Study on Dynamic Monitoring Technology of Soil and Water Conservation in Construction Projects using Multi-source Remote Sensing Information

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Abstract. It is the legal duty of water administrative departments to monitor and supervise construction projects, but the single image source and interpretation technology have stunted supervision efficiency improvement. By utilizing the characteristics and advantages of multi-source remote sensing information, we constructed dynamic monitoring technology of soil and water conservation in construction projects based on multi-source remote sensing data, and used Mi Zhi County and Zi Zhou County in Yu Lin City as the experimental area to extract new disturbance maps from 2017 to 2018. The results show that coordinated application of multi-source remote sensing information can effectively improve the monitoring frequency up 64%, and the accuracy up 25%, which can provide reference for the informatization of soil and water conservation supervision in construction projects.

1. Introduction

Soil and water loss in my country has a wide distribution, complex causes, and large losses, which seriously endanger the ecological environment[1]. With the rapid development of industrialization and urbanization, my country’s highways, high-speed railways, gas pipelines, wind power and other infrastructure construction and resource development activities are frequent, causing large-scale surface disturbances and vegetation damage in the region, which lead to regional soil erosion and is the main reason for the increasing amount[2][3]. But due to technical limitations of acquisition and extraction, the ability to obtain timely surface information of key monitoring objects such as spoil yard, borrow yard and soil & water conservation measures is still insufficient[4].

Reasonably utilize the advantages of medium and high resolution remote sensing images and radar images in terms of revisit period, coverage area, and acquisition cost, it is a good job in the coordinated application of multi-source and multi-scale remote sensing[5][6], which is a solution to the high frequency monitoring of water administrative supervision departments. This study uses Mi Zhi County and Zi
Zhou County in Yu Lin City, Shaanxi Province as the experimental areas to explore the development of production and construction projects based on multi-source remote sensing information collaborative support technology to provide assistance for the realization of full coverage and accurate supervision of soil and water conservation.

2. Multi-source remote sensing information collaborative monitoring technology

According to the different monitoring scales, the monitoring objectives are divided into regional monitoring and project monitoring. Among them, regional monitoring focuses on the area that have excavation, occupation, dumping and other disturbances and other damage to the surface; project monitoring is based on the upper level, and supervises the key projects, and tracks the implementation of the soil and water conservation plans.

![Flow chart of collaborative monitoring technology](image)

Figure 1. Flow chart of collaborative monitoring technology

2.1. Regional monitoring

2.1.1. New construction projects based on medium, high and high resolution image recognition and extraction. In densely-vegetated areas, new disturbances in production and construction projects have destroyed the original surface vegetation, especially before or after the start of construction, the vegetation information will change drastically, and the vegetation coverage can be enhanced and quantified by calculating the NDVI or inverting the vegetation coverage. According to the difference histogram of the inversion results, determine the extraction threshold of the new disturbance of the production and construction project, and extract the new disturbance map of the production and construction project; in the sparse vegetation area, considering the impact of the cultivated land under the non-farming state on the production and construction project The impact of recognition and extraction results accuracy can be achieved by using multispectral images of crops during growth, based on the vegetation index threshold segmentation algorithm to distinguish cultivated land from bare
ground, and selecting visual interpretation or automatic changes based on deep learning based on image quality Detection method, extracting new disturbance patterns of production and construction projects.

2.1.2. New construction projects based on high-resolution SAR data detection. The construction of production and construction projects will cause certain changes in the project construction area and surrounding, especially the spoil yard and steep fill slope formed by the construction are important deformation information for detecting new production and construction projects. Through two or more observations of radar The echo signals obtained in the same area are subjected to interference processing, an interference phase map is generated and phase unwrapping is performed, the vertical displacement of the deformation is calculated, and the position of the newly added production and construction project is identified and extracted according to the vertical displacement.

2.1.3. Analysis of construction status and compliance. Overlay analysis of the scope of responsibility for prevention and control of the approved projects with remote sensing images, analyze the construction status and compliance of the approved projects, carry out timely supervision and inspection of the projects that have already started, and if the scope of disturbance of the construction project exceeds the scope of responsibility for prevention and control or has no record Projects within the scope of responsibility for prevention and control shall be corrected and punished as construction projects that violate regulations.

