

CASE REPORT

Exploration of the construction of a municipal natural resources survey and monitoring system—Take Xuzhou City as an example

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ABSTRACT

Natural resources survey is an important premise and basic work for the realization of unified management of natural resources. Through the study of the classification system, survey scheme and database organization of natural resources, this paper constructs a natural resources survey and monitoring system based on the third national land survey and various special survey data, proposes a new database organization and update method, and conducts experiments to verify that in Xuzhou City, Jiangsu Province, forming prefectural and municipal survey results. It aims to provide reference for the natural resources survey work of prefecture-level cities nationwide and build a replicable and generalizable survey system.

Keywords: Natural Resources; Investigation and Monitoring; Data Updates

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1. Introduction

Surveying and monitoring the quantity, quality, distribution and ownership of various types of natural resources is an essential requirement for natural resource management. Natural resource survey refers to the use of certain technical methods to understand the current situation and overall information of natural resources^[1]. Natural resource monitoring refers to grasping the changes of natural resources and human life on the basis of the background data of natural resources^[2]. In order to solve the long-standing problem that natural resources survey data is investigated and managed by various departments, the Natural Resources Ministry proposes to establish a “six unified” “1 + X” natural resources survey and monitoring system, clarifying the objectives and tasks of natural resources surveys, and the survey and monitoring results will provide a systematic, scientific and long-term basis for the unified management of natural resources in China^[3].

Since the 1980s, some countries and international organizations have conducted corresponding survey or monitoring activities on natural resources at national/regional and global scales, such as the special investigation of the National Resources Inventory of the United States (NRI) on soil, water and related environmental resources. It aims to assess the situation and trends of non-federal lands in the United States every 5 a and use them as a basis for decision-making^[4,5]; the Ministry of Natural Resources and Ecology of the Russian Federation has carried out geological surveys, the construction of hydrological observation

networks, and cadastral surveys of forest land in the country heading^[6]; with satellite remote sensing, the Chinese Ecosystem Research Network (CERN) collects and analyzes multi-factor ecological data based on the observation of “water, soil, gas, and life” at the sample station^[7]. Since 2019, the Department of Natural Resources of Jiangsu Province has carried out pilot natural resource base surveys and special surveys in some parts of the province, and proposed a survey method based on the combination of high-resolution image interpretation and existing special survey data^[8]. This study surveys the properties of special resources for monitoring and characteristics of regional surface coverage surveys. Some progress has been made in the inves-

tigation, but it is not connected with the existing resource data management system in China, and as a new survey project, it is not easy to connect with the results of the land resources survey that have lasted for many years and update synchronously.

Based on this, when studying the technical route of municipal natural resources survey and monitoring, this paper focuses on the connection method and linkage update method between natural resource survey and original land survey data with special survey data, and thus build a municipal natural resources survey and monitoring system, and takes the urban area of Xuzhou City, Jiangsu Province as an example for experimental analysis.

Table 1. Natural resources classification

The Natural Resources Classification	Surface substrate layer	Follow the country classification ^[10]		Six primary classes, 27 secondary classes
	Surface overburden layer	Classification of space utilization layer (basic survey)	Land surface layer	The 12 secondary classes ^[11] classified by the third land survey were directly used
			Marine space layer	12 secondary categories including fishery and transportation
			Underground space layer	Two secondary categories: artificial space and natural space
		Classification of natural material layers (special investigation)	Water resources	Surface water and groundwater
			Timber resources	Arbor forest, shrub forest, bamboo forest and economic forest
			Grass resources	Natural grass and artificial grass
			Biotic resources	animals, plants, and microorganisms
			Mineral resources	Energy minerals, metal minerals, non-metallic minerals, gas minerals
		The Natural Resources Management Classification	Administrative boundary	
			Ownership boundary	
			“Three zones and three lines” in territorial spatial planning	
			Natural protected areas	
			Drinking water sources	
			

2. Research methodology

2.1 Classification system of natural resources

In 2019, Jiangsu Province issued the *Natural*

Resources Survey and Classification in Jiangsu Province (Trial Version)^[9] (hereinafter referred to as the “*Jiangsu Standards*”), which classifies natural resources by the spatial use layer, the natural strata

and the management of natural resources according to their spatial functional uses, natural characteristics and management attributes respectively. (**Table 1**).

