EasyChair Preprint

№ 10972

Information System Design of Remote Sensing Monitoring and Evaluation for Approval Major Construction Projects

Jing Tong, Hong Li, Xiaomin Du, Xu Wang and Jinzhong Yang

September 26, 2023

Information System Design of Remote Sensing Monitoring and Evaluation for approval major construction projects

Jing Tong*
dept. territoral spatial use control
China aero geophysical survey and remote sensing center for natural resources
Beijing, China
tongjing84@163.com

Hong Li*
dept. business and development
KQ GEO Technologies Co., Ltd
Beijing, China
13191018656@163.com

Xiaomin Du
dept. territoral spatial use control
China aero geophysical survey and remote sensing center for natural resources
Beijing, China
dxiaomin@mail.cgs.gov.cn

Xu Wang
school of Land Science and Technology
China University of Geosciences Beijing
Beijing, China
2012220002@email.cugb.edu.cn

Jinzhong Yang
dept. territoral spatial use control
China aero geophysical survey and remote sensing center for natural resources
Beijing, China
67786808@qq.com

Abstract*—Focuses on the implementation of the remote sensing monitoring and evaluation of the approved land of nationwide major construction projects, the paper presents a set of remote sensing monitoring and evaluation business system for the national wide major construction projects. The designed system achieved the integration of monitoring results, analysis and evaluation of land use control indicators, automatic screening of typical cases and one-click generation of case analysis reports by utilizing a distributed microservice architecture, integrated data service management technology, and Spark/Hadoop spatial big data analysis techniques. This remote sensing monitoring and assessment operational system for major construction projects, driven by the analysis and evaluation of the land use control indicators, has significantly improved the post-approval monitoring and supervision and annual dynamic assessment capacity of major construction projects nationwide, and provided a reliable data basis for the relevant management departments to further optimize and improve the land use approval policy for major construction projects.

Keywords—Information system design;major construction projects; land use control; monitoring and evaluation; approval and supervision

I. INTRODUCTION

In recent years, both central and local governments have introduced pertinent documents and policies aimed at bolstering the oversight of land use control throughout and following its execution [1-5]. Furthermore, there is an increased emphasis on refining the regulation of arable land utilization and advancing land conservation and intensification [6]. Since the inception of the Ministry of Natural Resources, the primary focus has centered on streamlining approval procedures and championing the protection of land and marine resources, thereby continuously propelling the evolution of land approval systems [7].

The 2023 National Spatial Planning Outline (2021-2035) places distinct importance on "strengthening the monitoring and early warning of significant control zones, major strategic areas, key urban centers, as well as substantial projects, pivotal sectors, and notable concerns."

Major construction projects encompass expansive public undertakings that wield substantial influence over politics, economics, society, technological advancement, environmental preservation, public well-being, and national security. They are characterized by substantial investments and intricate complexities[8]. These projects predominantly span transportation, energy, water resources, and other critical infrastructure domains, encompassing large-scale bridges, highways, railways, oil and gas pipelines, substantial hydroelectric plants, and initiatives aimed at alleviating poverty [9]. The approval process governing land use for major construction projects is particularly rigorous, particularly when it pertains to the utilization of permanent basic farmland, necessitating endorsement from the Ministry of Natural Resources. As China's economic trajectory transitions from high-speed growth to a focus on high-quality development, the annual tally of approvals for major construction projects remains elevated. Nevertheless, challenges emerge during project execution, such as construction exceeding approved boundaries, unauthorized construction commencement, and approved land lying idle. These issues often pertain to

encroachments on arable land, permanent basic farmland, and ecological preservation redlines[10]. Consequently, post-approval land monitoring and assessment for major construction projects constitute vital components of land use control monitoring and evaluation systems. This endeavor also plays a pivotal role in establishing a "perceptive, adaptable, well-governed, and learning" national spatial planning implementation monitoring network, facilitating the digital transformation of land space governance.