2.2. Project monitoring

Based on the results of regional monitoring, identify and select areas that need key monitoring such as waste slag yards, steep fill slopes, etc. for large-scale construction projects such as open-pit mines, water conservancy projects, railways and road construction; according to the monitoring scope, monitoring accuracy and monitoring Frequency and other requirements for route planning and ground control point layout, acquisition of multiple low-altitude remote sensing images, production of DSM, DOM, DEM products, and project construction progress, surface disturbances and changes, the number and location of spoil sites, and soil and water conservation measures carry out a comprehensive analysis of layout, scale and other content.

2.3. Key technology

2.3.1. Multi-source remote sensing information collaboration technology. By analyzing the remote sensing data acquisition methods, parameter information, and applicable conditions of different scales and different imaging principles, combined with the existing problems of water and soil conservation monitoring in production and construction projects, research and propose technical methods for the collaborative application of multi-source remote sensing data, breaking through the limitation of a single data source, effectively avoid the problems of lack of information and reduced availability of remote sensing data due to the influence of natural factors such as terrain and weather, and ensure the rapid monitoring of the dynamic changes of soil and water conservation in production and construction projects.

2.3.2. Computer semi-automatic recognition technology combining algorithm and visual interpretation. Remote sensing images contain abundant surface information, which can reveal the status and changes of surface elements in a macro, timely and reliable manner. Based on the collaborative application of multi-source remote sensing data, it analyzes topographic factors, vegetation information, weather conditions and other factors that may affect the accuracy of monitoring. Based on DEM data and multi-source remote sensing spectral information, the monitoring area is divided level by level to reduce redundancy. Focus on monitoring key information, explore and establish semi-automatic identification technology for new disturbances in production and construction projects, and improve the automation of dynamic monitoring.
3. Application practice

3.1. Experimental area and data source
Mi Zhi County and Zi Zhou County in the southeast of Yu Lin City are selected as the experimental areas for this soil and water conservation dynamic monitoring data. The data sources used mainly include: 2 scenes of Landsat OLI data (June 2017 and June 2018), 26 scenes of GaoFen No.2, Beijing No. 2 (July 2017 to April 2018), 5 meter resolution Refined DEM data and project data approved by the water administration department from June 2017 to June 2018.

Figure 2. Scope of the experimental area

3.2. Technical route
Using Landsat OLI, Gao Fen No.2, Beijing No.2, DEM and other data comprehensively, extract the bare ground in the area, and obtain the technical route of the disturbance map of the production and construction projects in the area.

Figure 3. Technology route map

3.3. Newly added computer automatic monitoring of disturbance dynamic changes

3.3.1. Analysis of characteristics of ground disturbance information. For open-pit mines, water conservancy projects, railway and highway construction projects with large area and earthwork
excavation and filling, the identification is made through the comparison of the second-phase image spectrum information; real estate and processing and manufacturing projects have a limited area, but the construction area has clear boundaries and regular shapes. Based on the comparative analysis of spectral information, the shape index, boundary index and area of the vector are analyzed and judged.

3.3.2. Computer extraction of disturbance information based on vegetation information. New disturbances in production and construction projects mean the destruction of the original ground cover, and the vegetation coverage of the area before and after construction will undergo drastic changes. This change can be used to discover the distribution of new disturbances in the area. On the basis of excluding areas with no change in vegetation, by calculating the difference in vegetation coverage of images, the newly disturbed areas during the monitoring period are extracted. The vegetation coverage algorithm is shown below.

\[
VFC = \frac{(NDVI - NDV_{soil})}{(NDVI_{veg} - NDV_{soil})}
\]  \hspace{1cm} (1)

NDVI_{soil} is the NDVI value of an area that is completely bare soil or no vegetation coverage, and NDVI_{veg} represents the NDVI value of a pixel completely covered by vegetation, that is, the NDVI value of a pure vegetation pixel.

