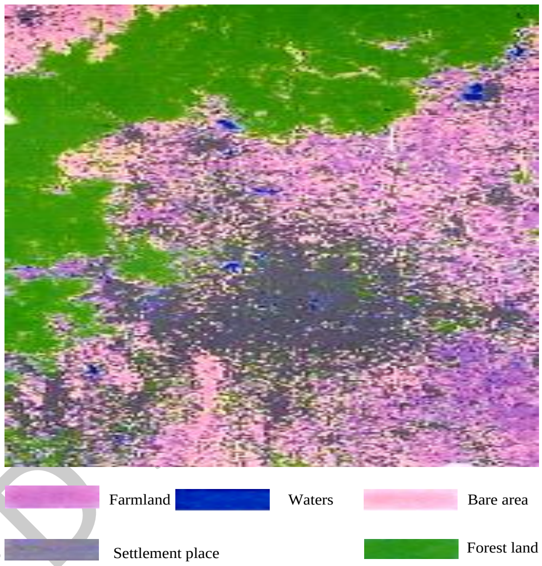
3.1. Classified remote sensing images

In order to study the effect of forest cover remote sensing image acquired after classifying remote sensing image by this method, practical analysis is needed. Taking Sanming City as an example, the forest covers remote sensing image acquired after classifying by this method is studied. The effect of forest covers remote sensing image obtained after classifying remote sensing image is shown in Figure 3.

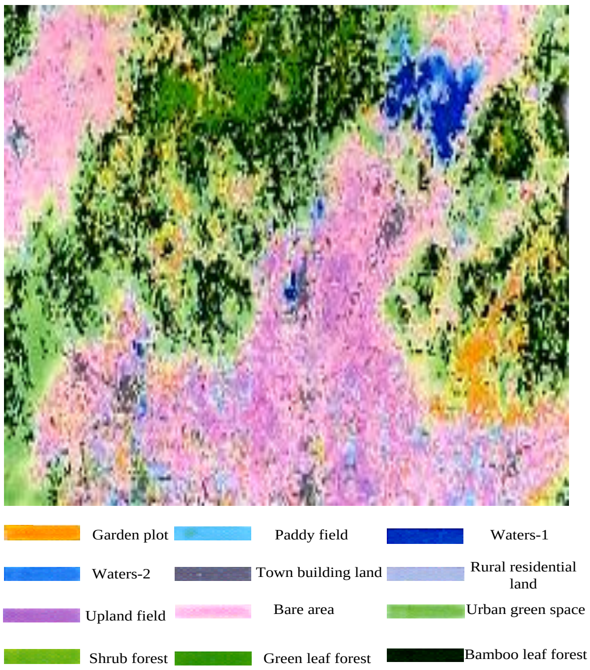
From Figure 3, we can see that the remote sensing image classified by this method can accurately represent the forest cover and land use of the classification system. From Figure 3(a), we can see that the classification map of grade I shows the five-level coverage effect of the classification map in detail. From Figure 3(b), we can see that the classification effect of grade II is better, and it may be clear in the map. We can clearly see the coverage of green space, shrub forest, broad-leaved forest, coniferous forest and so on. That is to say, the classification effect of this method is better, and the forest coverage can be clearly observed from the classified remote sensing images.

3.2. Dynamic monitoring of energy consumption

In order to verify the energy consumption of this method in the process of dynamic monitoring forest coverage, it is necessary to compare the energy consumption of this method, the dynamic monitoring method of forest coverage based on high resolution remote sensing image and number sampling, and the dynamic monitoring method of forest coverage based on TM effect (Pablo-Romero *et al.*, 2018). The comparison year is 2009-2017. The comparison results are shown in Table 2.



