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ORIGINAL RESEARCH ARTICLE

Mapping of township agricultural land use based on Sentinel-2A images

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ABSTRACT

Objective: to achieve accurately and rapidly the mapping of agricultural land use and crop distribution at the township scale. **Methods:** this study, based on specific methods, such as, time-series remote sensing index threshold classification and maximum likelihood, classifies each land use type and extracts crop spatial information, under the guidance of Sentinel-2A remote sensing images, to carry out agricultural land use mapping at township scale. And the mapping concerned will be verified by comparing with an agricultural spatial information map of a 0.5 m resolution, which is based on WorldVieW-2 fused images. **Results:** (1) the area accuracy of grain and oil crop land, vegetable land, agricultural facilities land and garden land is fairly good, with 92.93%, 98.98%, 95.71% and 95.14% respectively, and within 8% variation from actual area; (2) the spatial information of plot boundary, farmland road network, and canal network produced by OSM road data and historical high-resolution images was overlayed with the classification results of Sentinel-2A multi-spectral image for mapping, which can improve the accuracy of plot boundary information of classification results for the image with 10 m resolution. **Conclusions:** the use of multi-source information fusion method, agricultural land use and crop distribution space big data produced by Sentinel-2A optical image, can effectively improve the accuracy and timeliness of land use mapping at the township scale, to provide technical reference for the application of remote sensing big data to carry out agricultural landscape analysis at the township scale, optimization and adjustment of agricultural structure, etc.

Keywords: Multi-source Remote Sensing Data; Land Use; Township Scale; Mapping

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1. Introduction

Through the methods, such as long-time series remote sensing, geographical mapping, domestic and foreign scientific research institutions have produced several sets of products of global land coverage, land use status[1,2], planting structure[3,4], crop distribution[5,6]; Chinese land department regularly conducts the survey and update for national land use change ,and Ministry of Agriculture and Rural Affairs has carried out the work, such as contracted land confirmation survey and "two districts" demarcation in recent years. The government departments have accumulated large agricultural space data, such as land use type, land use and ownership. Land use space information reflects the information of multiple development and utilization of land for human, however, the description of spatial information with a variety of connotations, such as agricultural production, crop planting, and agricultural resource utilization is insufficient. Moreover, rural areas in China are generally small-scale peasant economy with small land area. In the early stage, they are limited by the factors, such as the spatial and temporal resolution of remote sensing images and incomplete data coverage, lacking open use of the agricultural spatial information with high-spatial resolution.

At present, the information on the crop planting structure is widely studied and applied in the scale, such as global and national, and its temporal-spatial resolution is generally 30–1,000 m[4,5]. It is difficult for large-scale information to accurately reflect the planting structure of various fine crops, and it can not meet the digital needs, such as agricultural planning, structural adjustment, and production management in towns and villages. With the free access of a variety of 10–30 m resolution remote sensing images, the cost of agricultural remote sensing monitoring, agricultural land classification and other applications, etc., can be reduced, and crop planting structure which is small-scale and high-resolution and the information on agricultural land use have received more attention and research, with application prospects and potential[7,8]. The article intends to use the Sentinel-2A images with 10 m resolution for agricultural land use and crop planting structure mapping at the township level, and evaluate the accuracy of the information for crop planting structure obtained by Sentinel-2A images compared to the 0.5 m resolution planting structure map, which is produced by WorldView-2 fusion images, so as to apply remote sensing big data to provide technical reference by carrying out agricultural landscape analysis at the township scale, optimization and adjustment of agricultural structure.

1. Data and methods

1.1 Overview of the study area

The typical agriculture-based town (Mouli Town, Qionglai City) in Chengdu, Sichuan Province was selected as the research area. The area is located in the southeast of Qionglai City, about 25 km and 60 km away from Qionglai City and the center of Chengdu City, which has convenient transportation and is a typical urban suburban town (**Figure 1**). The region has a subtropical humid climate with four distinctive seasons ,average temperature of 17.8 ℃ and average annual rainfall of about 1,300 mm; the internal area is flat, with flat dam and shallow hill, mainly flat dam. The size of cultivated land in this area is about 23.33 km^2, the layout of the field road is reasonable, and the drainage and irrigation facilities are supporting. With the development of urban agriculture, it has been gradually formed large-scale and specialized agricultural industries, such as grain, oil, fruit, vegetables and aquaculture, which is a town of the leading development in Chengdu with the suburban agricultural function.