In the practice of natural resource survey work in Xuzhou urban area, the above classification criteria are used. The specific classification structure is shown in **Table 1**.

2.2 Natural resource survey methods

There is a certain cross-cutting relationship between natural resources survey and land use survey, forestry survey, water resource survey, wetland survey, and geographical national condition monitoring, and this paper uses the method of extraction and reclassification to carry out the “basic—special” integrated survey of natural resources in Xuzhou urban area, which can shorten the survey period and save survey funds.

Natural resources surveys are divided into basic surveys and special surveys, and they have different characteristics. Basic surveys emphasize the spatial distribution and area of resources and other basic information^[12]. After delineating the survey unit, with survey plaques as the smallest survey unit, surveying all natural resources in the land surface space layer and the marine space layer, which is conducive to the subsequent management of superposition and statistical analysis with other data. The special investigation emphasizes the characteristics of the quality, category, structure, and ecological function of resources. It focuses on integrating existing professional investigation data, and supplements the investigation of necessary special attributes based on the reality of ecological and resource management.

2.2.1 Basic survey

Compared with the geographical national conditions and various types of special resource survey data, the data of the Third National Land Survey (hereinafter referred to as the “Third Survey”) are of strong current potential, high accuracy of graphic collection, and wide coverage^[13], and the degree of conformity with the current surface coverage is high, so the municipal natural resources basic sur-

vey is mainly based on the “Third Survey” data, and on this basis, field verification and natural reclassification is carried out (**Figure 1**).

In the *Third National Land Survey Classification*^[11] used by the “Third Survey”, there are some land types divided according to the needs of complex management, according to function and use, such as parks and green spaces, and special land may contain various natural resources such as forests, rivers, lakes, wetlands, etc. These resources meet the definition of natural resources. If such data are discarded in the basic survey, it will cause the lack of statistics on the total amount of natural resources, and also affect the analysis and evaluation of the ecological impact of natural resources. Therefore, in the investigation of natural resources in Xuzhou City, the spots such as parks and green spaces in the “Third Survey” data were extracted, interpreted using high-resolution remote sensing images, and then reclassified according to the type of resources and verified on the spot.

Wetland resources are an important space for the implementation of natural ecological space use control. The wetlands are the first class in the *Third National Land Survey Classification*, including 8 secondary categories such as mangrove land in the form of index, and in the wetland survey national standard *Wetland Classification*^[14], natural wetlands also include rivers and lakes. Based on the particularity of wetland resources, if they exist separately as a first-class class in the land surface space layer, they will inevitably overlap with other resources. Therefore, this survey adopted the *Jiangsu Standards* and made a trade-off between the wetlands in the *Wetland Classification* in the form of wetland indexes, and included 13 tertiary categories such as river water surfaces, forest swamps, and mangrove sea areas in “Land surface layer” in the **Table 1** into the wetland index.

The layers containing natural resource elements in the results of the “Third Survey” were extracted, and some functional land categories were reclassified, and all survey plaques were formed into a natural resource base survey database after image interpretation and field verification.