Remote sensing dynamic monitoring, a technique for objectively, routinely, and rapidly observing alterations in land use on construction sites, has evolved into a pivotal tool for monitoring post-approval land use in major construction projects [11-14]. In practical monitoring, the substantial volume of data generated by multi-temporal and high-frequency monitoring [15-16], the intricate data production process, and the susceptibility of results to human factors present formidable challenges in rapidly amalgamating, statistically analyzing, and evaluating data outcomes. Consequently, the effective integration of monitoring results and the swift provision of analysis and assessment services to support the optimization and enhancement of policies governing the approval of major construction projects emerge as primary technological challenges in information system development [17-18]. To address these challenges, this paper proposes a strategy to construct a business system for monitoring and evaluating land use in major construction projects, propelled by innovations in information technology that bolster post-approval land governance systems. The system's development is rooted in uniform data classification standards, entails a comprehensive survey of diverse data resources, and entails the establishment of a data resource system for land use in major construction projects, utilizing a standardized data resource coding and classification framework. Furthermore, predicated on the "one map" derived from the major construction project monitoring database and varying scenario requirements, an integrated analysis and assessment technical system is instituted.

Through the establishment of the remote sensing monitoring and assessment business system for land use in major construction projects, we have achieved intelligent monitoring and dynamic evaluation of project implementation. This has involved the objective assessment of the efficacy of control measures, the provisioning of objective data to optimize land approval systems, and the promotion of lawful, regulated, and results-oriented land utilization by stakeholders. Furthermore, the development of this system has fortified the quality management of monitoring outcomes, standardized monitoring workflows, and minimized the labor costs associated with monitoring activities.

II. ARCHITECTURE DESIGN

In alignment with the construction goals of the business system aimed at monitoring and evaluating land use in major construction projects, and embracing the software design principles of "pursuing truth, pragmatism, maturity, and innovation," the comprehensive architecture and functional design of the system have been meticulously crafted with a focus on meeting user demands. This approach ensures a clear delineation of the system's structure and functionalities. The overarching system architecture, as depicted in Figure 1, is guided by two key dimensions: "compliance with standards, regulations, and systems" and "ensuring security and service provisions." The specific construction comprises five essential components: the infrastructure layer, data resource layer, platform support layer, business application layer, and user interface layer :

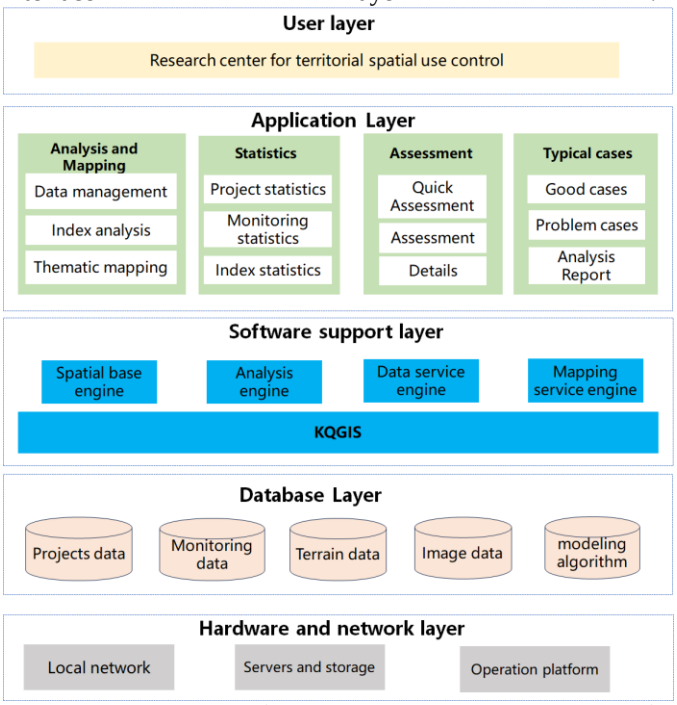

FIGURE I Overall structure of monitoring and evaluation business system for major construction projects

The system comprises five essential components:

Infrastructure Layer: This primarily encompasses various hardware and software components that support system operations. Hardware includes storage, networking equipment, while software encompasses foundational software support such as operating systems and databases. This system employs an Oracle database and operates within an internal local area network, providing the necessary conditions for network transmission, data storage, computation, and security.

Data Resource Layer: This layer includes fundamental geographic and topographic data, data related to major project approvals, interpretation data, and multi-temporal image data. It serves as a reliable spatial and business database storage, specifying the content, organization, and storage mechanisms of various data types. It forms the data foundation for system applications.

Platform Support Layer: Leveraging a domestically developed geographic information platform, this layer offers a range of functionalities. These include spatial analysis interfaces such as land classification analysis provided by the spatial analysis engine, as well as general support functions like spatial querying and visualization. It provides the underlying technological support for upper-level application functionalities.

Business Application Layer: This layer encompasses various applications, including analysis and mapping tools, statistical reporting, comprehensive assessments, typical case studies, and three-dimensional scenarios.