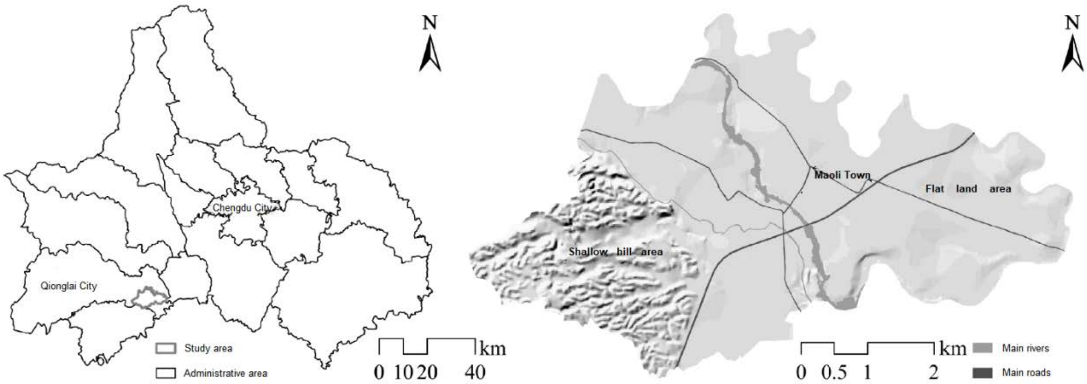

Figure 1. The location of the study area.

1.2 Data source

High-resolution remote sensing image is the main data source for extracting the use information of agricultural land, which is used in large-scale regular agricultural monitoring, but it is expensive based on a single high-resolution data. Extracting different types of land use information based on multi-source data can make full use of the advantages of all kinds of data, reduce data cost and improve information accuracy. Therefore, the text will use multiple open data currently and commercial data to extract the various spatial information needed for the study. Part of the historical high resolution images are from Google Earth platform; 0.5 m resolution WorldView-2 images were acquired through purchase; Sentinel-2A multi-spectral images were from Copernicus Open Access Hub of ESA. This article uses QGIS to download the open block data of the study area, and obtains the data on typical land interpretation markers and the use of land types in the study area through the field survey on February 5, 2018.

1.2.1 OpenStreetMap data

OpenStreetMap (OSM) open data were downloaded, and various information of construction land was extracted, such as roads and settlements. OSM is currently the most widely used open source geospatial database in the world, providing users with free spatially distributed vector data of a variety of ground objects, and users can download the metadata for further editing, modification and use.

1.2.2 Remote sensing image

The WorldView-2 satellite was launched on October 6, 2009, running on a 770 km high solar synchronous orbit. It is a versatile commercial remote sensing satellite. The satellite-borne multi-spectral remote sensor can provide 0.5 m panchromatic band images and multispectral images with 1.8 m resolution. Multispectral images include four commonly used standard segments (red, green, blue, near-infrared), and can customize images of four additional bands (coastal blue, yellow, red edge, and near-infrared 2). The Sentinel-2 satellite is a small satellite constellation launched by ESA in 2015 (Satellite A) and 2017 (Satellite B) respectively. The single-satellite revisit cycle of Sentinel-2 is 10 d and the A/B binary-satellite revisit cycle is 5 d. The multi-spectral imager equipped by the satellite has sensing capability at 13 spectral bands, with three spatial resolutions of 10 m, 20 m and 60 m. Image data acquired within the study area include: true color synthetic images at Google Earth on January 24, 2013, WorldView-2 images on February 28, 2018, and high-quality cloudless Sentinel-2A multi-spectral images on March 8, 2018, May 15, 2018, and December 16, 2018.

1.3 Extraction and mapping of agricultural spatial information

1.3.1 Arrangement of basic spatial information

The article uses geographic information system software such as QGIS, ArcGIS to complete data cleaning, sorting, cutting, editing and update, and based on Google Earth 0.5 m resolution image data, to extract plot boundary information and supplement the missing farmland road network and canal network, etc., in OSM and use ArcGIS and ENVI remote sensing image to process software for mapping. The basic spatial information in the research area is shown in **Figure 2**.

1.3.2 Extraction of agricultural space information

According to the field survey, land use type includes agricultural land and construction land in the sample, among which agricultural land includes cultivated land (grain and oil crops, vegetables and other crops, etc.), woodland, garden land (orchard land mainly for kiwi, grape, plum, citrus, etc.), agricultural facilities land, pit surface (artificial pits and ponds except for natural rivers, aquaculture and irrigation reservoir, etc.), construction land for buildings and main roads.