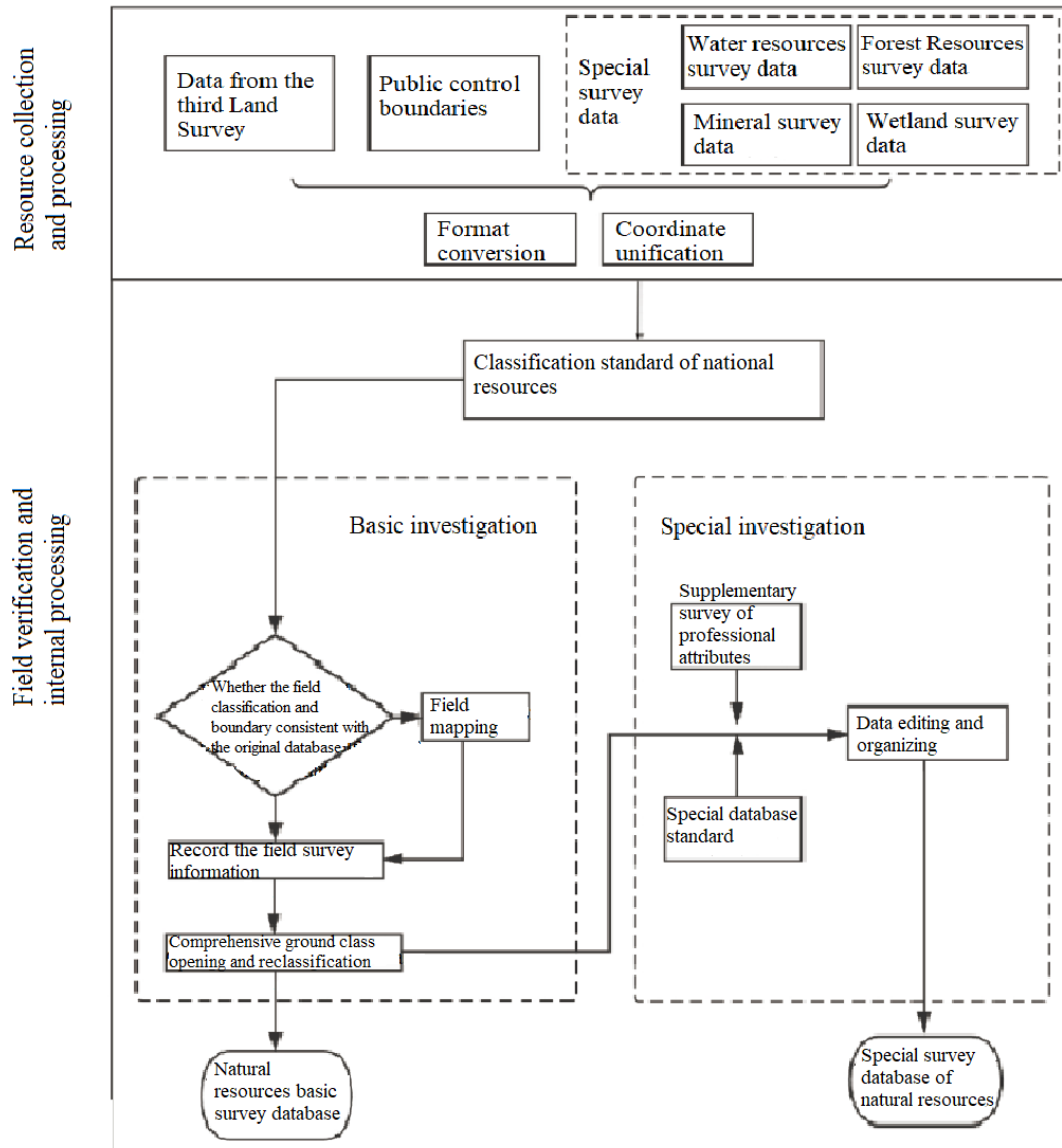


Figure 1. Technical route of natural resources surveying.

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2.2.2 Special investigations

In the basic survey, the resource map spots in the “Third Survey” are extracted and reclassified to form resource survey patches. In accordance with the *Jiangsu Standards* and the management needs of various types of natural resources, a special attribute structure table is established for each type of resource, and the corresponding character attributes are extracted from various types of thematic data collected to fill in the special attribute structure ta-

ble fields, and supplementary investigations are conducted on the vacant attribute sections to form a special survey database for natural resources.

2.3 Database organization

Natural resource survey is different from traditional land survey, various resources may intersect spatially and logically, so there will be overlap when projected in two-dimensional surface space, and it is reasonable to regard resources as a three-dimensional “resource body”. In the database organization, all resources are layered by type, and exist in the form of basic databases and specializes databases; the common management boundaries and tenure boundaries are stored separately as reference layers (**Figure 2**), neither of which cuts the survey plaque, and after the survey monitoring is completed, a summary table is generated by ownership.

