Design and Implementation of Time Point Approval and Dynamic Monitoring for Rural Illegal Occupation of Farmland for Constructing Houses

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Abstract

The illegal occupation of farmland for building houses has impact not only on the land resources, but also the agricultural production, ecological environment, and food security. In order to protect farmland resources, maintain stable agricultural production activities and improve ecological environment, this paper designs and implements a time-point approval and dynamic monitoring solution and system for the problem of rural illegal occupation of farmland for constructing houses by comprehensively utilizing the satellite remote sensing technology(RS) and geographic information system technology.(GIS) The result shows that the time-point approval and dynamic monitoring system can identify the illegal construction of houses accurately, thus this work can curb the generation of new illegal houses, and support the special governance of the construction of illegally occupied farmland effectively and continuously.

1. Introduction

The rural illegal occupation of farmland for constructing houses has impact not only on the land resources, but also the agricultural production, ecological environment, and food security. In order to prevent the increase of rural illegal occupation of farmland for constructing houses, it is inevitable to apply the information technology to detect and stop it in time, and support the goals on the action of "early detection, early stop, and strict disposal".

Satellite remote sensing technology has the advantages of wide coverage and short data-return time, and has become a mainstream means to monitor new illegal construction (Guanhua Xu et al,2016. Lei Huang,2019. Mingchao Jia et al,2013). With the rapid development of satellite remote sensing technology and the gradual increase in the number of satellites, it has become possible to curb the increase indiscriminate occupation of farmland for building houses with the abundant data resources from variable satellites. However, the problem of rural illegal occupation of farmland for constructing houses has a long history, with the complexity that the disposal policy and means of illegal new-built construction and history construction are not the same in different periods. How to correctly measure the construction time of illegal occupation of farmland for constructing houses, and how to accurately identify new-built or history constructions have become the key issue of the disposal strategy of rural illegal occupation of farmland for constructing houses.

At present, there are many achievements in the research of target detection and land use/land cover change(LULCC) monitoring based on satellite remote sensing images. Many researchers have carried out the technical and theoretical innovation and exploration in object recognition and automatic semantic segmentation in images(Yilong Gong,2017. Zhiqiang Zhao,2018. Zuoxia Yin et al,2009.Willis, Katherine S,2015. Liasis, Gregoris, Stavrou, Stavros,2016.). However, it should be pointed out that the studies mentioned above focus on the analysis results as the basis for the feasibility discussion of technical paths, the practice of research paradigms, or the decision-making advice of small spatial areas, which is difficult to meet the needs of actual production. Some researchers have also made a discussion on the method of target dynamic monitoring for actual production scenarios based on practice experience (Panfeng Fan,2017. Xiaoping Lin,2020. Rawat, J.S., Kumar, Manish, 2015.), and used satellite remote sensing images to detect changes and illegal constructions. There have been many referable cases of using remote sensing images as important evidence for law enforcement (Tianjun Wu et al,2016. Peng Chen et al,2018. Hong Ma et al,2018). However, there is still any effective and mature solution for the whole process of image time point approval and periodic dynamic monitoring of rural illegal occupation of farmland for constructing houses.

In order to correctly control the time point of rural illegal occupation of farmland for constructing houses, accurately identify increase and historical stocks, and curb increase of illegal occupation of farmland for constructing houses, this paper comprehensively evaluates the existing research results and practical schemes, combines their advantages according to actual needs, and designs a time-point approval and dynamic monitoring scheme for the problem of rural illegal occupation of farmland for constructing houses. The results show that the scheme and its implementation can effectively identify the pattern spots of illegal occupation of farmland for constructing houses, and curb the increase of rural illegal occupation of farmland for constructing houses.