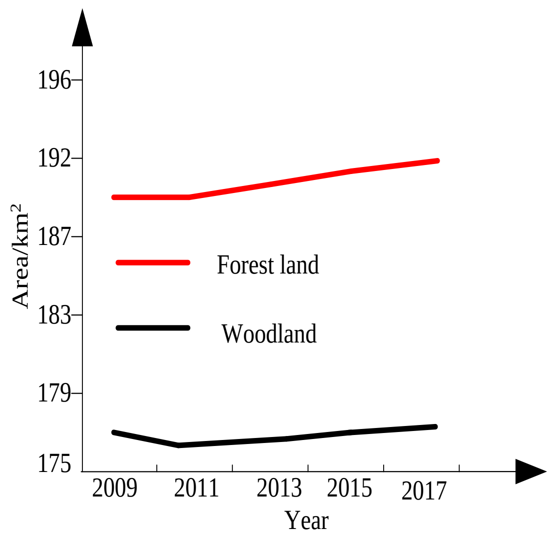
(a) Classification diagram of Grade I



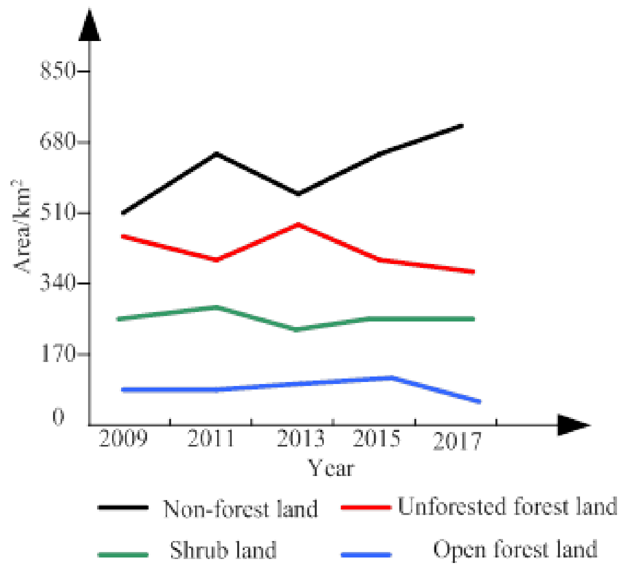
(b) Classification diagram of Grade II

Figure 3. Classification effect

From Table 2, it can be seen that the energy consumption of dynamic monitoring of forest coverage in the same year is the lowest. Through actual statistics, it is found that the average energy consumption of dynamic monitoring of forest coverage in the study area is 324.09 J, while the dynamic monitoring of forest coverage based on high-resolution remote sensing images and number sampling is 324.09 J. The average energy consumption for dynamic monitoring of forest coverage is 409.43 J. The energy consumption for dynamic monitoring of forest coverage based on TM is 476.31 J. Compared with the two methods, the energy consumption for dynamic monitoring of forest coverage is the least. Therefore, this method can be used in actual dynamic monitoring of forest coverage. Reduce energy consumption.



(a) The dynamic change of the land and the forest land in the forest



(b) Dynamic changes of open forest land and shrub land

Figure 4. Dynamic monitoring results

3.3. Dynamic monitoring results

In order to study the dynamic monitoring effect of this method, it is necessary to analyze the dynamic changes of forestry land and forest land area after dynamic monitoring with this method from 2009 to 2017 (Guerrini *et al.*, 2018). At the same time, it is necessary to analyze the dynamic changes of open forest land, shrub land, unforested forest land and non-forested land. The analysis results are shown in Figure 4 and obtained by this method. The dynamic changes of forest cover are shown in Table 3.