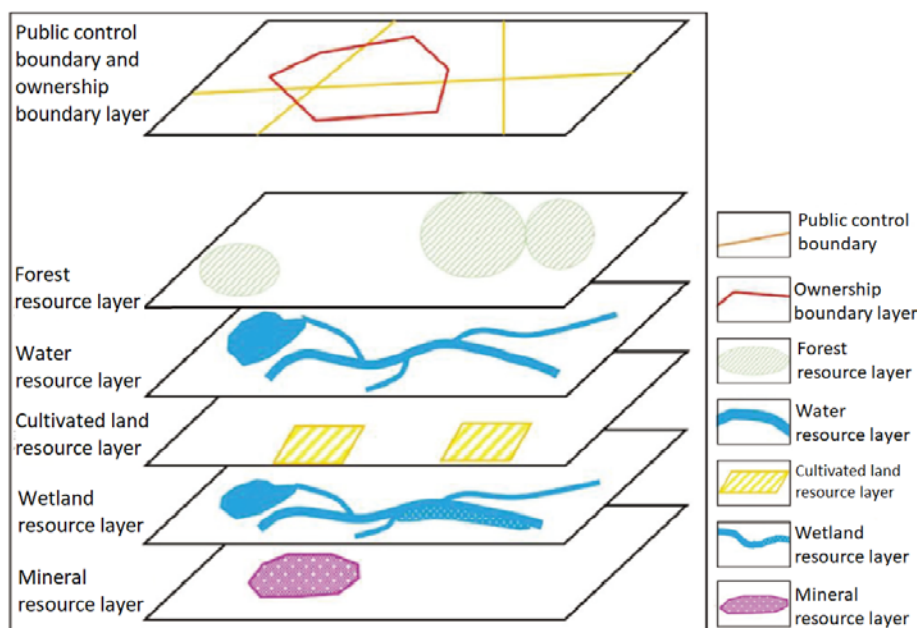


Figure 2. Organization form of natural resources database.

2.4 Natural resource monitoring and data update methodology

Natural resources monitoring is to use various information collection and processing methods within a certain time and space range to systematically observe, measure, record, analyze and evaluate the state of natural resources, so as to reveal the relationship between various factors and the internal

law of changes in the process of regional natural resource changes, and to show the trajectory and trend of resource evolution, the purpose of which is to provide macro and micro resource status data and dynamic change data for resource authorities and governments at all levels^[15].

With the continuous development of satellite sensor technology, high-resolution remote sensing

images provide specific and rich feature information, spectral information, space geometry information, and texture information^[16], which can provide great support for the classification of natural resource graphic boundaries and boundary changes. Since 2012, deep learning has made a lot of progress in the classification of surface coverage of remote sensing images^[17-20], realizing the automatic learning of classification characteristics of non-artificial design, which not only reduces manual intervention, but also improves the classification accuracy, and gradually becomes the main technical means of resource surface coverage monitoring.

After the establishment of the natural resource database, the changes in natural resources should be

grasped regularly through monitoring activities, and their updates in the database include updates of changes in the scope of resources, updates of changes in resource attributes, and updates of both at the same time. Municipal data monitoring and updating adopt the method of synchronous updating of basic surveys and special surveys: the changes in the range of resources in the basic data database are mainly extracted through high-resolution remote sensing images and deep learning algorithms, and then confirmed and updated by field verification; changes in specific attributes can be renewed through specialized surveys. The specific process is shown in **Figure 3**.