2. Overall Scheme Design

The overall design of the approval and dynamic monitoring plan for the rural illegal occupation of farmland for constructing houses is shown in Figure 1. In order to correctly control the

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construction time of rural illegal occupation of farmland for constructing houses, accurately identify the new and stock, and curb the increase of the construction. This paper comprehensively constructs the technical system of image and thematic source data acquisition and coordination, standard time-point base image acquisition and production, illegal spot rolling detection and monthly report mechanism establishing, problem verification and rectification supervision. With July 2020 as the time point, we will comprehensively coordinate multi-source and multi-resolution satellite constellations such as resource series satellites, Gaofen image satellites, Gaojing series satellites and other commercial satellites, and coordinate the acquisition and production of time-point remote sensing image data sets. Based on time-approved images and farmland area data, the illegal map spots of stock were extracted and identified. Based on time-point images, new illegal houses are collected through continuous acquisition of high-resolution satellite images, providing clues for "zero tolerance" disposal. At the same time, in order to timely deliver clues to front-line law enforcement personnel and achieve closed-loop management from clue discovery, processing and rectification, and number cancellation, the monitoring system for rural illegal occupation of farmland for constructing houses is designed to achieve "early detection, early stop, and strict investigation" through information means.

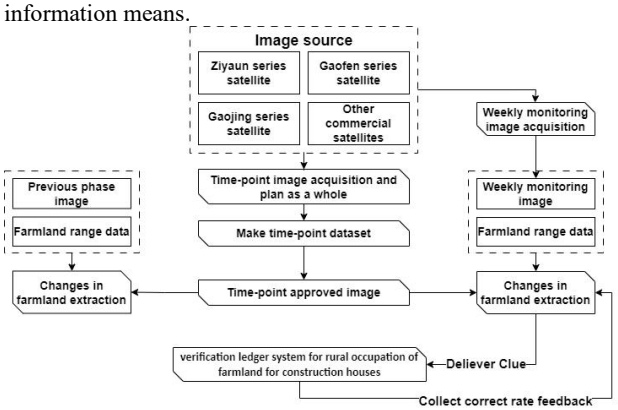

Figure 1. The overall design of the time-point approval and dynamic monitoring program for rural illegal occupation of farmland for constructing houses.

3. Time Approved Image One Map Construction

The standard time-point approved base image plays a basic support and fundamental reference role in the realization of the whole program. The standard time-point approved base image is used as the judgment basis for the illegal occupation of farmland for constructing houses stocks and new additions. Due to the great difference between the stock and new disposal methods, it is related to the interests of the people, and must be highly valued and carefully produced. At the same time, as the main reference data source, it is compared with the continuously newly acquired images in the later stage to extract the new housing patches of indiscriminately occupying farmland.

The approved images at the time point are the images in July 2020, which are mainly based on the images obtained by Hainan Province in 2020 and the images pushed by the natural resources satellite remote sensing cloud service platform, and are the basis for the law enforcement judgment of all stock and new housing. The image data includes satellite images such as Beijing-2, GeoEye-1, Gaofen-6, Gaojing-1, WorldView-2, WorldView-3, Ziyuan-1 and Ziyuan-3, covering the entire Hainan Island. The imaging period is from July 4, 2020 to July 29, 2020, and the image resolution is from 0.5 meters to 2 meters, as detailed in Table 1 and Figure 2.

Satellite Name	Resolution (meter)	Number of images (PCS)	Coverage ratio(%)
GeoEye-1	0.5	4	1.67%
WorldView-2	0.5	48	21.69%
WorldView-3	0.5	6	1.81%
Gaojing-1	0.5	77	21.58%
Beijing-2	0.8	1	1.67%
Gaofen-6	2	2	3.49%
Ziyuan-3	2	2	2.50%
Ziyuan-1	2	16	45.59%

Table 1. Statistical table of specific information of time approved images.

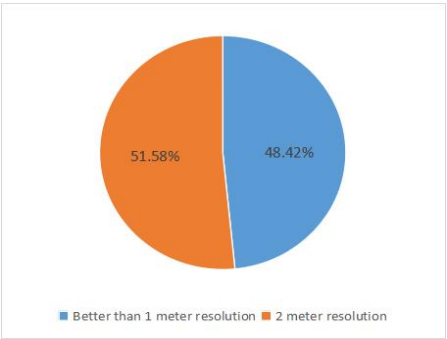

Figure 2. Statistical chart of time-point approved images by resolution.

3.1 Image Selection

Select clear, easy to interpret images, more effective information, more conducive to information extraction images. When there are multiple scenes in the same location, the image with new phase and high resolution is selected, or the advantages of different images are combined according to the need for comprehensive selection.