As can be seen from Figure 4, the area of forestry land and forested land showed a steady upward trend from 2009 to 2017. The area of forestry land increased from 189.32 km^2 in 2009 to 192.09 km^2, a total increase of 2.77 km^2, an average annual increase of 0.34 km^2, with an average annual net increase rate of 0.0035 %. The forest area was 177.28 km^2 in 2009 and 177.89 km^2 in 2017, which increased by 0.61 km^2, with an average annual increase of 0.076 km^2. Within nine years, the area of open forest land and unforested land decreased continuously, with an average annual rate of 2.41 % and 1.63 %, respectively (Gerami *et al.*, 2017). The area of shrubbery land decreased from 259.86 km^2 in 2009 to 198.72 km^2 in 2012, with an average annual decrease rate of 25.03 km^2, with an average annual decrease rate of 2.68 %, while the area of shrub land changed little from 2012 to 2017. The area of non-forest land changed little in 9 years. On the basis of the above research, the dynamic changes of forest cover obtained by this method are analyzed. From the table, it can be seen that the forest cover increased steadily from 76.81 % in 2009 to 78.62 % in 2011. The forest covered area increased by 26.97 km^2, and then gradually declined. In 2013, the forest cover increased steadily and steadily. The coverage rate was basically stable, ranging from 76 % to 77 %. In summary, the forest coverage in this area is better. The monitoring results of the dynamic monitoring method of forest coverage in this paper are consistent with the statistical results of the actual statistical yearbook, which shows that the dynamic monitoring effect of this method is better.

4. Discussions

It is of great significance to study the dynamic monitoring method of forest coverage. Firstly, studying the dynamic monitoring method of forest coverage is helpful to formulate the forestry production policy. The dynamic monitoring of forest coverage is an important basis for formulating the forestry production policy. All aspects of forest coverage, such as forest area, accumulation, land type and distribution state, are always in constant dynamic change, so we should know and grasp them in time. If we grasp the current situation and changing process of resources, we can formulate forestry production plans, policies and so on. Secondly, the research on dynamic monitoring methods of forest coverage meets the needs of sustainable forest development. The role of forests can be summarized in three aspects: protecting the environment (ecological role), producing various products (economic role) and meeting people's spiritual and cultural needs (social role). Economic benefits of forests refer to the economic value that forests can provide a variety of forest products and non-wood products for human beings, as well as the production and sale of these products (Hanafiah *et al.*, 2017). The social benefits of forests refer to that forests can meet various social, cultural and spiritual needs of human beings for forests. Only through the coordinated development of economic, ecological and social benefits of forests, can the sustainable management of forests and the sustainable development of forestry become a reality, and only by timely grasping the situation of forest resources can the relationship among the three be coordinated. Moreover, the study of dynamic monitoring method of forest coverage can effectively save forestry expenditure. The purpose of forest resources survey is to find out the quantity and quality of forest resources, understand the current situation and growth and decline of forests, and provide necessary basic data for decision-making, development, planning and operation of forestry work. Because of the vast land and vast distribution of forest resources in China, the traditional survey method mainly relies on field detailed investigation and sample sampling control. It usually takes five or even ten years for each survey to be conducted. Labor intensity, long cycle and low efficiency are not suitable for the needs of forestry development in today's society. In the past, traditional methods to obtain data and information often have some shortcomings, such as insufficient current situation, unstable accuracy, huge consumption of manpower, material resources and financial resources. The update and management of a large number of forest data and various information make forestry workers feel more difficult. Establishing a dynamic monitoring system of forest cover can effectively reduce expenditure in the long run. At the same time, it is conducive to revitalizing and utilizing the original historical data, promoting the co-construction and sharing of resources and environmental data, standardizing the release and exchange of forestry information, and laying the foundation for "digital forestry".

Table 2. Energy consumption comparison results/J

Year	The method	Dynamic monitoring method of forest cover based on high resolution remote sensing image and component sampling	Dynamic monitoring method of forest cover based on TM
2009	318.62	399.81	468.76
2010	319.46	398.76	469.52
2011	325.68	401.52	470.31
2012	324.36	406.98	474.68
2013	320.57	410.37	472.56
2014	321.96	412.49	479.31
2015	327.48	416.79	481.24
2016	328.92	418.52	483.62
2017	329.73	419.63	486.78

Table 3. Results of analysis of dynamic changes in forest cover

Year	Land area covered with trees (%)	Forest covered area (km^2)
2009	76.83	1157.82
2010	77.46	1167.31
2011	78.62	1184.79
2012	77.25	1164.15
2013	76.68	1155.56
2014	76.79	1157.22
2015	76.82	1157.67
2016	76.93	1159.33
2017	77.05	1161.14