In ENVI 5.5, the WorldView-2 images were preprocessed such as the data fusion, geometric registration, to obtain the remote sensing images with spatial resolution of 0.5 m in the survey sample area. Through visual interpretation, all kinds of information on agricultural land use and crop planting structure were extracted from the images. Then, the basic spatial information such as roads and residential buildings is integrated with them to obtain the agricultural spatial information data set with 0.5 m resolution.

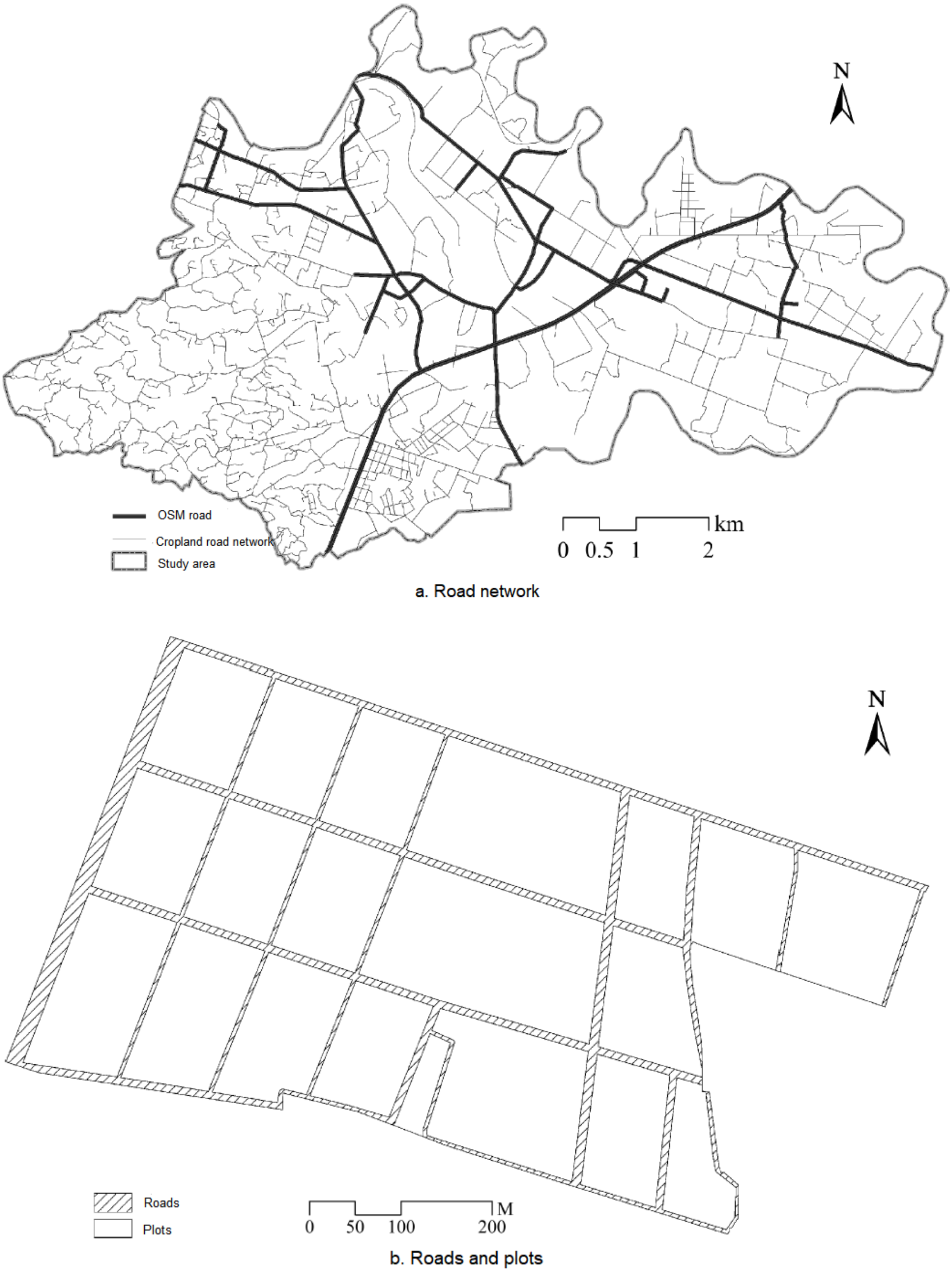

Figure 2. Basic spatial information of the study area.