3.2 Making and Publishing Mosaic Data Sets

Mosaic data set making is an essential step in the construction of a graph. In order to ensure the clear recognition, timeliness and maximum resolution of the image objects, it is necessary to make mosaic images that fully contain the effective information of the objects to form the image layer that covers the target area, has no cover, has the target integrity and has the latest and highest resolution based on the acquired images.

The projection information of all images is defined and the File Geodatabase and Mosaic data set are created in the ArcCatalog directory after the pyramid is constructed, and the filtered images are loaded into the Mosaic data set. The Mosaic method and sequence were set to make the data set, the shooting time was assigned to the time field of the new image, and the image resolution information was assigned to the new image resolution field. According to the values of the two fields, the image was sorted and the higher resolution and recent time images were assigned a larger Z value to make the overlapping area of the images preferentially display the higher resolution

and newer images. This is used as the principle to complete the image Mosaic. When there is a large cloud area in the image, the cloud-free image needs to be selected for replacement. After the Mosaic is completed, the outline view is constructed, and the specific Mosaic image combination table is shown in Figure 3. After the establishment of the Mosaic data set, according to the requirements of the standard map service, the tile data set will be produced and released into the standard map service that can be called. An approved image at the construction point is shown in Figure 4.

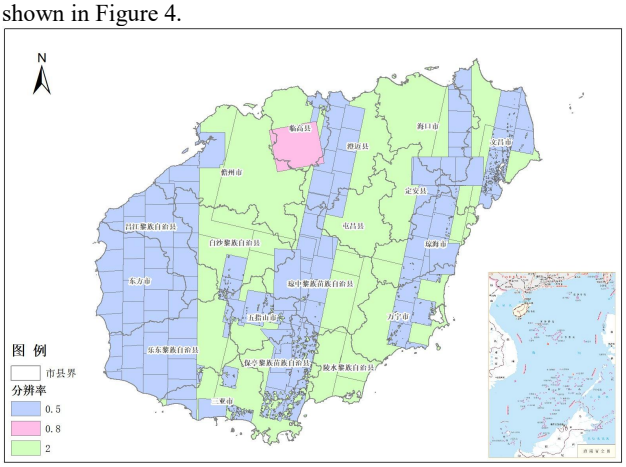

Figure 3. Distribution diagram of time-point approved image binding table.

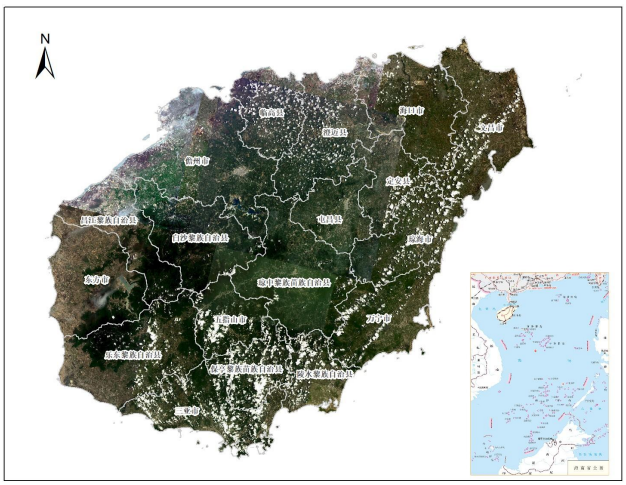

Figure 4. One map of the time point approval image.

4. Dynamic Monitoring Mechanism and Technical Process

4.1 The Establishing of Interpretation Flag

The establishing of interpretation marks means that the corresponding relationship between images and targets is established according to the preprocessed image features, which directly reflects and discriminates the image features of field information, including shape, size, hue , texture, position, etc. (Duanyang Zhang,2015). For the selected remote sensing satellite images, the interpretation characteristics of the illegal occupation of farmland for constructing houses are established. Building architecture has obvious features in orthophoto interpretation and recognition (Li Guan et al,2007. Xiaole Shen et al,2014. Hanqiu Xu,Liping Du,2010). In this paper, manual visual interpretation is used as the main method of image spot recognition by assist of automatic recognition, so the geometric shape and texture features of the building are used as the main discrimination basis. Considering the needs of production practice and referring to the existing research results, the interpretation mark is established according to the following house characteristics: ① the interior color and texture of the house show consistent characteristics, and the texture direction is relatively uniform; ② the edge of the house is clear, the shape is mostly rectangular or rectangular combination, and the building area of the independent house is small; ③ Shadows are generated with buildings in remote sensing images. A more specific explanation of interpretation details can be found in the Acquisition requirements section of Section 4.2 of this paper.

