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Design and implementation of management information system of crops

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Abstract: *Under the current situation where the protection of cultivated land in China and the food security situation in other countries and regions are extremely severe, how to better manage cultivated land resources and crop resources has become an urgent task. By making use of the existing information technology means, establishing a crop information management system is one of the important ways to achieve the effective utilization and management of crop data resources. Based on the basic demands in agricultural production, this system uses the secondary development platform of Supermap iServer to design and develop a management information system of crops that is convenient for users to master crop information. Through this system, users can conveniently manage, query and analyze crop information.*

Keywords: *WebGIS; Information management system; Supermap iserver; JavaScript*

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I. Introduction

Arable land is an important strategic resource in China and the foundation of social stability and sustainable development. Farmland protection is not only related to food security, but also plays an important role in ecological security, soil and water conservation, and the agricultural resource cycle. China's basic national condition of having a large population and limited land determines the necessity of ensuring the quality and quantity of arable land.

According to the data from the third national land survey, the country's arable land area is about 127,861,900 hectares, including 31.392,000 hectares (24.55%) of paddy fields, 32.114,800 hectares (25.12%) of irrigated land and 64,355,100 hectares (50.33%) of dry land. There is a significant regional distribution, with the most arable land in Northeast China and the least in South[1] China. With economic development, the expansion of non-agricultural land has exacerbated the reduction of arable land, and the intensity of multiple cropping has increased and the quality of arable land has[2][3] declined. The change in arable land is showing a trend of "increasing in the north and decreasing in the south, advancing in the west and expanding in the north, and decreasing along the coast", and there is an inversion of arable land in some areas. The situation is severe.

Despite the fact that China's grain imports have exceeded 100 million tons for seven consecutive years, it has little say in international grain trade. Meanwhile, grain consumption has continued to grow rigidly, the supply and demand structure is unbalanced, and problems such as the decline in planting income, the increase in costs, and the incoordination of industrial policies are prominent[4]. In agricultural production, the acquisition and management of crop data are particularly important[5]. Agricultural information systems are the key infrastructure[6][7] for digitizing and modernizing agriculture. Establishing a crop information management system based on information technology helps to manage basic farmland resources[8] efficiently and dynamically.

Crop information management is the core direction[9] of agricultural information development. This system combines WebGIS with remote sensing technology, integrates the SuperMap platform (using ArcMap to process cultivated land data and publish it through iServer), Gaode Weather API and ECharts visualization tools to build an intelligent decision-making platform for the entire crop cycle. It supports spatial query and maintenance of crop species, plot attributes and agricultural activities, and combines remote sensing images, NDVI analysis, heat maps and meteorological warnings to achieve visualization and real-time monitoring of crop growth status, improve management efficiency, and provide spatial decision support for agricultural structure adjustment and disaster prevention and control.

In the middle of the 20th century, GIS began to be applied in agriculture, effectively solving various problems in agricultural production and management through integration with technologies such as 3S and the Internet, generating significant economic benefits. In the 1970s, with the development of computer technology, GIS advanced rapidly in its practical direction, and many countries successively established specialized farmland resource management systems. In the 1980s, GIS-based farmland information systems were widely used, such as the Land evaluation system built by the Soil Conservation Service of the United States Department of Agriculture in 1981, the SOTER database released by the International Society for Soil Science in 1985, and land resource information systems[10] in countries like Australia and the United Kingdom. Most of these systems were built under government leadership, covering a wide range and serving a clear[11] target group.

Research on GIS in China began in the mid-1980s, with the first GIS research laboratory located at the Institute of Remote Sensing Applications of the Chinese Academy of Sciences. Since the 1990s, research on the management of cultivated land resources has gradually deepened. In 1994, the Ministry of Agriculture built the China Agricultural Information Network, which connects more than a thousand counties and cities. Agricultural authorities at all levels, universities and research institutes also established agricultural information service platforms[12] based on GIS. In recent years, some commercial GIS vendors have also launched products related to the management of farmland resources. Modern information technology, especially WebGIS, provides strong[13] support for the development of China's agriculture towards informatization and efficiency.