For multi-time Sentinel-2A satellite images, 10-band data with spatial resolution of 10 m were obtained, including geometric correction, image fusion, data synthesis, image cutting and image fusion; NDWI index of each period was calculated, NDWI data were formed through data synthesis, and water bodies and rivers were extracted by the remote sensing index threshold method.

Through pre-processing, such as geometric correction, image fusion, data synthesis, image cutting and image fusion, 10-band data with spatial resolution of 10 m at Phase 3 was obtained; NDWI index in each period was calculated, which was formed through data synthesis, and the information such as water and river, was extracted by the remote sensing index threshold method. Then use the supervision classification method and the existing spatial information as masks to gradually extract the grain and oil crop land, garden land, forest land and vegetable land, etc.

2. Results and analysis

2.1 Evaluation of information accuracy

This article compares the information of land use and crop land type at the 10 m resolution with the 0.5 m resolution results, to evaluate the classification accuracy based on Sentinel-2A images.

The sample area with validation was randomly selected in the study area and the results are shown in **Table 1**. The regional area accuracy of all types of land objects reached more 92%, indicating that Sentinel-2A images at the 10 m spatial resolution have good accuracy in extracting land use and the information of crop land type. Based on the method of agricultural spatial information mapping, we can quickly obtain the products of agricultural spatial information with higher accuracy by using the advantages of high spatial and temporal resolution of remote sensing images of such satellite and open and free data.

Table 1. Classification accuracy of major land use and crop land types in the study area

	Grain and oil crop land	Vegetable land	Agricultural facilities land	Garden land
Accuracy of Area (%)	92.93	98.98	95.71	95.14

2.2. Agricultural spatial information

The classification results were superimposed with the road boundary vector data, and the classification results were postprocessed by graph spot expansion and edge fusion, etc., to obtain the data set of the agricultural spatial information with 10 m resolution. The local mapping effect is shown in **Figure 3**, and the distribution of land use and crop land types is shown in **Figure 4**.

Figure 3 shows that the decomposition results have blurred boundaries and there is an obvious phenomenon of sticky parcels. The basic spatial information is superimposed with the Sentinel-2A multi-spectral image classification results to optimize the plot edges and form closed plot boundaries, which can effectively integrate the image classification results at the 10 m resolution and improve the accuracy of plot boundary information.

From **Figure 4**, it can be seen that the garden land is mainly concentrated in the shallow hill area, while the land for grain and oil crops, vegetable land and facility agricultural land are mainly distributed in the flat dam area, and there is an obvious partition of land use and crop land types. The agricultural structure is gradually diversifying from traditional monoculture, and the trend of industrial scale is strengthening.

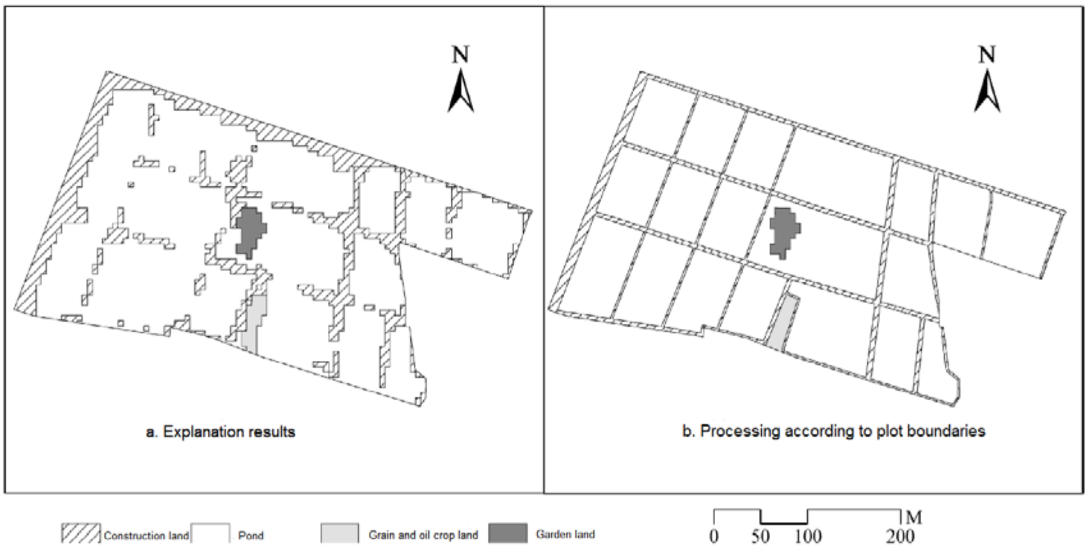

Figure 3. Comparison of land use and crop land types.