4.2 Monitoring Technical Indicators and Acquisition Requirements

Establishing of monitoring indicators: 1) general houses and houses under construction: houses with an area greater than 10 square meters need to be collected; 2) Hut Acquisition requirements are as follows: independent huts in the field and beside the pit pond, houses with an area greater than 50 square meters are collected; Connected shanties should be collected comprehensively, and connected shanties with a total area of more than 50 square meters should be collected; If the shack is located next to the main road with convenient transportation, even if the area is less than 50 square meters, it still needs to be collected.

According to practical experience, the collection follows certain requirements: 1) for the houses with the same ownership, the collection is directly carried out in accordance with the peripheral area; For single-family houses, it is collected by single house. Figure 5.a. In the figure, No. 1, 2, 3, and 4 are new general houses, and the rose red is the indiscriminately occupying farmland house in 2017. 2) For houses under construction, only those with obvious foundation are collected. If multiple buildings belong to the same residential area, some are under construction and some have been completed, they can be collected comprehensively nearby, see Figure 5.b. 3) Next to farmland, pits and ponds, scattered single houses, scattered single houses for farm-caring with an area of less than 50 square meters do not need to be collected, and contiguous ones need to be collected, as shown in Figure 5.d and 5.e. FIG. d The red house does not need to be collected; FIG. 5.e blue sheds need to be collected. 4) Farmland, pothole ponds or uninhabited houses in sparsely populated areas that can be seen visually will not be collected, as shown in Figure 5.c. 5) False changes caused by the accuracy difference between multi-phase images or the Angle during image shooting cannot be collected as new houses, as shown in Figure 5.f. In Figure f, there is a difference in the position accuracy of the two images, resulting in false changes (red box range). The housing across cities and counties is not allowed to overlap or split the plot, and the housing should be attributed to the city and county with a large proportion of the area.

a. Example of new house collection

b.Examples of comprehensive collection of houses under construction

c.Example of a suspected unoccupied house

d.Example 1 of houses of farm-caring

e.Example 2 of houses of farm-caring

f.Example of false changes

Figure 5. Sample of spot acquisition requirement.

4.3 Dynamic Monitoring Mechanism and Technical Process

In order to ensure the timeliness and reliability of dynamic monitoring results of rural illegal occupation of farmland for constructing houses, this paper designs a dynamic monitoring mechanism for rural illegal occupation of farmland for constructing houses. The mechanism has three main characteristics: 1) Rolling monitoring: Follow the principle of data first come first monitoring, and the monitoring results of higher resolution images shall prevail. If the latest cycle of 1 meter resolution image has been used, the 2.5 meter resolution image will not be adopted. For those who have been monitored with 2.5-meter resolution images, the monitoring results with 1-meter resolution images should be supplemented. The core of the algorithm is to set the priority according to the higher resolution and timeliness, and construct and maintain the association map in a monitoring cycle. The image contained in the association map must be the highest resolution and latest in time obtained in the current monitoring cycle. 2) Monthly report feedback: send monitoring chart patches to the verification unit at any time on a weekly basis to shorten the monitoring period. Formulate monthly monitoring and verification reports on a monthly basis, give upward feedback, maintain the awareness and activity of monitoring matters, and improve the attention of personnel and units involved in the business chain. 3) The combination of automatic monitoring and manual monitoring: the building sample database of the full cycle of dynamic monitoring was made, which provided reference data for manual visual discovery in the forward direction, supplemented error map spots for machine automatic interpretation in the reverse direction, added samples in the forward and reverse directions, and carried out iterative optimization of the closed loop of monitoring operation.

