

Remote Sensing Supplying Technical Support for Innovation of Land Management

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Key words: Geoinformation/GI, GIM, Land management, Remote sensing, Innovation

SUMMARY

This paper will briefly introduce the main goal, missions and implementation of the project, which is named the “annual inspection of land law enforcement with adopting satellite remote sensing technology all over the country” and has been taken charge and organized by the Ministry of Land and Resources (MLR). Since it first time began to implement in 2000, up to now, this project has carried out for 10 years and it also is to do once a year. The paper will focus on obtaining outstanding effects in aspect of land monitoring for 10 years, especially in the innovation approach and technique method of land management with the application of satellite remote sensing technology, which has brought into play not only the more important role and also conventional methods can't replace it, e.g. in terms of discovering at an early date, finding quick speed and locating accurately as well. The article conclusion therefore is that remote sensing is able to make full use of its technique advantages in effectively preventing land illegal action, protecting the cultivated land and improving land informatization management level, and also to bring favorable social and economic advantages.

论文摘要

本文概要介绍了由国土资源部负责部署并进行组织实施的“年度全国土地卫片执法检查”项目工作目标、任务及实施情况。自2000年项目首次开展至今已持续十年，而且是每年开展一次。重点介绍了该项目利用卫星遥感技术为手段在全国范围开展年度土地卫片执法检查，十年来在土地监管上取得的显著成效，特别体现出卫星遥感技术为土地监管在方式与手段上的创新提供了技术支撑。在土地执法检查中不仅发挥了重要作用，而且是传统的人工执法无以替代的，如在及早发现、快速查处及精准定位、实现全覆盖等方面。文章结论是卫星遥感在有效遏制土地违法行为、保护耕地以及促进土地信息化管理水平的提高上充分发挥了优势作用，并对经济社会发展产生效益具有重要意义。

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1. INTRODUCTION

As we all know, land is especially valuable resources and assets, as well as the basis for human survival and development. China has issued a basic national policy to make careful and rational use of land and to put arable land under proper protection.

The year from 2000 to 2010 has always been regarded as China's critical period for national economic construction and social development. In this decade, not only in the beginning of this century, in the eastern region of China, particularly in the southeastern coastal cities accessed to a rapid development, and also in recent years, the key national construction and major project investments are beginning to tilt to the central and western regions. Meanwhile the constructions of infrastructure in these regions are greatly strengthened, and the development and utilization towards natural resources has also been improved significantly. At the same time, along with the expansion of urban population, contradictions rising from the mutual development of human, land and ecology have become increasingly prominent. Behind the great development of economic construction, there is increasing number of illegal land-use cases, which become more and more serious and difficult to be controlled by traditional way of land regulation. In the face of increasingly severe problems in illegal land-use cases and increasing difficulties in land-law enforcement, it's urgent for law-executors and supervisors to solve the issues of how to innovate the approach of land regulation and how to improve the efficiency of law enforcement and supervision.

In the 90's, developed countries represented by Europe and America reached a rapid improvement in the research and development of satellite remote sensing technology, which has greatly contributed to the growing field of remote sensing technology. Therefore, it becomes inevitable to make full use of satellite remote sensing technique to conduct law enforcement and inspection of satellite Land Images, and there is no doubt that its advantages and features will provide effective technical support contributing to innovative ways of land supervision. The remote sensing technology was first used by the Ministry of Land Resources in 2000 to support the launch of "Annual Law Enforcement and Inspection of Satellite Land Images." As of 2010, it has gone through a period of 10 years. The project's overall objective is to gradually realize "land supervision by images" - that is, to implement land management

informationization ^[Yang G.Q. & Yu ZH.L., 2001], and give full play to the importance of satellite remote sensing technology in monitoring the land by quick discovery and timely investigation, with purpose of effectively control illegal land activities.

2. INNOVATIVE WAYS AND MEANS OF LAND REGULATION

A few basic concepts and terms are explained as follows:

Remote sensing refers to the modern detection technology that integrates physical means, mathematical methods and ground rules. **Satellite remote sensing** is the general term referring to a variety of remote sensing technology systems using artificial earth satellites as remote sensing platform. **Remote sensing technology** is the general term referring to all kinds of integrated technical systems for observing the earth and celestial bodies from the ground to the upper air, consisting of remote sensing platforms, remote sensing instruments, and the applications for receiving, processing and analyzing information.

Law Enforcement of Satellite Images is to detect and deal with illegal land-use cases, illegal exploitation and exploration of mineral resources by using satellite remote sensing technology based on the annual remote monitoring results ^[Tang, B., 2010].