WebGIS is the result of the integration of GIS and Web technologies, enabling users to access spatial data through any node on the Internet and conduct spatial retrieval and analysis operations [14]. Compared with traditional single-machine GIS, WebGIS is based on the communication architecture between the browser and the Web server, which is more suitable for the current online and distributed data service requirements [15]. Common implementations include CGI interfaces, server application programming interfaces, GIS plugins, and Java methods. WebGIS is now widely used in fields such as farmland environmental monitoring [16]. The feature of being able to remotely access GIS data and perform analysis tasks without local installation has driven GIS towards networking and popularization, making it a hot topic in current GIS research and a focus of industrial competition.

II. Solutions and key technologies

2.1 Solution

This crop information management system is built on WebGIS technology, integrating crop distribution data, NDVI index, satellite images and meteorological information, providing visual query, spatial positioning and attribute analysis functions, enabling users to obtain real-time dynamics of cultivated land resources through any terminal, and optimizing planting planning in combination with vegetation growth monitoring and weather prediction data. It enables precise decision-making for irrigation and fertilization. The system uses a distributed architecture to ensure real-time data updates and cross-platform sharing. Relying on the advantages of geographic information spatial analysis, it promotes the transformation of agricultural management towards digitalization and networking, featuring both low usage threshold and high timeliness.

2.2 Key Technologies

2.2.1 SuperMap iServer

SuperMap iServer is a distributed server development platform built on a high-performance cross-platform GIS core, fully supporting SOA architecture and open standards such as REST and OGC, enabling unified management, aggregation, and distribution of multi-source spatial services (such as maps, data, and analytics functions). Its core capabilities include data editing, real-time analysis and seamless integration with third-party IT systems in a distributed environment, and it provides a full-stack development toolkit (such as the iClient series) from Web (JavaScript/Flash), desktop applications to mobile terminals (Android/iOS) through a multi-level service expansion framework. It also supports WebGL/Plugin 3D scene building. The platform outputs professional-level GIS services with high reliability and stability, enabling users to invoke geocomputing resources across devices through standardized interfaces, meeting the needs of enterprise-level spatial data governance and agile business system construction, and promoting the deep integration of GIS capabilities into a diversified industry application ecosystem.

2.2.2 ECharts

Apache ECharts is a JavaScript data visualization library open-sourced by Baidu and donated to the Apache Foundation. It is compatible with mainstream browsers and multiple devices. It is based on the ZRender vector graphics engine and offers dozens of interactive chart types such as line graphs, maps, and relationship graphs. It supports cross-dimensional mix-and-match and customization. Its core advantage lies in the built-in dataset functionality, which can seamlessly parse two-dimensional tables, key-value peer-to-peer data sources, directly map to graphs through the encode attribute, skip the data transformation step and support multi-component sharing. The renderItem series allows users to freely expand graphic logic, combined with a rich array of interactive components, to achieve flexible presentation from basic analysis to complex scenarios such as BI dashboards and geodynamics. As an Apache incubated project, ECharts continues to iterate with an open-source ecosystem. Version 5.0 further enhances dynamic narrative and multi-dimensional data presentation capabilities, balancing development efficiency and visualization depth.

III. Requirements Analysis

The functions implemented by this system are based on the types of data obtained, including vector surface data of the distribution of cultivated land in Fugou County and attribute data related to crops, as well as the NDVI layer and satellite layer of the corresponding area, which can be superimposed and displayed with the vector surface data of cultivated land. Users can use it to roughly judge the growth of crops in the area. Since NDVI data and satellite images need to be frequently updated to the latest time period, the system also provides links to some websites for obtaining these data, which can be directly published as a map service and compared for viewing; There are also real-time and forecasted weather data for the area. Based on the above data, the system divides the plots into different units, and each unit has its corresponding attribute information, and also assigns them the corresponding center coordinates of the particle to facilitate the user's location of the plot of interest. Using the above data, it is feasible to generate the workspace files of the layers using the Supermap desktop software, and then publish the map data on the Supermap iserver platform for invocation. Add other basic features to the map through the JavaScript API provided by Supermap, and use other methods such as Autonavi API to help provide more intuitive visualization.