The specific contents of dynamic monitoring are as follows:

4.3.1 The Process of Finding Patches by Dynamic Monitoring: After mosaicing the remote sensing images of the latest period to form an image covering the whole area, the overlay comparison analysis with the historical images of the previous period based on manual visual interpretation was carried out, and the patches monitoring of the problem of newly occupying farmland building was carried out by each working grid. This part mainly focuses on the comparative analysis of visual interpretation methods, including the comparative analysis of multi-band, multi-temporal images, multi-type images and the comparative analysis of each interpretation mark for multi-phase images. (Dongmei Zhang,2006) compared and analyzed the difference sets of ground objects construction under the same conditions, extracted the change information between ground objects, found the new pathes of illegal occupation of farmland for constructing houses, and drew the new patches on map layer.

4.3.2 Patches Selection and Attribute Association: Patches selection. In order to ensure that the extracted map patches meet the definition of rural illegal occupation of farmland for constructing houses after the standard time point, the following three conditions should be met on the basis of monitoring data results: (1) outside the scope of agricultural conversion data or the scope of registered facilities agricultural land; (2) more than 90% of the total area (including 90%) falls into the scope of farmland or permanent basic farmland as a result of land use investigation; (3) General houses or sheds more than 500 square meters.

Attribute assignment. Attribute assignment is to map the geographic space and attribute space with certain rules, so that the extracted patches forms an organic whole with both geospatial information and discriminant attribute information of rural illegal occupation of farmland for constructing houses for subsequent investigation and disposal analysis. Attribute association work mainly includes the following contents:

The structure and specification definition of attribute table based on demands: In order to meet the judgment and identification requirements of rural illegal occupation of farmland for constructing houses , the definition of the attribute structure of table is according to the actual business. The attribute includes four aspects: ① Patches code: patches code is the unique code to identify the patch, which is composed of region information, source information, and unique code. ② Relationship with farmland: the occupation of farmland, set the thresholds of completely falling into farmland, partially falling into farmland, and not falling into farmland for calculation, and use the analysis results to assign values to the fields. ③ falling into the red line of overall planning and ecological protection: the threshold values of the three conditions are also set, and the values are assigned to the fields after calculation. ④ land types by the current land use status over the years of the land occupied: analyze the land types over the years of the land occupied by the map patches , trace the land use types of the map patches over the years, and count the land use status of the map patches over the years as farmland patches for statistical analysis of monitoring reports.

The definition of the constraint specification for the attribute field: the accuracy of the data, the field constraints and conditions, and the field value range are defined in detail. ① Accuracy: the specification of accuracy mainly includes the measurement unit, data accuracy, and data format specification. ② Field constraints and conditions: M(required), C(required), O(optional) three ways as the constraints and conditions of the field in the attribute table. ③ Field value range: there are four attribute field ranges, including comprehensive code, single code, free text and limited text.

4.3.3 Dynamic Monitoring Results Integration: The dynamic monitoring results are integrated to form the result data. The data result is in .gdb format, the type is the layer of polygon data, and the attribute contains the attribute items generated in the attribute definition phase. The metadata file is generated for the result data layer, and the metadata storage format is ".xls".

4.3.4 Monthly Report Preparation: The monthly report is written with the monthly monitoring data results as the main object, and the combined report of graphs, tables and texts is generated based on the output data results. The statistical analysis results of the monitoring data results accurately and objectively reflect the changes of the patches, and can provide information such as the number of patches, the area covered, the use of images and the specific data of single patch.