Through theoretical analysis and experimental research, it is found that the dynamic monitoring method of forest coverage based on GIS proposed in this paper has the advantages of technical feasibility, management feasibility and basic feasibility. At present, the county (city), region (city, autonomous prefecture) and autonomous region governments at all levels have forestry authorities, the forestry authorities in autonomous region and parts of the region have established forest cover management or monitoring institutions, and the forestry stations network of towns (farms, pastures) below the county level is sound, which creates a management innovation for the dynamic monitoring system of forest cover (Siaudinis *et al.*, 2017). Conditions have been established, and the forestry departments at all levels can form a management system for dynamic monitoring of forest coverage by slightly adjusting their original internal institutions. Information collectors can select conscientious and responsible technicians with a certain cultural level from township forestry stations, and can be encouraged by appropriate salary increase policies. A dynamic monitoring system of forest coverage in the whole region has been established, which has a certain data base. Firstly, after several generations of forestry work, a large number of original data and survey data have been accumulated, and many remote sensing monitoring and information system application experiments have been carried out to lay the foundation for the dynamic monitoring system of forest coverage. Dynamic monitoring of forest coverage is conducive to revitalizing and utilizing the original historical data. Secondly, after several successive forests cover inventory and forest resource planning and design surveys, a number of forestry engineers and technicians have been trained at all levels in the region who have mastered the techniques of forest cover monitoring and investigation. These technicians will give full play to their technical expertise in the process of establishing a dynamic forest cover monitoring system. Thirdly, the forestry departments of autonomous region, most of the counties and cities have computer equipment, computer networks have been linked to all regions above the county level, and have a certain number of 3S equipment, which has laid a good hardware foundation for the establishment of the region's forest resources dynamic monitoring system. Therefore, the dynamic monitoring system of forest coverage based on GIS technology constructed in this paper can be put into practical application.

When using this method to dynamically monitor forest coverage, the following measures should be taken to ensure the realization of the dynamic monitoring method. Firstly, the governments at all levels and the competent forestry departments fully recognize the importance of establishing a dynamic monitoring system of forest coverage in the whole region, and take this work as an important responsibility to implement it. Secondly, we should establish a system to test the tenure target management of forest resources by monitoring the forest coverage. Only with the guarantee of the system, can the dynamic monitoring system of forest coverage play an effective role in the management of leading cadres' tenure objectives. According to the situation of the autonomous region, the feasible management objectives of forest resources for leading cadres during their tenure of office are determined. Thirdly, we should establish and improve the dynamic monitoring and management system of forest coverage in the whole region, establish forest coverage monitoring centers in autonomous regions, establish forest resources monitoring stations in regions and counties rely on forestry stations in townships and towns, and establish forest coverage monitoring points with full-time personnel at all levels. On the premise of consistency with the national monitoring system, the competent forestry authorities of the fourth autonomous region should formulate unified standards, achieve unified software, unified database format, unified code and so on, to ensure the smooth interconnection of superiors and subordinates and the sharing of data resources.

5. Conclusions

At present, the main problems of forestry in China include insufficient total forest resources, exhaustion of exploitable resources, low productivity of forest land and comprehensive utilization of resources, and low efficiency. It is imperative to strengthen the protection of existing forest resources, especially natural forest resources, vigorously develop afforestation, increase forest area, increase forest coverage and promote urban forestry construction. Because of the functional diversity of forest resources and ecological environment, the uncertainty of forest maturity, the wide-area and spatial structure of forest area distribution, the study of forest resources needs a series of forest resources information. The basic measure of forest resources information is area and accumulation, mainly through forest coverage rate representation. After the above analysis, in order to explore the situation of forest coverage, it is necessary to monitor the forest coverage dynamically. In this paper, the dynamic monitoring system of forest coverage based on GIS technology is constructed to monitor the forest coverage dynamically. Through theoretical analysis and experimental verification, it is found that the dynamic monitoring method in this paper can accurately detect the change of forest coverage. The test results are in good agreement with the actual results.