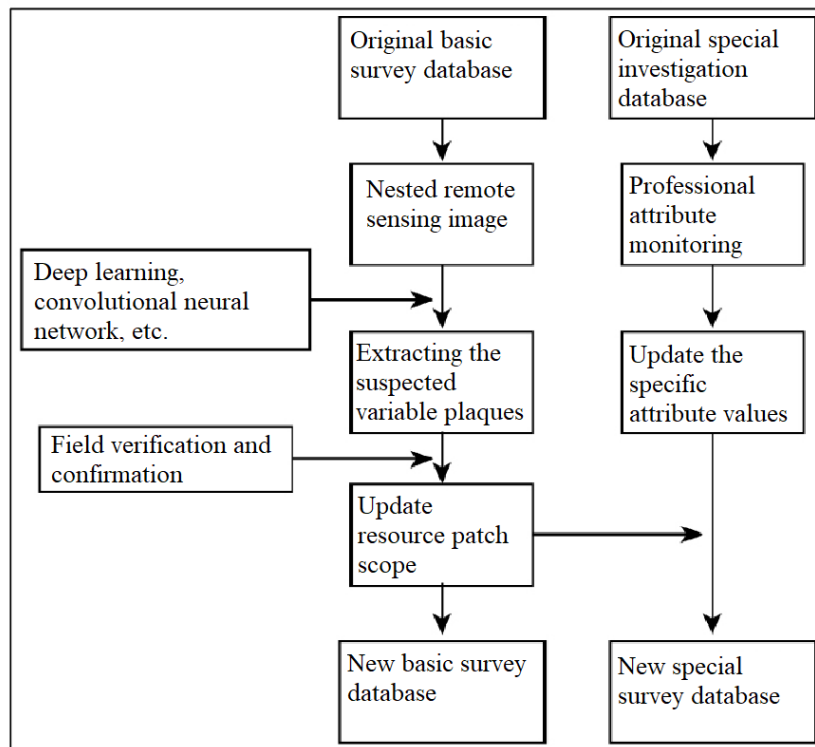


Figure 3. Flow chart of natural resources monitoring and data updating.

3. Practice verification

In order to verify the effectiveness and rationality of the *Jiangsu Standards* and the survey methods, database organization methods and monitoring and updating methods, this paper takes the main urban area of Xuzhou City, Jiangsu Province, as an example, and verifies the investigation and monitoring system.

3.1 Overview of the study area

The total area of Xuzhou City main urban area and economic and technological development zone is about 579.29 km². It is located in the southeast of the North China Plain, and influenced by the temperate seasonal climate, and it has four distinct seasons. The natural resources in the area mainly include arable land resources, water resources, forest resources and wetland resources.

3.2 Survey classification execution and verification

In this paper, the secondary categories of natural resources involved in the *Third National Land Survey Classification* are collected into the classification of natural resources stipulated in the *Jiangsu Standards*, and a comparative index table between the types of natural resources and the “Third Survey” land types in the study area is established. For example, the water resources in this survey are mainly surface water, and there are 6 kinds of surface water of rivers, lakes, reservoirs, ponds, ditches and swamps within the scope of the study area, which are collected into the 5 types of water resources classification of river water, lake water, reservoir water, pond water and other surface water. For another example, there are arbor forests, bamboo forests, shrub forests and other forests within the scope

of the study area, which are further classified into five kinds of forest resources in practice as 5 kinds of forest resources of coniferous forest, broad-leaved forest, coniferous and broad-leaved mixed, other bamboo forest, and special shrub forest, and the gardens in the “Third Survey” results such as peach forest and pear forest are collected into special shrub forest.

3.3 Analysis of natural resource data

The spatial distribution of natural resources in the study area is shown in **Figure 4**, and the statistical summary of natural resource area is shown in **Table 2**. From **Figure 4** and **Table 2**, it can be seen that the natural resources are counted by area from large to small as arable land resources, forest resources, water resources and wetland resources.