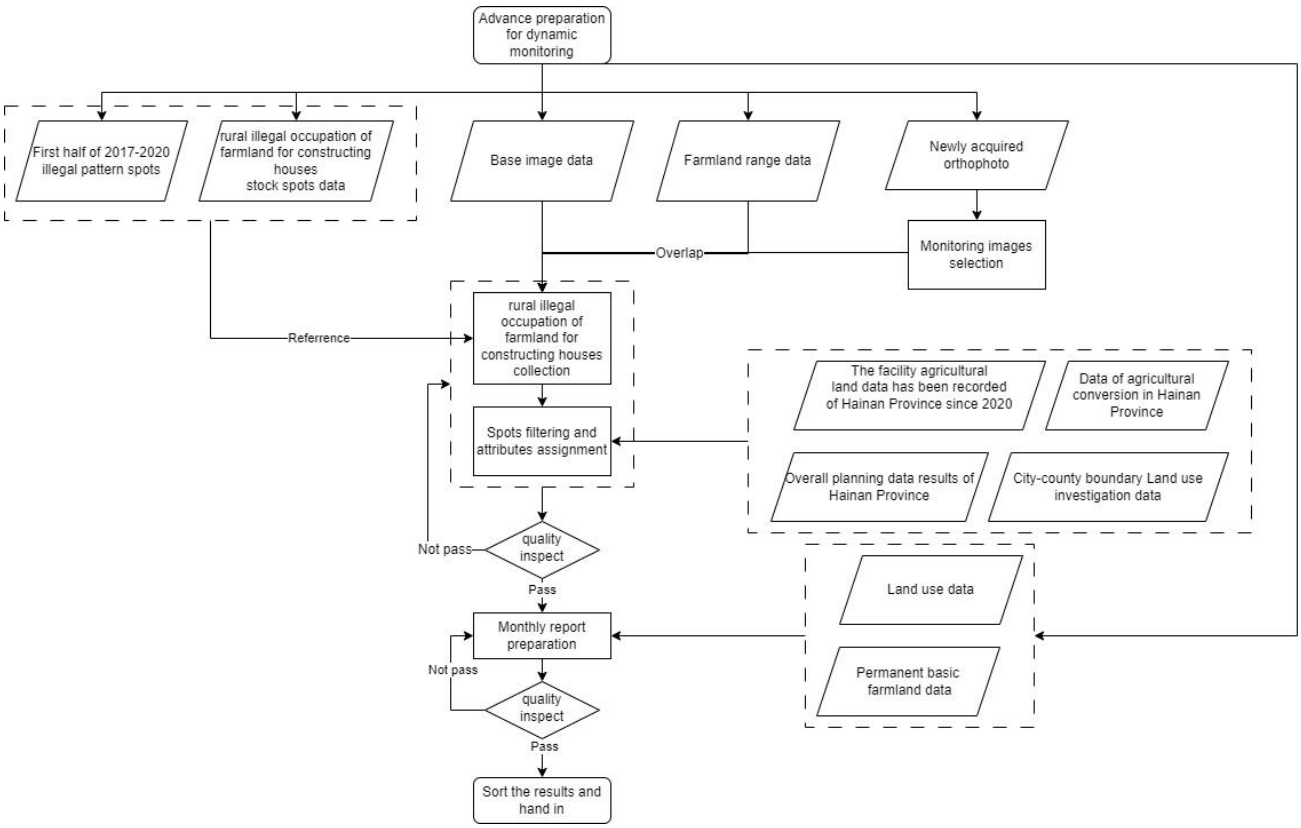

Figure 6. Design of dynamic monitoring technology for rural illegal occupation of farmland for constructing houses.

5. Construction of Verification Ledger System for Rural Illegal Occupation of Farmland for Constructing Houses

In order to implement the route of combining image dynamic monitoring and manual field verification, clarify the work functions of all parties in the business chain of construction occupying farmland and rectification, and realize closed-loop management and tracking of the whole process, a verification ledger system for construction occupying farmland rectification has been designed and established, and advanced technologies such as automatic recognition of remote sensing images, big data and mobile Internet have been utilized. To achieve early detection, early suppression, and continuous dynamic tracking on a large scale, improve the dynamic monitoring and supervision mechanism for rural illegal occupation of farmland for constructing houses, and promote the transformation

rectification of construction of illegally occupying farmland from investigation and punishment after event to prevention and supervision in advance. The system interface is shown in Figure 7.

Figure 7. Information display of newly monitored rural illegal occupation of farmland for constructing houses.

5.1 System Architecture and Main Functions

The system business process is shown in Figure 8:

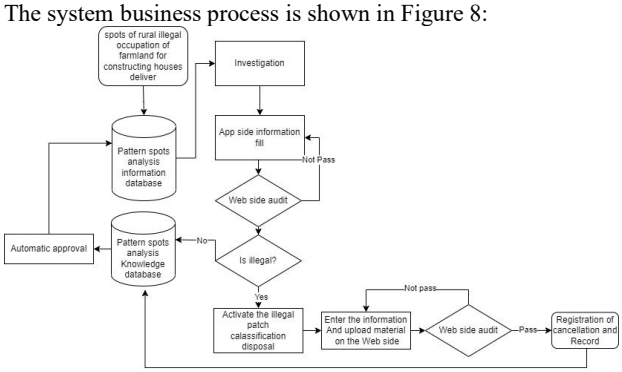

Figure 8. Business process design of the verification ledger system for rural illegal occupation of farmland for constructing houses.

