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Monitoring of Land Use Change in Shijiazhuang City Based on Remote Sensing Data

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Abstract: *With the rapid development of cities, urban land use monitoring has become the focus of increasing attention. In order to monitor the change of land use in Shijiazhuang City, the Sentinel-2 remote sensing data images from 2019 to 2022 were selected, processed by supervised classification and analyzed for dynamic changes. The result shows: the area of building land has shown an increasing trend, and the proportion of cultivated land occupied by urban expansion is the highest, and the change is most obvious in the city center; forest area increased; rivers show a tendency to expand, and the rivers represented by the Hutuo River have the most obvious changes. During the four-year period, the center of gravity of the city has changed, and the center of gravity of the city will move to the southwest in 2019-2020; the center of gravity of the city moves to the north from 2019 to 2022. Relevant land use changes can provide important references for urban development planning.*

Keywords: *remote sensing; monitor; land use; supervised classification*

1. Introduction

The physical cover observed on the Earth's surface is called “land cover” and the use of land by humans is called “land use”[1]. Information on land use and land cover and their changes in urban areas is critical for urban land management decision-making, ecosystem monitoring and urban planning. Traditional on-the-spot detection and ground object analysis have the disadvantages of time-consuming and labor-intensive. With the development of space technology, satellite remote sensing collects multi-spectral, multi-resolution, and multi-time data, which can be used for long-term dynamic monitoring[2].

With the continuous development of remote sensing technology and the improvement of spatial-temporal resolution and spectral resolution of remote sensors, remote sensing data has become the best data source for studying the dynamic changes of urban land use, and it is also a key tool for natural resource management[3]. Over the past few years, a great deal of research has been done on urban growth and sprawl development patterns using satellite data and geographic information systems[4]. Herold et al. (2002, 2003) conducted a comprehensive study of urban land cover dynamics using remote sensing data to develop spatial (landscape) indicators, analyzed and interpreted in conjunction with results from spatial models of urban growth[5]. In 2010, Boori et al. used satellite remote sensing technology to monitor land cover changes at different scales and achieved beneficial results[6].

This paper selects the Sentinel-2 remote sensing data images of Shijiazhuang City from 2019 to 2022, and adopts the supervised classification method for processing.The dynamic degree of land use and the migration model of urban center of gravity are obtained, which provide the development basis for the development planning of Shijiazhuang City.

2. Study Area and Data

2.1 Study Area

The research area is Shijiazhuang City, Hebei Province, which is located in North China, central and southern Hebei Province, and Bohai Bay Economic Zone, between 37°27′-38°47′ north latitude and 113°30′-115°20′ east longitude, as shown in Figure 1. The seasonal variation of solar radiation is significant, with four distinct seasons, cold and hot. The longest point from north to south is 148.02 kilometers, and the widest point from east to west is 175.38 kilometers, with a total area of 14,530 square kilometers. As of the end of 2021, the permanent resident population of Shijiazhuang is 11.2047 million people, population density is high, and land resource utilization is tight, so how to plan and use land reasonably is particularly important.