When using this system, the starting point is to meet the automated office needs of the relevant departments for managing business, with the aim[Error! Reference source not found.] of improving labor efficiency and reducing the labor intensity of business personnel. It helps users adjust crop planting plans, crop irrigation/fertilization plans, quickly search for information on plots of interest, and view the planting situation of the area from a macro perspective, etc. To provide data for policy formulation, land planning, etc., and to promote the stable development of agriculture.

The people using this system may not have GIS knowledge. Therefore, the system should be as simple and easy to understand as possible, and the use of technical terms should be reduced to facilitate the user's operation.

IV. Detailed system design

Based on the conclusions obtained from the analysis section, divide the functions of the system into modules to make the entire system appear clearer.

4.1 Login and registration

The form login system developed based on Visual Studio 2019 realizes user authentication and management through the SQL Server database. The system includes login and registration functions: after verifying that the UserName/Password is not empty when logging in, compare the database User table (including username and encrypted password fields) through parametric SQL commands. If the match is successful, jump to the main interface; if it fails, prompt an error. During registration, the uniqueness of the account is detected. If there is no repetition, the new user data is encrypted and stored. If it already exists, an alert is given to change the account. SqlConnection is used throughout to ensure the security of database interaction, and MessageBox is combined for operation feedback to achieve seamless connection between form interface and data layer.

4.2 Basic functions

The basic functional modules of this system adopt a modular design architecture: (1) The core GIS interaction component integrates layer management, multi-level scaling (accuracy ±0.5 m), dynamic scale and eagle eye navigation system to build a professional-level map operation environment; (2) The intelligent measurement engine supports arbitrary polygon/line drawing (based on the CGCS2000 coordinate system) to achieve centimeter-level accuracy area/distance measurement, automatically clears historical data using the server's asynchronous computing mode, and displays measurement results in real-time pop-up Windows; (3) The dynamic data update channel connects to the AI Earth platform through the external link jump mechanism, allowing users to independently obtain the latest NDVI and remote sensing image data, in conjunction with the version comparison function to achieve temporal analysis of crop growth. The three functional layers achieve service invocation through standardized REST API, forming a closed-loop workflow of "interaction-computing-update", significantly enhancing system scalability and data status.

4.3 Query location

This system builds a dual-mode spatial query engine: (1) Geometric query supports interactive drawing of polygons/circles, automatically retrieves covered plots and highlights them (with color differentiation), and provides real-time feedback on 8 core attributes such as land type, crop variety, and fertilization records, as well as planar coordinates; (2) SQL query provides keyword search for crop/cultivated land type and generates a heat map of the entire distribution. Both types of query results are linked with attribute tables for map positioning, supporting click-jump and coordinate reproduction to achieve a full-process visual decision-making loop of "spatial screening - attribute analysis - precise positioning", and the coordinate system uses CGCS2000 projection to ensure centimeter-level positioning accuracy, providing multi-dimensional data support for refined farmland management.

4.4 Statistical analysis

The statistical analysis module of this system deeply integrates meteorological data and planting data to build a two-dimensional decision support system: (1) The weather analysis end acquires meteorological elements such as temperature and precipitation in real time through Gaode API, implements dynamic visualization with Apache ECharts, supports line chart/bar chart switching, local zooming and chart export functions, synchronously displays refined meteorological parameters (wind speed, humidity, etc.), and builds an intelligent irrigation model in combination with the weather forecast for the next 3 days. It can automatically optimize irrigation and drainage plans based on drought warnings; (2) The planting analysis end, relying on the ArcMap spatial statistics engine, generates a thermal map of the planting area of multiple crops, provides interactive area proportion ring chart/accumulation bar chart switching analysis, and realizes the full-chain automation of "data acquisition - spatial calculation - visual presentation - scheme output". Both modules are designed with responsive interaction and service invocation through a standardized REST API interface, which triggers the background data cleaning and visualization rendering process with a user click, significantly enhancing the timeliness and scientific nature of agricultural decision-making.