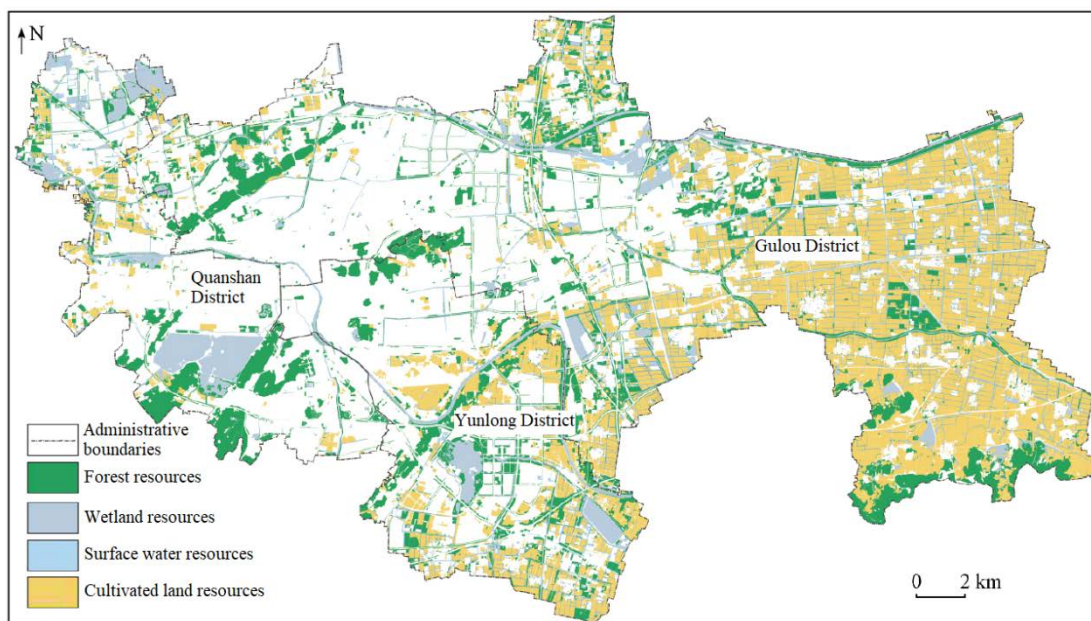


Figure 4. Spatial distribution of natural resources in Xuzhou City.

Taking forest resources as an example, the forest resources data in the 2018 natural resources survey are compared with the forest land resource data in the land use survey (**Table 3**), and the forest resources area (86.17 km²) is significantly larger than the woodland area (22.70 km²), which is due to the different classification criteria and the minimum

area of the two surveys, and the natural resource survey focuses on reflecting the amount of resources, while the land use survey focuses on distinguishing between land use forms and functions, which also explains the necessity of conducting resource surveys and finding out the total amount of resources.

Table 2. Statistical summary of urban natural resources areas in Xuzhou City

Administrative region	Cultivated land resources/km ²	Forest resources/km ²	Water resources/km ²	Wetland resources/km ²
Gulou District	118.73	49.76	30.60	21.76
Yunlong District	23.86	19.74	10.24	8.59
Quanshan District	6.39	16.67	13.55	12.80
Total	148.98	86.17	54.38	43.16

Table 3. Comparison of forest resources data in natural resources survey and forest resources data in land use survey in 2018

Administrative region	Forest resources/km ²	Forestry area/km ²
Gulou District	49.76	12.31
Yunlong District	19.74	3.39
Quanshan District	16.67	7.00
Total	86.17	22.70

4. Conclusion and problems

4.1 Conclusion

Based on the third land survey and various special survey data, this paper carried out the municipal natural resource survey practice, verified the *Jiangsu Province Natural Resources Survey and Classification* (Trial Version), and constructed the natural resource base survey database and the special survey database.

Taking Xuzhou City as an example, the natural resource survey practice carried out can better complete the survey of the quantity and quality of natural resources in the region, and has the ability to continuously update and form a multi-period data set, which can be used as the basic data for subsequent resource and ecological evaluation. This research result can provide a reference for the survey and monitoring of natural resources in prefecture-level cities.

4.2 Existing problems

At present, the scope and depth of natural resource surveys are not clearly defined, and the next step can be to explore the content of special surveys suitable for different survey scales at the national, provincial, and municipal levels, and sort out the appropriate attributes of special surveys, forming special survey specifications.

Conflict of interest

The authors declared no conflict of interest.

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