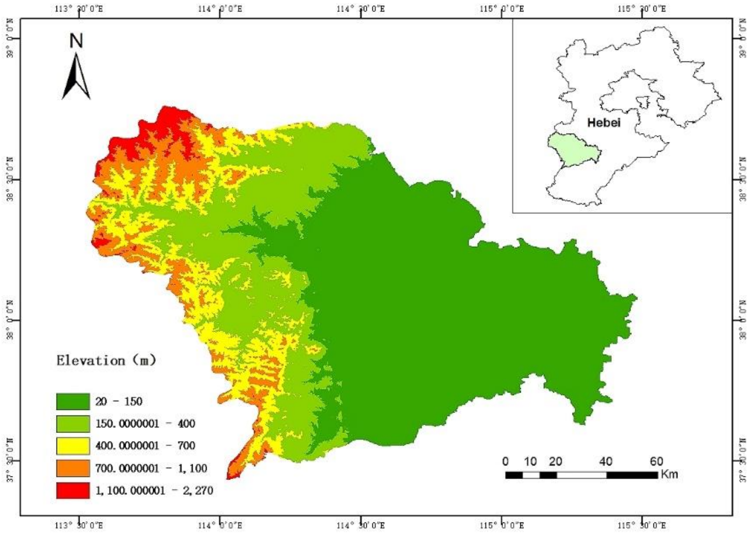

Figure 1: Location of the study area

2.2 Data

The research data uses the multispectral data of Sentinel-2, and selects images from four periods of spring, summer, autumn and winter from 2019 to 2022, as shown in Table 1. The Sentinel series is currently the most powerful free remote sensing data, with high spatial resolution, good spectral quality, and a full range of categories. The optical sensor carried by Sentinel 2 is combined with Sentinel 1. It has a height of 786km, can cover 13 spectral bands, and has a width of 290 kilometers, large-scale, high-revisit data can be obtained, which can be used for forest monitoring, land use change, vegetation health monitoring, etc.

Table 1: Image data time of the study area

Spring	Summer	Autumn	Winter
May 28, 2019	August 16, 2019	November 14, 2019	December 4, 2019
April 27, 2020	June 6, 2020	October 24, 2020	December 13, 2020
April 27, 2021	June 26, 2021	September 29, 2021	December 18, 2021
April 7, 2022	August 25, 2022	October 24, 2022	February 2, 2022

3. Research Methods

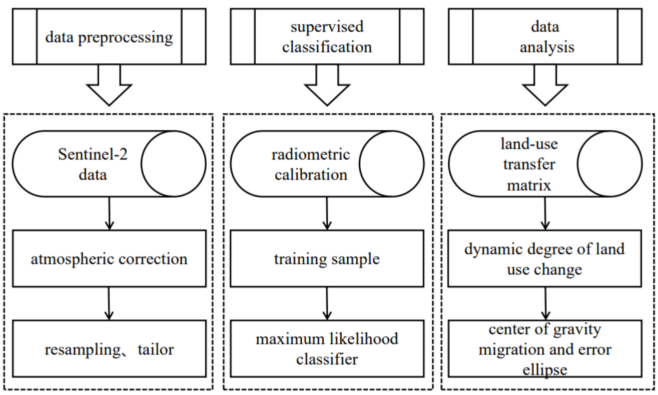

Figure 2: Research process

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In this study, data preprocessing such as atmospheric correction, resampling, and cropping is performed on the downloaded Sentinel-2 data image first, then the supervised classification method was used to select training samples, since all images have the same spatial resolution for a particular band, maximum likelihood classification is performed [4]. Finally, the conclusion is drawn by data analysis using the land transfer matrix, land use dynamics, center of gravity offset and ellipse error. As shown in Figure 2.

3.1 Data Processing

Perform atmospheric correction on Sentinel-2 multispectral data downloaded from ESA in sen2cor software, and complete the transformation from L1C data to L2A data. Secondly, the resampling process is performed. Since there are three different resolutions between the Sentinel-2 bands, if the data is not unified into the same resolution, many subsequent operations will not be possible. Therefore, the image is resampled in SNAP with a resolution of 10m.

3.2 Supervised Classification Based on Maximum Likelihood

Supervised classification is the most commonly used technique in the quantitative analysis of remote sensing image data. At its core is the concept of segmenting the spectral domain into regions associated with application-specific ground-cover classes of interest [7]. According to the land classification standard, the land use types in Shijiazhuang City are divided into five categories: building, cultivated land, forest land, river and bare land. There are many algorithms available for this classification, and the maximum likelihood method is selected for all images in this paper.