4.5 Layer marking

To help users mark plots of interest, a marking function is provided that can be set to be editable, selectable, and locked, allowing users to rotate, drag, scale, and transform the drawn graphics.

V. System implementation

5.1 User login

User login and registration interface (as shown in Figure 1) .

Figure 1 Login interface

Here is the data from the user information table stored by SQL Server (as shown in Figure 2) :

DESKTOP-BM534LI\...- dbo.usertable

	userid	password
	aaa	123
	bbb	123
	ccc	123
▸*	*NULL*	*NULL*

Figure 2 User Information Table

When a user successfully registers, the user data table is updated accordingly (as shown in Figure 3) :

DESKTOP-BM534LI\...- dbo.usertable

	userid	password
	aaa	123
	bbb	123
	ccc	123
	newID	123
▸*	*NULL*	*NULL*

Figure3 The post-registration information table

5.2 Measurement function

The measurement situation when the user selects the distance measurement function and draws the line segment (as shown in Figure 4) :

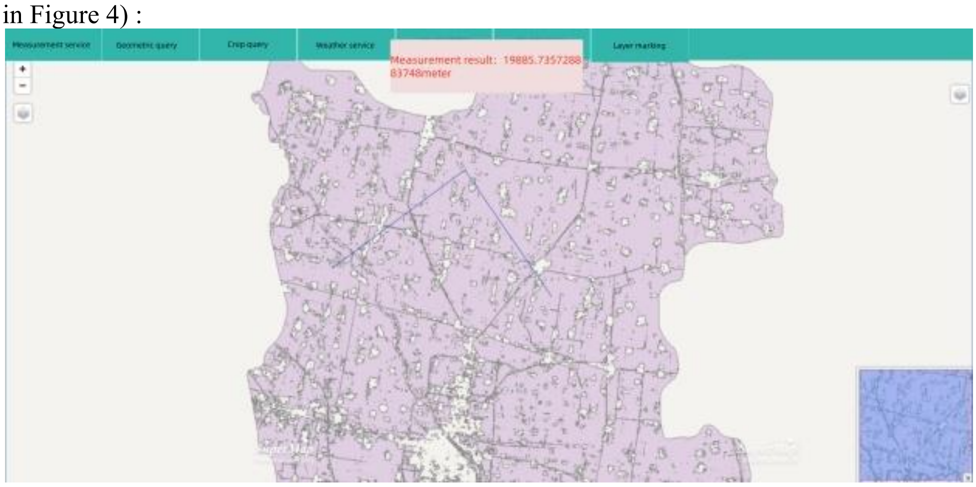

Figure 4 Distance measurement

The measurement situation when the user selects the area measurement function and draws a custom graph (as shown in Figure5) :

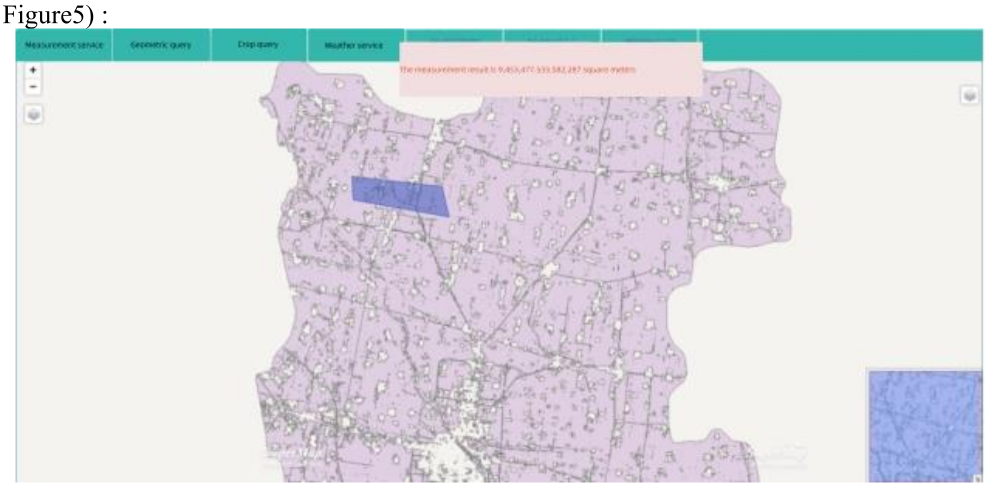

Figure5 Area measurement

5.3 Query function

The query situation when the user selects the rectangle query function and draws the graph at any position (as shown in Figure 6) :