2.1 The development and application of satellite remote sensing

- The development of satellite remote sensing

Currently, there are three categories of diversified systems of data satellite network mainly composed by commercial satellite groups and internationally classified by different resolutions ^[Wang X.H., 2004]. The three categories are as follows: Satellite groups with higher resolution better than 1 meter and up to 0.5 meter for the best, such as QuickBird, WorldView, IKONOS, GeoEye, EROS-B, etc.; satellite groups with higher resolution better than 5 meters such as SPOT 5, ALOS, P5, RapidEye, etc.; and satellite groups with medium and low resolution of lower than 10 meters such as the SPOT series, ETM, etc. At present, China has the satellites of ZY-2, CBERS-02B, BJ-1, HJ-1/2 and other independent satellites. They can receive panchromatic and multispectral remote sensing data with different scales, different modes, and resolution from 32 meters to 2 meters. In applications of satellite remote sensing, it is predicted that, by coordinating domestic and foreign satellites, it can basically meet the requirements of annual major works on satellite remote sensing for covering satellite data over the whole country. Common satellite sensors and technical parameters are shown in Table 2-1.

- Application of remote sensing data

Since China adopted law enforcement of satellite images in the past 10 years, now there has been an increasing number of available sensing platforms, and remote sensing data with multi-source, multi-resolution and multi-time-phases compared with before. Viewing from the beginning, we can see that China was almost entirely dependent on foreign satellites for

monitoring in the late 90's, and there only satellite data such as the U.S. Landsat TM (30m) and French Spot 4 (20m, 10m), etc. with few choices but high prices. Since 2002, the resolution of foreign satellite remote sensing data has been increased, especially represented by the French Spot 5 (2.5m), and the domestic resource II satellite data is used to assist the monitoring. Especially after 2004, there was commercial satellite data with higher resolution for civil use, mainly represented by the U.S. QuickBird (0.58m), IKONOS (1m) and other satellite remote sensing data. Since then, more choices were available in domestic and foreign data sources of remote sensing satellites in orbit, including the domestic self-developed satellites with medium-resolution, such as CBERS-01/(02, 02B), and HJ -1 / 2, also used for assistance. (Situation in the use of satellite remote sensing data for law enforcement of satellite images (year 2000'-2009'), as shown in Table 2-2.) In addition, practical application should be based on the resolution of remote sensing data, and a combination of factors such as national monitoring regions should be taken into account. For example, when producing ortho-photo map in scale of 1:10000, it is required in principle that the resolution is no lower than 2.5m (such as the selection of aerial photo, SPOT 5, QuickBird, P5, DK-1, ALOS, etc.), and if in scale of 1: 50000, it is required in principle that the resolution is no lower than 10m (such as the selection of ZY-2, BJ-1, ALOS (multi-spectral), IRS-P6, SPOT 2/4, etc.). Some economically developed regions require higher resolution data when applying a larger scale.

2.2 Innovative ways and means of land regulation

2.2.1 Innovative approach of land regulation

In the land regulation before, illegal land-use cases could be found relying only on reports from local people, media (newspapers, television) exposure, and personal supervision to obtain information. For inaccessible remote areas, it will be even more difficult to timely arrive at the scene. The main drawback of the traditional regulatory approach is the fact that illegal land-use cases couldn't be found and stopped in a timely manner, so the effective supervision scope is very limited, and it is difficult to guarantee the lasting effects of investigation and implementation. At the same time, the illegal number and spatial distribution is very hard to control.

Since 2000 when the 2000' law enforcement of satellite images was first used, ways and means of land regulation have been greatly changed, innovated and improved. The specific and innovative ways is to make full use of all modern high-tech means, including the integrated applications of satellite remote sensing technology, computer information technology and network technology; and to give full play to the advantages of satellite remote sensing. The images can directly reflect the land-use activities carried out by construction projects in a monitoring period within regulatory regions, especially the occupancy of arable land for new construction sites, so we can be timely aware of changes in the area of arable land, and illegal land-use cases. Therefore, by using remote sensing data as a basis and

applying satellite remote sensing technology, the activities of law enforcement can not only overcome the technical backwardness of traditional regulatory approach, but also improve the passive situation appeared in law enforcement, and it will timely detect and deal with illegal land-use cases to the utmost extent, so as to gradually construct and improve the comprehensive and tridimensional law enforcement & supervision system of "seeing from the sky, detecting from the ground, and managing on the Internet" for land and resources [Xu SH.SH. etc., 2010]

2.2.2 Innovative techniques

Law enforcement of satellite images is generally is divided into two phases. The first is to acquire satellite remote sensing data and process the image data, that is, the monitoring phase of satellite remote sensing, and the second is the inspection phase for law enforcement of satellite images, which is carried out based on the results of satellite remote sensing.