5.2 System Business Process

According to the needs of the investigation business scenario, the Web and mobile applications are designed and developed for six types of business roles: township investigator, township auditors, city and county administrators, city and county auditors, city and county reviewers, and provincial auditors. The business process of the system mainly focuses on the investigation of suspected illegal pattern spots and the classification and disposal of illegal pattern spots. The basic idea is to combine dynamic image monitoring with manual field verification, confirm the basic information and illegal situation of suspected illegal spots through field verification, and start the classification and disposal process on the premise of confirming the illegal situation.

5.2.1 Investigation Process: Establish an information table of suspected illegal spots found by image dynamic monitoring, and the city and county administrators assign the spot authority to the township level. Township investigators check suspected illegal spots on the spot through the mobile APP, fill in the investigation information and take photos. After the filling results are approved by township auditors, city and county auditors, and city and county reviewers in the Web system, if it is an illegal spot, the spot will automatically enter the classification and disposal process; If it is a legitimate pattern spot, the pattern spot will be included in the pattern analysis knowledge database as a reference to determine the next suspected pattern spot.

5.2.2 Classification and Disposal Process: Classification and disposal are carried out for the spots identified as illegal in the investigation process. Township investigators fill in the disposal information of illegal map patches on the Web side and upload relevant supporting materials, disposal and rectification photos, etc. After township auditors, city and county auditors, city and county reviewers are gradually audited on the Web side, they are handed over to provincial auditors for audit on the Web side. After the audit is passed, the illegal pattern will be recorded in the system, and the pattern will be added to the pattern analysis knowledge database.

5.3 Construction of Auxiliary Analysis Knowledge Database

In this paper, the auxiliary analysis knowledge database is constructed. By analyzing the content of the filling data and the existing result data of each business department, the automatic analysis rules are formulated, the data elements required for the automatic analysis rules are defined, and the pattern analysis knowledge database is constructed to realize the automatic interpretation and analysis of the spatial graphics collected by users and the filled information. Through the intelligent comparison and analysis of multi-condition and multi-dimensional pattern spots, it can accurately identify the pattern spots of filled problems, and automatically approve the filled data, avoid manual interpretation errors, reduce the workload of manual interpretation, and solve the problem of low efficiency of manual mapping.

5.3.1 Formulation of Spatial Automated Analysis Rule: Based on the spatial location and attributes of the illegal construction verified by the township investigator, the spatial overlap analysis was carried out with the existing spatial results data of various business departments, and the information filled in by the township investigator was automatically determined from the geographical space, so as to develop the automatic analysis rules of the spatial location of the check map spots and the content filled in. If the township investigator has checked the option of "houses on the temporary land that has been legally obtained and has not expired", the spatial scope and temporary land data will be used for spatial analysis. If the space scope intersects with the temporary land use data and the temporary map spot is still within the validity period, it is judged that the content of the submission is not abnormal; If the space scope does not intersect with the temporary land use data or the temporary map spot has expired after the intersection, it is judged that the content is abnormal.

Filled attributes	Judgement rules	Involved data
Houses on land on which the examination and approval procedures for the conversion of agricultural land have been obtained according to law	The shape falls into the agricultural land conversion data	Conversion of agricultural land
Houses built on a lawfully approved homestead	Shape falls into real estate issuing data	Rural housing application data
The houses on the temporary land which has been obtained according to law and has not expired	Shape falls into the temporary land area and the temporary land area is within the validity period	Temporary land use data
Houses that have obtained property rights certificates according to law and have not expanded illegally occupied arable land	Shape falls into the real estate issuing data, and does not exceed the real estate data range	Real estate issuing data

Table 2. Spatial automation analysis logic and related data.