User Layer: The target users for this system encompass the Land Use Control Research Center.

III. KEY TECHNOLOGY

3.1Distributed Microservices Architecture

The system is developed using JAVA as the framework programming language and is built on a distributed microservices framework using Spring Cloud. It incorporates technologies such as containerization (Docker), automatic orchestration, service registration and discovery, distributed deployment and distribution, multi-layer intelligent clustering, and dynamic load balancing. It leverages high-performance cloud GIS services to manage and centrally share map base layers and monitoring data from significant construction projects in a distributed manner. It provides unified data access interfaces based on the domestic KQGIS Server, enabling access to historical imagery, topography, and other map data services.

3.2Integrated Data Service Management

To manage diverse and heterogeneous remote sensing monitoring data from multiple sources, the system establishes a unified management system. Considering the varied data types, formats, and unstructured nature of the data, a multi-source data integration solution is designed to efficiently store and manage remote sensing monitoring data from major construction projects. Additionally, a three-dimensional data model is constructed to meet the multidimensional analysis needs of remote sensing monitoring data from significant construction projects, enabling rapid query, analysis, and sharing of monitoring data.

In the process of integrating data from multiple sources, the system employs a hybrid storage mechanism based on data type and access methods. For structured data, such as business data related to remote sensing monitoring and approval, and interpretation, two-dimensional vector data, a distributed relational database cluster is used. For unstructured data, such as historical remote sensing imagery required for monitoring, a distributed file system (HDFS) is utilized for efficient management, enhancing the efficiency of reading large files like remote sensing images.

3.3Spatial Big Data Analysis with Spark/Hadoop

Considering the need for spatial queries and overlay analysis of monitoring results, and recognizing the characteristics of large and distributed data, the system utilizes Spark computing technology and HDFS distributed storage to significantly boost distributed computing capabilities. It combines massive data storage, distributed spatial data processing, and distributed spatial data analysis within the system, effectively managing historical monitoring data on a large scale. By extending Spark's RDD (Resilient Distributed Dataset) or Hadoop's MapReduce, it achieves nationwide spatial data analysis of historical construction projects.

IV. PROCESS ANALYSIS

4.1Functional design

In response to the demands arising from the monitoring, management, and assessment of various data types and algorithmic computations for monitoring indicators in the remote sensing monitoring process of major construction projects, the system has been structured into four distinct functional modules. The specific functionalities are illustrated in Figure 1 as follows:

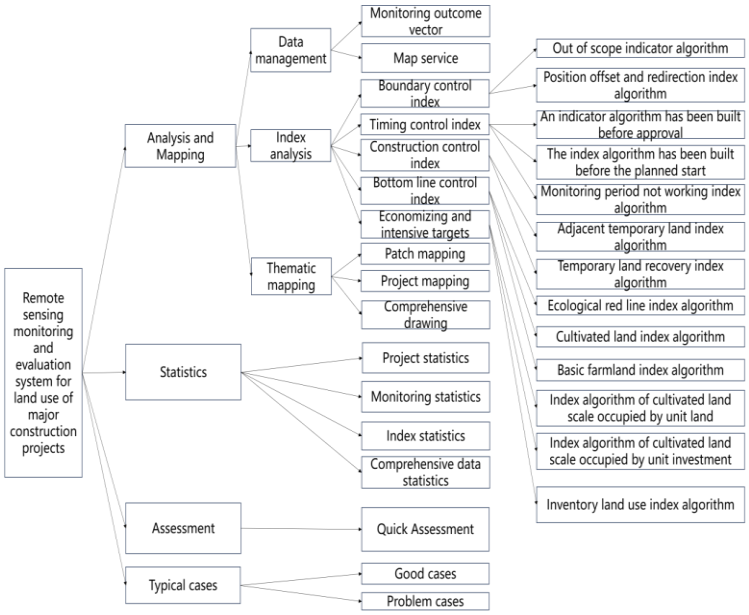

FIGURE II System business flow chart

4.1.1 Mapping and Analysis Module

Under a unified vector spatial framework, the system consolidates the monitoring results of major construction projects, facilitating the integration and display of data from various sources. Leveraging the concept of a unified map of monitoring results, the system provides algorithms for monitoring factors across five major categories: boundary control, temporal control, construction control, baseline control, and conservation and intensification. It supports intelligent analysis of land use control issues, offering users comprehensive and efficient monitoring result statistics based on maps. This enables users to gain insights into the project's monitoring status. By integrating data from multiple sources and offering intelligent retrieval and analysis capabilities, the system achieves automated and intelligent thematic map generation and output. This assists technical professionals in performing control monitoring and assessments more intuitively and efficiently.