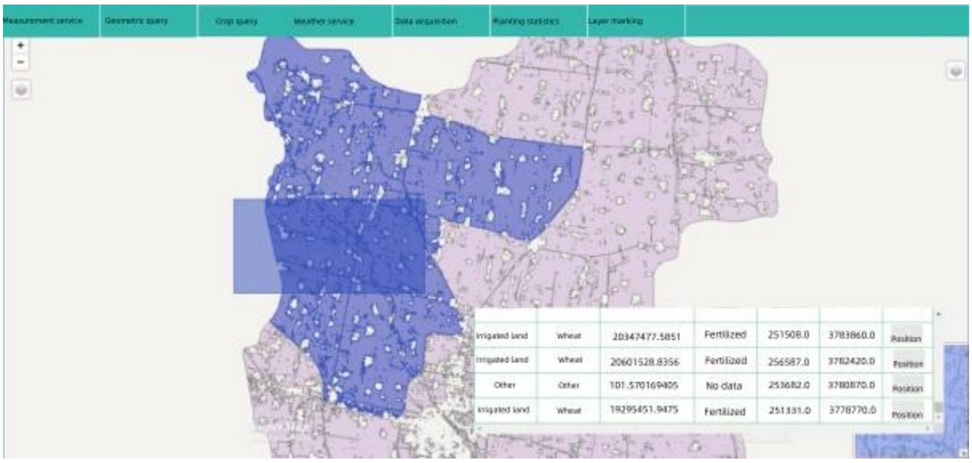

Figure 6 Rectangular query

The query situation when the user selects the circular query function and draws the graph at any position on the map (as shown in Figure 7) :

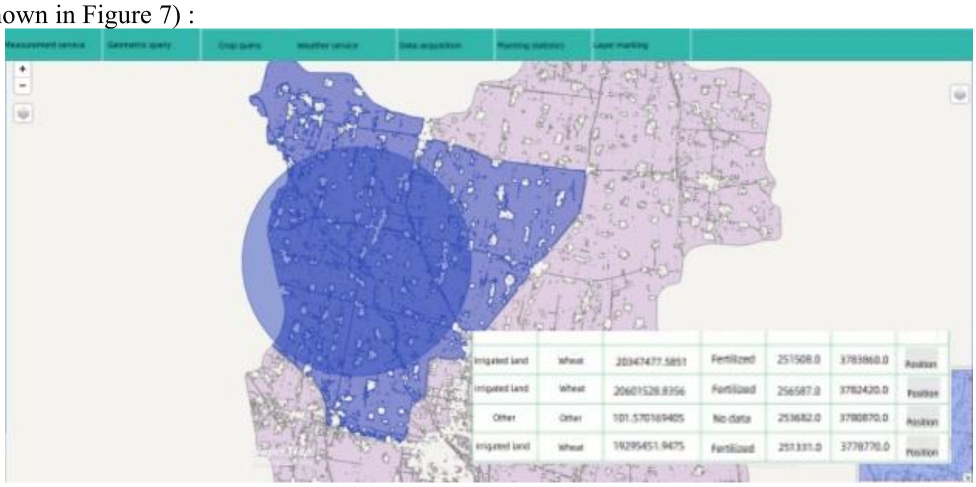

Figure 7 Circular query

Zoom to the corresponding plot when you click the location button in the property table of any query function result (as shown in Figure8) :

Figure 8 Location function

The query result when the user clicks on the crop query (for example, querying wheat) (as shown in Figure 9) :