5.3.2 Attribute Logical Rationality Rules: The verification data attributes filled in by the user are automatically determined to determine the logical rationality of the attributes, so as to avoid manual errors. For example, the land ,farmland and the permanent basic farmland area occupied by farmhouses are compared with the shape area after filled in by the user, and if the difference is large, the user is prompted the information filled is error; For example, if the property of "one household and one house" is compared with the data obtained from other special projects, if it is found that the owner of the house has other houses, it is suggested that the owner of the house is not in the "one household and one house" situation.

5.4 Establish a Supervision Mechanism

This paper designed a supervision mechanism for the problem of rural illegal occupation of farmland for constructing houses. Through the information system's message distribution and system notification functions, it coordinated the personnel of all departments to follow up the verification and review process of problem spots, and encouraged the personnel to cooperate to promote the business process, so as to improve the efficiency of problem spots rectification. Based on the unauthorized buildings with problems verification ledger system supervision means are as follows:

5.4.1 SMS Supervision: 1) SMS reminder to be done: after the city and county investigator submits the information, SMS reminder to the city and county auditor at the next level to handle the case as soon as possible; 2) SMS reminder to solve: one level of the office can send SMS to urge the next level of the office, as soon as possible to deal with the case; 3) SMS warning: when the early warning time, deadline or overdue time, according to the status of the case to send a short message to the relevant office, as soon as possible to deal with the case.

5.4.2 Ranking Notifications: For the two main business parts, the ranking notification is carried out to urge the city and county departments to promote the verification and disposal of problem spots. The ranking of the verification progress is based on the proportion of the verification pattern approved by the city and county reviewers to all the verification pattern patterns in each city and county. The ranking of disposal progress is based on the proportion of the illegal spots approved by the city and county reviewers in each city and county and all illegal spots as a statistical standard.

6. Analysis and Conclusion

6.1 Effect Analysis

The design and implementation of the scheme of time-point approval and dynamic monitoring for rural illegal occupation of farmland for constructing houses proposed in this paper have achieved good results in the practical implementation process. In order to highlight the superiority of this plan, in the 9 months after the implementation of the plan, the rectification action on the building with problem of rural illegal occupation of farmland for constructing houses has been steadily carried out, and a total of statistics found that the proportion of stock and new illegal houses is 95% and 5% respectively. At the same time, the number of new illegal houses monitored weekly showed a significant downward trend and remained stable at a low level, as shown in Figure 9. The results of the study show that the scheme provided in this paper can accurately identify the stock and new illegal houses, and can continue to effectively curb the generation of new illegal houses, and the effect is remarkable.

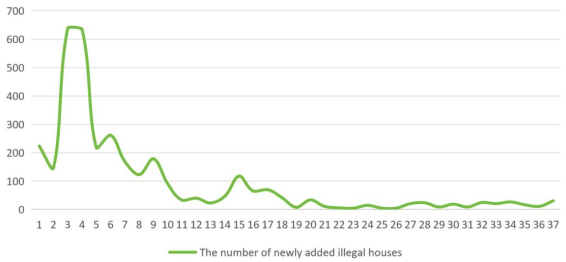

Figure 9. Statistical curve of weekly monitoring new quantity.

6.2 Conclusion

Based on the increasingly mature satellite remote sensing technology and the increasingly abundant satellite image data resources, this study designed a time-approved and dynamic monitoring scheme, coordinated the multi-source satellite constellation images, and obtained the time-approved image results. Based on the time approved images, a dynamic monitoring mechanism for rural illegal occupation of farmland for constructing houses has been formed. We established a problem verification ledger system, and improved the dynamic supervision and supervision mechanism for the construction of rural illegal occupation of farmland for constructing houses. Taking the special work of the rural illegal occupation of farmland for constructing houses as an example, the paper expounds the monitoring and effectiveness of rural illegal occupation of farmland for constructing houses. The research results can better identify the new and existing illegal houses,

provide solutions for continuously and effectively curbing the rural illegal occupation of farmland for constructing houses, and have certain reference significance for the determination and classification of the illegal nature of subsequent regional and even national monitoring and inspection projects. In the follow-up research, the sample database of houses with regional characteristics will be continuously expanded, the house interpretation algorithm model will be iteratively optimized, the house recognition accuracy will be further improved, and more accurate location information will be provided for problem spot recognition and automatic judgment.

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