References

Abishkar K. and Pragya A. (2020), Effect of various organic fertilizers on seedling health and vigour of different varieties of cucumber in Rautahat condition, *Malaysian Journal of Sustainable Agriculture*, **4,** 81–85.

Cao J.B. and Feng Y.P. (2018), An improved shadow mapping algorithm, *Journal of Jilin University (Science Edition)*, **56**, 89–94.

Çetinkaya C., Kabak M. and Erbaş M. (2018), Evaluation of ecotourism sites: a GIS-based multi-criteria decision analysis, *Kybernetes*, **47**, 1664–1686.

Du P. and Hu H. (2018), Optimization of tourism route planning algorithm for forest wetland based on GIS, *Journal of Discrete Mathematical Sciences & Cryptography,* **21**, 283–288.

Gao Z.R, Zhou F. and Zhao Q.J. (2018), Research on dynamic testing Technology of photoelectric sliding Ring performance, *Journal of China Academy of Electronics and Information Technology*, **13**, 174–180.

Gazi M.Y., Tafhim K.T., Ahmed M.K. and Islam M.A. (2019). Investigation of heavy-mineral deposits using multispectral satellite imagery in the eastern coastal margin of Bangladesh. *Earth Sciences Malaysia*, **3,** 16–22, DOI: 10.26480/esmy.02.2019.16.22

Gerami M., Abbaspour H., Ghasemiomran V. and Pirdashti H. (2017), Effects of ethyl methanesulfonate on morphological and physiological traits of plants regenerated from stevia (stevia rebaudiana bertoni) calli, *Applied Ecology and Environmental Research*, **15**, 373–385.

Guerrini G., Landi E., Peiffer K. and Fortunato A. (2018). Dry grinding of gears for sustainable automotive transmission production, *Journal of Cleaner Production*, **176**, 76–88.

Han Q.Q., Dai K. and Chen X.W. (2017), Research on reactive power compensation control strategy of single-phase buck dynamic capacitor, *Journal of Power Supply*, **15**, 23–30.

Hanafiah M.M., Ali M., Aziz N., Ashraf M.A., Halim A.A., Lee K.E. and Idris M. (2017), Biogas production from goat and chicken manure in Malaysia, *Applied Ecology and Environmental Research,* **15**, 529–535.

Héctor L., Venegas Q., Mark T. and Garcia-Chevesich P.A. (2020), Water scarcity or drought? The cause and solution for the lack of water in Laguna De Aculeo, *Water Conservation and Management*, **4,** 42–45.

Jahdi R., Darvishsefat A.A. and Etemad V. (2018), Wind effect on wildfire and simulation of its spread (case study: Siahkal forest in northern Iran), *Journal of Agricultural Science & Technology*, **16**, 1109–1121.

Khalile L., Rhinane H. and Kaoukaya A. (2018), Forest cover monitoring and change detection in Nfifikh Forest (Morocco), *Journal of Geographic Information System,* **10**, 219–233.

Kim H. (2018), Economic and environmental implications of the recent energy transition on South Korea's electricity sector, *Energy & Environment*, **29**, 752–769.

Li R. (2017), Analysis of development path and network communication of dynamic reconfiguration wearable computer software platform, *Automation & Instrumentation*, 184–186.

Liu Z. and Baghban A. (2017), Application of LSSVM for biodiesel production using supercritical ethanol solvent, *Energy Sources Part A-Recovery Utilization and Environmental Effect*s, **39**, 1869–1874.

Liu Z., Peng W., Motahari-Nezhad M., Shahraki S. and Beheshti M. (2016), Circulating fluidized bed gasification of biomass for flexible end-use of syngas: a micro and nano scale study for production of bio-methanol, *Journal of Cleaner Production,* **129**, 249–255.

Luo Y., Dong Y.B. and Zhu C. (2017) Research on suitable distribution of Paris yunnanensis based on remote sensing and GIS, *China Journal of Chinese Materia Medica,* **42**, 4378–4386.