– Monitoring phase of satellite remote sensing

Technical route: To determine the monitoring period (usually receiving from the previous October to the following October) according to the annual monitoring program; to order and access satellite remote sensing data; to ortho-rectify the panchromatic data (generally referring to high-resolution data) of satellite remote sensing by using the control point database of actual measurement, or pre-phase corrected images, or large scale maps; to re-use the multi-spectral data (referring to relatively low-resolution data) to match and integrate with the corrected panchromatic data, and to make standard map by taking the county as a unit; to extract thematic patches (such as the patches for a new construction site) by using professional image processing software and techniques of remote sensing; to verify the patches by combining office work and field work; to eliminate false changes and enhance credibility; and to update the processing of office to give final monitoring results and provide the results of basic data for the relevant departments.

– Inspection phase for law enforcement of satellite images

The key point of national inspection for law enforcement of satellite images is to ensure the work of organization and implementation. Generally, the Ministry of Land and Resources is responsible for overall national co-ordination, the Department of Law Enforcement and Supervision is in charge of organization, implementation and guidance, and the local provincial Department of Land and Resources takes the responsibility for organizing and guiding local Departments of Land and Resources in its administrative area to implement inspection work for law enforcement of satellite images. During this period, all local governments are required to make an active cooperation, and their relevant departments should actively collaborate together to complete established goals.

Workflow: Work plan and preparation (organization, equipment, funds, information),

extraction of suspected illegal patches, production and distribution of satellite images, field verification of patches (identifying the land type, number and coordinate file, reviewing the legality of land, and judging the types of illegal land use), rectification and investigation, information summary and report, inspection and check, supervision and handling (major and typical law cases), sorting, interviewing, reporting, starting accountability, acceptance of work and archiving results.

3. REMARKABLE EFFECTS IN THE INNOVATION OF LAND REGULATION

Although there were only 66 pilot cities when first use satellite remote sensing technology to enforce laws on land, the law enforcement of satellite images entered into a new era. Today, the law enforcement of satellite images has been continuously improved and become mature at the technical level. Particularly in 2010, the 2009' law enforcement of satellite images satellite images covered 337 cities (including 4 municipalities, namely Beijing, Shanghai, Tianjin and Chongqing) and 2859 counties for the first time. It has been ten years since the law enforcement of satellite images was carried out, and people have not only seen continuous innovation in land regulation approaches, but also witnessed the increasing level of land management with remarkable achievement. Specific description is as follows:

- The coverage of law enforcement of satellite images has been continuously expanded.

With the progress in modern high-tech, especially the rapid development of satellite remote sensing technology, computer information technology and network technology in recent years, effective technical support has been established for an earlier realization of law enforcement of satellite images covering the whole country. From the year 2000' to 2009', cities covered by law enforcement of satellite images increased from 66 to 337 all over the country. See Table 3-1. With the scope of regulation reaching a nationwide coverage, the law enforcement of satellite images will exert more deterrent on land violations.

- The land management has been gradually improved

With the increasing scope of land regulation, supervision and law enforcement has been gradually strengthened. Statistics from the Ministry of Land and Resources show that, the number of illegal land-use cases is declining nationwide, and the land management is gradually improving.

During the year 2004-2006, illegal land-use cases had always remained high. With the surge in demand for urban land, phenomenon of illegal land use is still growing, imposing multiple pressure on land law enforcement.

After 2006, China attached more attention to violations of land, relevant laws and regulations were constantly improved, and in particular, law-enforcing departments has made progress in

means and approaches of law enforcement, resulting in a declining amount of illegal land use in total. According to the comparable inspection results of 85 cities for law enforcement of satellite images, the total amount of illegal land use and occupied area of arable land in 2007' have been respectively decreased by 36% and 48% compared to the number in 2006'; for the same 85 cities, their total amount of illegal land use and occupied area of arable land in 2008' have been respectively decreased by 44% and 44% compared to the number in 2007'.

From the year 2010, the inspection of 2009' law enforcement of satellite images covered 31 provinces and 2859 counties for the first time. Results for law enforcement of satellite images in 2009' showed that, China's land management and utilization continued a trend of improvement, which is more obvious for key cities, particularly the provincial capital cities. According to another 172 comparable cities, the total amount of illegal land use and occupied area of arable land in 2008' have been respectively decreased by 3.55% and 2.7% compared to the number in 2009'.