3.3.3. Newly added disturbance computer extraction based on building information. Using the remote sensing index of impervious surface proposed by Xu Hanqiu, the changes of the building information are extracted. The calculation formula of the normalized impervious surface index is as follows:

\[
NDISI = \frac{TIR - (MNDWI + NIR + MIR1) \times 3}{TIR + (MNDWI + NIR + MIR1) \times 3}
\]  \hspace{1cm} (2)

MNDWI is the improved normalized water index, and the calculation formula is as follows:

\[
MNDWI = \frac{(Green - MIR1)}{(Green + MIR1)}
\]  \hspace{1cm} (3)

In the formula, NIR, MIR1 and TIR are the near-infrared, mid-infrared 1 band and thermal infrared band of the image respectively, Green is the green light band.

3.4. Rule set construction

According to the disturbance characteristics of production and construction projects, the vegetation coverage index (VFC) and impervious surface index (NDISI) are used to construct a classification rule set.

![Figure 4. Classification rule set](image-url)
4. Results and discussion

4.1. Accuracy comparison analysis
Select Zi Zhou County to evaluate the accuracy of the method, the result of visual interpretation based on high-resolution satellite images is the true value, and the accuracy rate, missed score rate, working time are used as analysis indicators to separately analyze the collaborative technology method and the supervision classification method Perform accuracy verification. Among them, the correct rate refers to the ratio of the correct pattern to the extracted pattern, and the missing rate refers to the ratio of the undiscovered pattern to the real pattern.

Accuracy verification results show that multi-source information collaboration can improve the efficiency of monitoring work, improve the accuracy of work, and especially reduce the interference of cultivated land on the extraction of disturbance plates in the non-farming state. However, there may be missing points due to the mixed pixels of medium and high resolution images and the presence of DEM data.

Table 1. Evaluation of interpretation accuracy in Wu Bao County, Yu Lin City

| Extraction Method                | Total number of spots | Disturbance area (hm²) | Correct rate | Omission rate | Operating hours (h) |
|---------------------------------|-----------------------|------------------------|--------------|--------------|--------------------|
| Supervised classification       | 53                    | 84.37                  | 53.73%       | 5.39%        | 56                 |
| Multi-source information collaboration | 48                    | 65.82                  | 79.32%       | 1.57%        | 20                 |

4.2. Disturbance pattern extraction and compliance analysis
The results show that Zi Zhou County and Mi Zhi County have newly added 71 disturbance maps for production and construction projects, with a total disturbance area of 134.98hm², and Mi Zhi County has added 9 disturbance maps with a disturbance area of 18.79 hm², and Zi Zhou County’s disturbance map There are 24 spots and the disturbance area is 36.19hm². Based on the obtained real disturbance map, combined with the scope of responsibility for prevention and control approved by the water and soil conservation plan of the production and construction project, the compliance analysis of the results revealed that there were 7 new compliance disturbance maps in Mi Zhi County and 19 compliance disturbance maps in Zi Zhou County.

5. Conclusions and prospects
By using the characteristics of different remote sensing information, a zoning plan based on terrain and vegetation information was designed, and a set of multi-source remote sensing information-supported production and construction project water and soil conservation dynamic monitoring methods were proposed, and based on Mi Zhi County and Zi Zhou County, Yu Lin City. As an example, Zhou County extracted the newly-added disturbance maps from 2017 to 2018, and analyzed the compliance of the newly-added disturbance maps with the approval data of water and soil conservation projects. The
conclusion showed that the support of multi-source remote sensing information technology can effectively improve the work. 

Taking into account the urgency of "world-ground integration" monitoring, concentrating scientific research strength and technical resources, breaking through key node technologies such as multi-source data fusion, image information mining, and establishing a general monitoring infrastructure are issues that need to be resolved in the future. In this research, the identification and extraction of disturbance information mainly relies on prior knowledge such as the easily destroyed surface vegetation of production and construction projects or the information of newly added constructions of production and construction projects, and through the vegetation information and building information of phase 2 images change analysis to identify and extract disturbance patterns of construction projects. In addition to identifying vegetation or building information, many scholars at home and abroad have developed image mining models for construction information recognition, including the use of high-resolution SAR data to carry out surface deformation monitoring and timely detection of surface vertical deformation or fusion of SAR data and optical remote sensing information to enhance and refine the image texture [9]. In addition, with the development and maturity of hyperspectral remote sensing technology, the identification of building materials based on spectral information and the decomposition of mixed pixels become possible. Hyperspectral information provides new ideas and solutions for the dynamic monitoring of soil and water conservation in production and construction projects.

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