Nan S.P. and Zheng Y.B. (2018), Real-time detection and simulation of dynamic information transmission efficiency in big data, *Computer Simulation,* **35**, 400–404.

Ogbemudia F.O., Ita R.E. and Kekere O. (2019), Distributional patterns of flora species in response to salinity gradients in a palustrine wetland, *Environment & Ecosystem Science*, **3,** 20–25.

Pablo-Romero M.D.P., Pozo-Barajas R. and Sanchez-Braza A. (2018), Analyzing the effects of the benchmark local initiatives of Covenant of Mayors signatories, *Journal of Cleaner Production*, **176**, 159–174.

Palmate S.S., Pandey A. and Kumar D. (2017), Climate change impact on forest cover and vegetation in Betwa Basin India, *Applied Water Science,* **7**, 103–114.

Paramasivam C.R. and Anbazhagan S. (2020), Soil fertility analysis in and around magnesite mines, Salem, India, *Geology, Ecology, and Landscapes*, **4,** 140–150.

Qin L.B., Chen D. and Qian H. (2017), Research on expert evaluation system for dynamic capacity increase of load Channel, *Chinese Journal of Power Sources*, **41**, 305–309.

Rana S.N., Fiaz H. and Muhammad U. (2020), Evaluating selected soil physical properties under different soil tillage systems in Arid Southeast Rawalpindi, Pakistan. *Journal Clean Was*, **4,** 41–45.

Randhawa I.A., Ijaz U., Ijaz A., Butt A.D. and Malik M. (2019), Efficient energy solution for wasa faisalabad taking into consideration the environmental impact assessment, *Earth Sciences Pakistan*, **2,** 9–13.

Rijal S. (2019), Highlights on appropriate management practices against fall army worm (Spodoptera Frugiperda) in the context of Nepal, *Environmental Contaminants Reviews*, **2,** 13–14.

Sachdeva S., Bhatia T. and Verma A.K. (2018), GIS-based evolutionary optimized Gradient boosted decision trees for forest fire susceptibility mapping, *Natural Hazards*, **92**, 1399–1418.

Schroeder W. and Grabkowsky B. (2017), Itemisation of statistical relationships between needle loss in spruce and other information from three forest monitoring programmes in North-Rhine Westphalia. *Schweizerische Zeitschrift Fur Forstwesen,* **158**, 50–64.

Shen R., Guo J. and Zhang J. (2017), Construction of a drought monitoring model using the random forest based remote sensing, *Journal of Geo-Information Science,* **19**, 125–133.

Siaudinis G., Skuodiene R. and Repsiene R. (2017), The investigation of three potential energy crops: common mugwort, cup plant and virginia mallow on western lithuania's albeluvisol, *Applied Ecology and Environmental Research*, **15**, 611–620.

Siyal, Siyal and Mahar. (2017), Spatial and temporal dynamics of Pai forest vegetation in Pakistan assessed by RS and GIS, *Journal of Forestry Research,* **28**, 593–603.

Ştefan B., Sanda R. and Ioan F. (2018), Quantitative evaluation of the risk induced by dominant geomorphological processes on different land uses, based on GIS spatial analysis models, *Frontiers of Earth Science*, **12**, 311–324.

Yassemi S., Dragićević S. and Schmidt M. (2017), Design and implementation of an integrated GIS-based cellular automata model to characterize forest fire behaviour. *Ecological Modelling*, **210**, 71–84.

Yuan C., Cui H., Tao B. and Ma S. (2018), Cause factors in emergency process of fire accident for oil-gas storage and transportation based on fault tree analysis and modified Bayesian network model, *Energy & Environment*, **29**, 802–821.

Zhang D., Liu J. and Ni W. (2019), Estimation of forest leaf area index using height and canopy cover information extracted from unmanned aerial vehicle stereo imagery, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, **12**, 1–11.

Zhang S. (2018), Optimal planning algorithm of forest wetland tourism path based on GIS, *Journal of Discrete Mathematical Sciences & Cryptography*, **21**, 393–397.