Figure 9 SQL query

When the user clicks on the farmland query, take the irrigated land query as an example (as shown in Figure 10) :

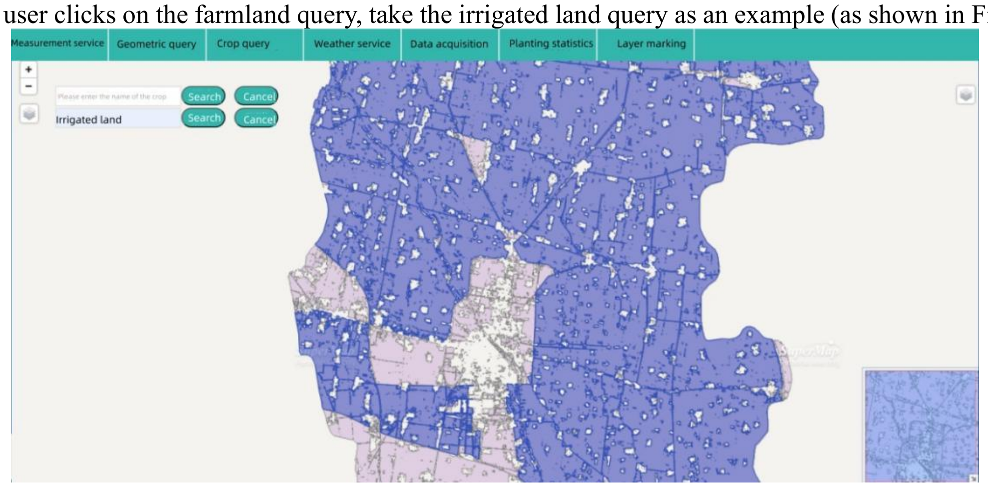

Figure 10 Farmland query

5.4 Weather Services

When the user clicks the weather Service button, real-time and forecast weather information is provided (as shown in Figure 11) :

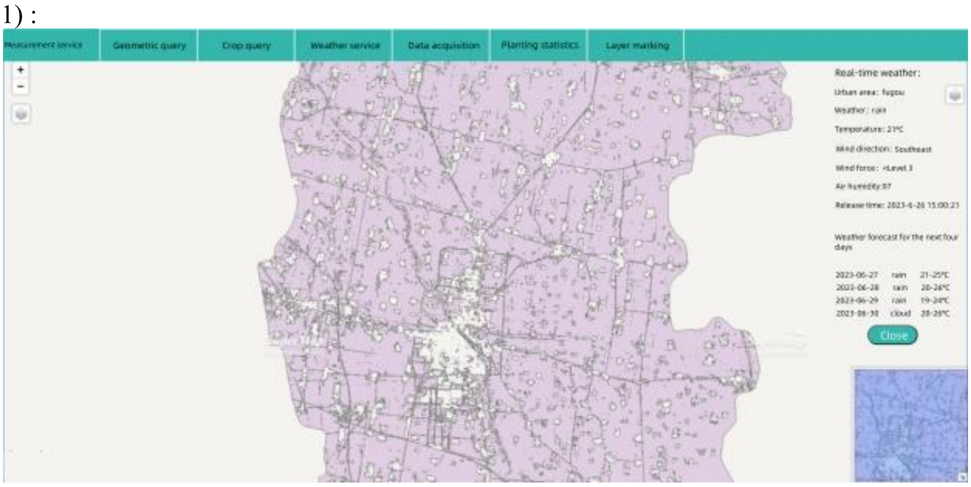

Figure11 Weather service

After the user clicks the forecast statistics button, a statistical chart of the highest and lowest temperatures predicted for the next three days is given, and simple suggestions are provided based on the actual weather conditions for the next three days (as shown in Figure 12) :

Figure 12 Activity suggestions

5.5 Planting statistics and data acquisition

When the user clicks on planting statistics, a statistical graph of the planting area of various crops in the study area is provided (as shown in Figure 13) :