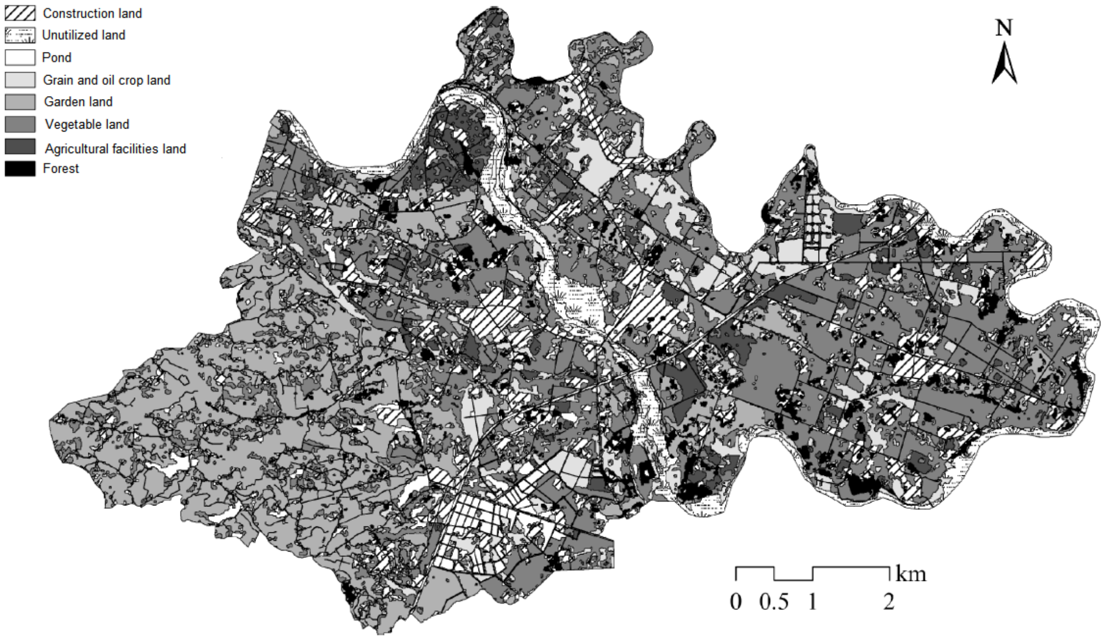

Figure 4. Distribution of land use and crop land types in the study area in 2018.

3. Discussion

Mouli Town is close to Chengdu City. In order to meet the production and living needs of urban residents, the types of crops in the region are diverse and the land use is complex. The spatial resolution of Sentinel-2A multi-spectral remote sensing images is different from that of WorldView-2 images, whose spatial heterogeneity and scale differences[9,10] will lead to a certain error. In addition, the supplement of the basic spatial information based on Google Earth mainly relies on manual visual interpretation with large human cost. In future, we should try to explore more advanced methods to quickly improve the basic spatial information, and provide technical support for the construction of the spatial and temporal big data of agricultural land in the plain area, Chengdu, the quantitative analysis of land use and agricultural pattern, and the attempt to evaluate the economic, social and ecological comprehensive effects of the change of land use.

4. Conclusion

Using Sentinel-2A multi-spectral remote sensing images, taking Mouli Towns, Qionglai City as the study area and based on domestic and foreign open-access multi-source remote sensing data and the products of spatial information, a method of producing products of township-scale agricultural spatial data with high accuracy was established. Through timing remote sensing index threshold classification and maximum likelihood method, etc., the classification of the land use type was completed, with crop spatial information extracted, producing the township-scale agricultural land use map, and comparing and verifying agricultural spatial information map with the 0.5 m resolution based on WorldView-2 fusion images. The results show that: (1) in the study area, the area accuracy of grain and oil crop land, vegetable land, agricultural facilities land and garden land is good, with 92.93%, 98.98%, 95.71% and 95.14% respectively, and the difference with the actual area is within 8%. (2) The spatial information of plot boundary, farmland road network, canal network, etc., produced by OSM road data and historical high-resolution images, etc., was overlayed with the classification results of Sentinel-2A multi-spectral images for mapping, which can improve the accuracy of plot boundary information of classification results for the images with 10 m resolution.

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