4.1.2 Reporting Module

This module primarily presents fundamental information about major construction projects, monitoring plot details, and statistical analysis results of monitoring indicators in the form of reports. It allows for comprehensive querying based on multiple conditions.

4.1.3 Comprehensive Assessment Module

Upon completing land monitoring at the provincial administrative level and project-based evaluations for major

construction projects, the system aims to generate "Comprehensive Assessment Indicators for Major Construction Project Land Monitoring." By incorporating an embedded project assessment model and utilizing a one-click assessment function, it achieves holistic assessments at the project level. These assessments objectively reflect land use control conditions in various administrative regions and across different types of projects over the years.

4.1.4 Case Study Modules

Following the one-click comprehensive assessment of monitoring projects, the system allows users to query and select exemplary projects with approved land use and problematic project cases based on specified conditions. It incorporates analytical rules and intelligently analyzes the characteristics of exemplary and problematic project cases, as well as the reasons for discrepancies between actual land use and approved land use. This module provides optimization recommendations for the approval process of major projects.

4.2 Business process analysis

The system, built upon a distributed microservices architecture and utilizing integrated data management and spatial big data analysis technologies like Spark/Hadoop, facilitates the monitoring and assessment of major construction projects. The overall business process encompasses data ingestion, service publication, and visualization, followed by overlaying indicator models for monitoring and statistical analysis. A comprehensive monitoring and analysis of major construction projects, from their inception to implementation, necessitates project-based assessments of land use control across various administrative regions and project types. This dynamic assessment evaluates the effectiveness of control measures. To achieve this, assessment models are introduced to comprehensively evaluate each project. For typical projects and regions identified after assessment, the system includes built-in case analysis models. These models analyze the disparities between actual land use and approved land use for typical projects, delve into institutional issues and advantages, and provide information support and technical assistance for post-approval monitoring and macro-level decision-making. The overall business process is illustrated in the diagram below:

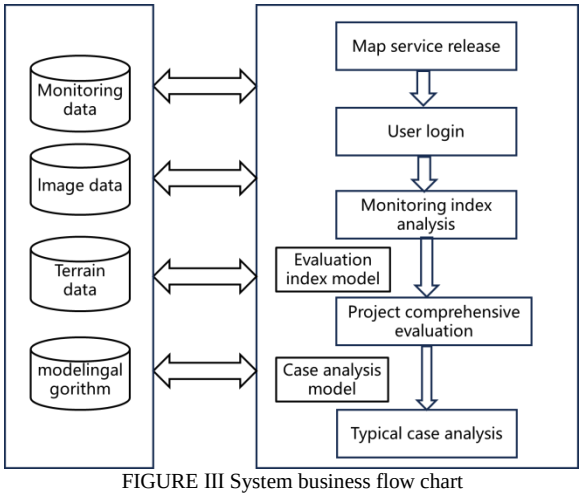

FIGURE III System business flow chart

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

Ⅴ Achieve effect

System users can access the website and utilize various services through their web browsers. The current monitoring and assessment system is integrated with modules for data and user management. Users can import data through the backend and perform comprehensive analysis, mapping, and typical project assessments on the frontend, all within a unified platform.

5.1 Multi-Source Data Integration and Presentation Data resources are the primary support for conducting monitoring and evaluation of major construction projects, and the system's numerous functionalities are built upon the project monitoring data. The system achieves integration and management of various data sources, including vector data, remote sensing imagery, terrain data, and more, for major construction projects. It provides data users with a unified data view, enabling efficient utilization of data.

5.2 Intelligent Analysis of Control Indicators Addressing five major categories of monitoring and evaluation indicators – boundary control, temporal control, construction control, baseline control, and efficiency control, along with their subcategories, the system automates the analysis of historical monitoring data. This comprehensive and efficient approach assists in completing land monitoring and evaluation work for major construction projects.

5.3 Convenient and Rapid Automated Mapping Utilizing integrated multi-source data and intelligent retrieval and analysis functions, the system facilitates the creation of thematic maps for various categories, including land parcels, projects, and comprehensive mapping. It achieves intelligent and automated generation and output of thematic maps, aiding technical personnel in swiftly generating various result graphics required for report writing.