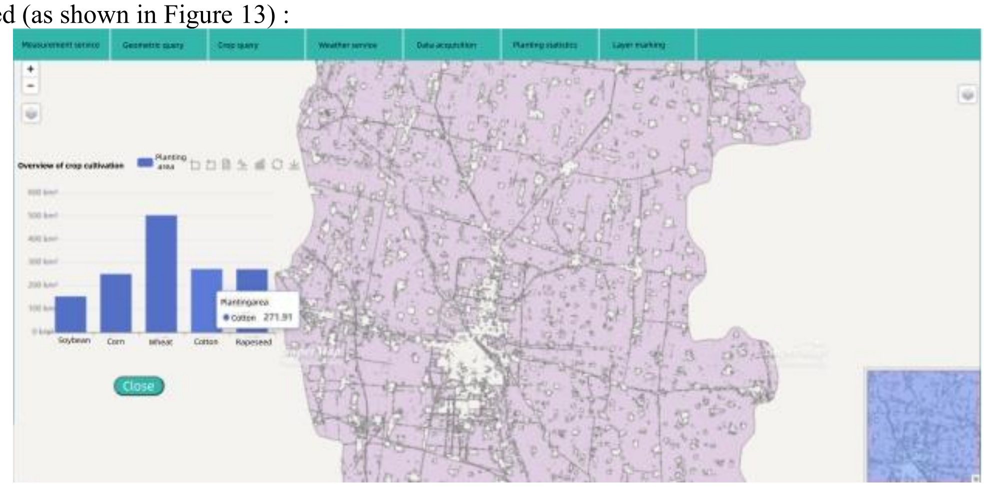

Figure 13 Planting statistics

5.6 Layer marking

When a user clicks on a layer mark, they can set the mark to be drawn, and after the drawing is completed, they can perform operations such as rotating, scaling, dragging, and changing shape on it (as shown in Figure 14) :

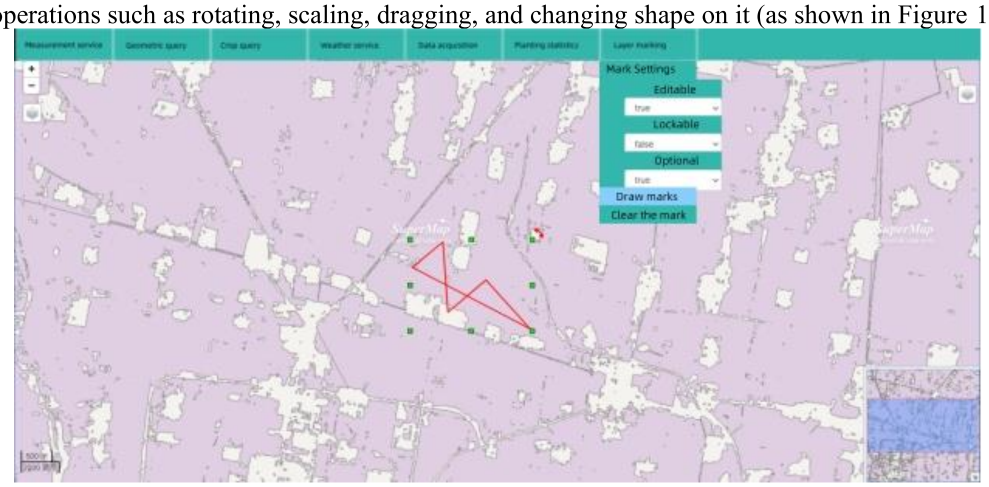

Figure 14 Layer markings

VI. Conclusion

This system integrates multi-source geographic information data to build an agricultural decision support platform for the county scale. The fusion processing of AI Earth remote sensing data (10-meter ground object classification dataset, NDVI, satellite images) and Gaode Weather API was achieved at the data layer. The processing procedures such as mask cropping and raster vectorization of the cultivated land data in Fugou County were completed through ArcMap, and the spatial data release and management were implemented using the SuperMap technology stack. The front end of the system integrates ECharts visualization components and SuperMap JavaScript API to build an interactive WebGIS interface with multi-dimensional analysis capabilities.

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