- Laws and regulations have been continuously improved

In the last decade, the Central Government, State Council, Ministry of Land and Resources introduced a lot of policy documents related to law enforcement work on land and resources [MLR, 2010]. Among them, there were 11 documents on laws and administrative regulations; 6 on judicial interpretation; and a total of 69 issued papers, approaches and notifications, covering areas such as planning activities, farmland protection, land use, land registration, management of mineral resources, and case investigation, etc. These documents on laws, regulations and policies timely helped and guided all officers in administrative departments of land and resources, and particularly provided the supervisors with laws to abide by, continuously improving their service quality and implementation capacity in handling cases.

- The inspection approaches are changing

With the growing number of remote sensing data, increasing image resolution, and enhancing hardware and software, it has effectively guaranteed that the law enforcement of satellite images will be continuously carried out and the work ways and approaches will be innovated constantly [Tang B., 2010]. Specifically speaking, in the face of expanding coverage, the mold giving priority the office work, which is supplemented by field work, is adopted to reduce the intensity of work; As for the verification of data results, the method of self-verification in the earlier year 2006' is changed to a cross-check by each other; when the issue of warning interviews and accountability was raised in 2007', it started from the interviews at ministerial level and provincial department level, to visiting notification, group interviews, and reduced Land using indicators in 2008', and to the fully started accountability system in 2009'. The 2009' is known as the first year time to affix the responsibility of government officers and other responsible people held accountable in regions with serious illegal land use in strict accordance with inspection results of satellite images and based on the law of Punishment

4. CONCLUSIONS AND RECOMMENDATIONS

To sum up, law enforcement of satellite images gradually reached a nationwide coverage from 2000 to 2010 with more innovative techniques and improved working specifications. It has changed the traditional way of law enforcement, and gradually formed a tridimensional supervision system of "seeing from the sky, detecting from the earth, and managing on the Internet" for land and resources. It has been ten years since the law enforcement of satellite images was carried out, and people have not only seen significant effectiveness and changes in law enforcement brought about by innovative land regulatory approaches, but also realized that there are more law enforcement problems yet to be solved. Here are some conclusions on this issue:

First, land regulatory situation is still tough. At present, there are fewer and fewer illegal land-use cases, but the problem remains very serious. The inspection results for law enforcement of satellite images in 2009' show that, the national situation of illegal land use allows of no optimist, and even makes people worried. There are many cities and counties, whose illegal land use reached or surpassed a proportion of 15%, which is the red line of accountability. It might be caused by many reasons. For the 2009' law enforcement of satellite images, this is a special period when China was responding to the global financial crisis by expanding domestic demand and holding growth, and implementing a series of key projects above the provincial level such as South-to-North water diversion. In some areas, illegal occupation of arable land has repeatedly occurred in an evident rebound trend. In the face of severe national land supervision, it is still arduous task to warn people to protect China's 18 million mu of arable land without going beyond the red line.

Second, we should give play to the advantages of law enforcement of satellite images, and improve our capabilities for precise and rapid detection. Law enforcement of satellite images has gained attention since its very beginning due to its superior advantages compared to the traditional way of law enforcement - accuracy, high speed and wide range. As the "Eye of Heaven", it gives no place to hide for illegal land use. Now it has become a very important and irreplaceable means for land regulatory of land and resources management. With the continuous development and progress of remote sensing technology, there will more remote sensing data source and more remote sensing data with multi-temporal high-resolution to meet the demand, thereby it can greatly increase people's capabilities for precise and rapid detection, and further contain the illegal land use from the source in a timely manner, particularly against the occupation of arable land.

Third, the land-regulatory approach should be promoted to a new level. We often say that there are "three difficulties" in law enforcement work - difficulty in detection, difficulty in prevention and difficulty in investigation ^[Xu SH.SH. etc., 2010]. The law enforcement of satellite

images has played an important role in providing technical support to solve the "difficulty in detection", and improved the "detection gateway" in the regulation links of early detection, early prevention and early investigation. However, we must continue to promote the land-regulatory approach to a new level by attaching importance to developing and improving relevant land & resource management system, laws and regulations as a guarantee. In this regard, we have reason to believe that, from the "detection of law enforcement of satellite images" in early 2000' to the "system of accountability by law enforcement of satellite images" in 2009', this "quality" stride will enable the law enforcement of satellite images to be more effective and deterrent to curb the illegal cases, and to provide better technical support to improve the level of land management, especially in the protection of resources and arable land.

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From 2002 to 2004, studied in the Department of Geoinformatics, ITC, Netherlands

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From 2004 to up now, work in the China Land Survey and Planning Institute, Ministry of Land and Resources (MLR)

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