5.4 One-Click Comprehensive Assessment

Based on the calculation results of multiple indicator categories, the system enables one-click comprehensive assessment. It categorizes project evaluations according to administrative divisions and project types, visualizing statistical results through diverse formats such as reports and bar charts. It also supports one-click result export.

Ⅵ Conclusion

The design and implementation of the Remote Sensing Monitoring and Evaluation System for Major Construction Projects hold significant importance in post-approval supervision of major construction projects, monitoring and evaluation of land use controls, and monitoring the implementation of land spatial planning. The system, built upon a domestically developed GIS platform, integrates monitoring and evaluation indicator models. It offers a flexible

human-computer interaction interface and visual representation, facilitating intelligent monitoring analysis and assessment for nearly a thousand major construction projects. Through comprehensive monitoring of nationwide major construction projects and dynamic assessment of control measure effectiveness, it provides objective data to optimize land approval processes, effectively preventing spatial destruction, and promoting the lawful, regulated, and approved land use by landowners.

Currently, in the realm of two-dimensional and three-dimensional integrated monitoring scenarios for major construction projects, there is a need for further exploration of analysis services for large-scale scenarios in construction project monitoring and supervision. This will enhance the visualization capabilities and efficiency of monitoring land use for these projects.

REFERENCES

[1]Huang W. Improve the efficiency of examination and approval and strengthen supervision services[N]. China Natural Resources News,2023-05-23(006). DOI:10.28291/n.cnki.ngtzy.2023.001460.

[2]Yi j,Guo j,Ou M,et al.Territorial space use regulation:Institutional change, goal orientation and system construction[J].Journal of natural resources,2023,38(06):1415-1429.

[3]Tian S,Chen L,Jiang Hai,et al.From Land Use Control to Territorial Space use Control: Evolution, track characteristics and policy Implications[J].Reform of the economic system,2020(04):12-18.

[4]Fang Y.Study on the Regulation Rules of Territorial Space Zoning Classification Use[J].Land and resources of Shanghai,2023,44(01):10-14.

[5]Tang R.On the use control system of territorial space under the vision of Constitution[J].Journal of Chongqing University (Social Science Edition),2023,29(03):189-199.

[6]Teng X,Zhou C.Keep to the red line in protecting arable land and improve the mechanism for conserving and intensive land use[J].Comprehensive utilization of resources in China,2020,38(05):69-72.

[7]Zhao Y.System change and governance logic of land use approval[J].China land,2020(04):4-6.DOI:10.13816/j.cnki.ISSN1002-9729.2020.04.02.

[8]Zeng S.Major Works Management[J].Science Focus,2018(6):45-47.

[9]Zeng S.Major Works Management[J].Science Focus,2018(6):45-47.

[10]Yu J,et al.Design and Implementation of Land Use Verification and Approval for Major Construction Project[J].Journal of Spatio-temporal Information,2020,27(03):135-138.

[11]Yu J,et al.Design and Implementation of Land Use Verification and Approval for Major Construction Project[J].Journal of Spatio-temporal Information,2020,27(03):135-138.

[12]Zhao Y,et al.An application example of satellite remote sensing technology in the monitoring and identification system of illegal construction projects[J].EnvironmentalEngineering,2015,33(01):146149+158.DOI:10.13205/j.hjgc.201501034.

[13]Taiwo B E, Kafy A A, Samuel A A, et al. Monitoring and predicting the influences of land use/land cover change on cropland characteristics and

[14]Abutaleb K, Yones M S, El-Shirbeny M, et al. Modelling and monitoring house fly M. domestica using remote sensing data and geographic information system[J]. The Egyptian Journal of Remote Sensing and Space Science, 2020, 23(3): 311-319.

[15]Guo H.Science Big data and digital Earth[J].Chinese Science Bulletin

,2014,59(12):1047-1054.

[16]Liu W, Liu S, Zhao J, et al. A remote sensing data management system for sea area usage management in China[J]. Ocean & Coastal Management, 2018, 152: 163-174.

[17]Vrieling A. Satellite remote sensing for water erosion assessment: A review[J]. Catena, 2006, 65(1): 2-18.

[18]Sajjad A, Lu J, Chen X, et al. Operational monitoring and damage assessment of riverine flood-2014 in the lower Chenab plain, Punjab, Pakistan, using remote sensing and GIS techniques[J]. Remote Sensing, 2020, 12(4): 714.