The maximum likelihood algorithm (MLC) is one of the most commonly used supervised classification methods for remote sensing image data. The method is based on the probability that a pixel belongs to a particular class. The underlying theory assumes that these probabilities are equal for all classes and that the input bands have a normal distribution [8]. On this basis, the land use change transfer matrix is output to further analyze the dynamic changes of land cover types.

3.3 Land use dynamics

This paper uses the dynamic degree analysis method to calculate the change speed of land use types in Shijiazhuang City. Land use dynamics index for quantitative monitoring of intensity changes in a land use type [9]. Its calculation formula is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\% \qquad (1)$$

U_a and U_b are the area of a certain land use type at the beginning and end of the study period, respectively. T is the length of time. When T is the year, the value of K represents the annual rate of change of a certain land use type [10].

3.4 Urban Center of Gravity Migration and Standard Deviation Ellipse

Urban growth, especially the shift of residential and commercial land to rural areas on the periphery of urban circles, has long been seen as a sign of regional economic vitality [11]. The center of gravity migration model can intuitively reflect the spatial variation of the research land type. The standard deviation ellipse method is one of the classic methods to analyze the directional characteristics of spatial distribution. The size of the ellipse reflects the concentration of the overall elements of the spatial pattern, and the declination (semi-major axis) reflects the dominant direction of the pattern. In order to study the migration of the center of gravity of buildings in Shijiazhuang City from 2019 to 2022, was used to draw the location of the center of gravity of the buildings and the standard deviation ellipse for each year.

4. Results Analysis

4.1 Classification Results and Accuracy Evaluation

Taking Shijiazhuang City as an example, this paper uses the supervised classification method to analyze the spatial distribution characteristics of the five land types in the study area from 2019 to 2022.

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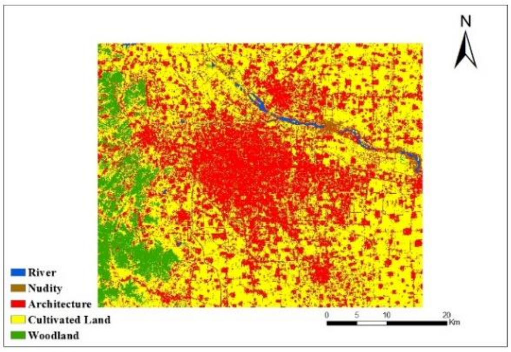
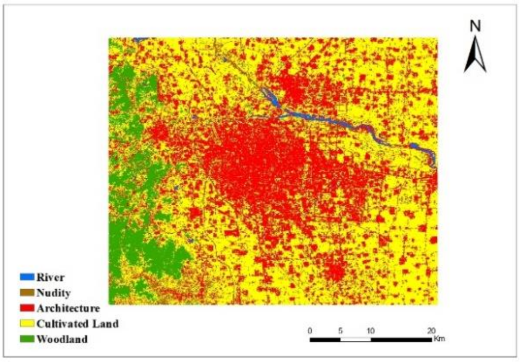
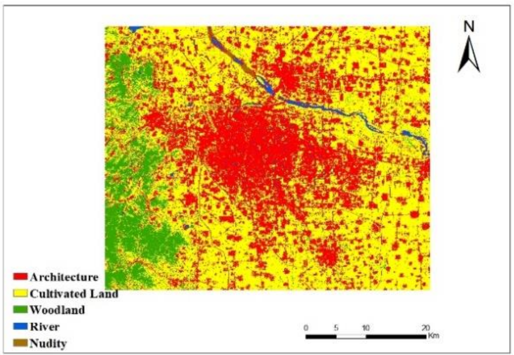
From Figure 3, we can clearly see the distribution of various types of land use in Shijiazhuang City under the four times phases: buildings are concentrated in the central region, Hutuo River runs across the middle and upper parts, cultivated land is surrounded and distributed around the city, woodland is concentrated in the western mountainous area. After classification, sample accuracy was verified, and Kappa coefficient was all above 0.85, which proved that the classification results were highly reliable.



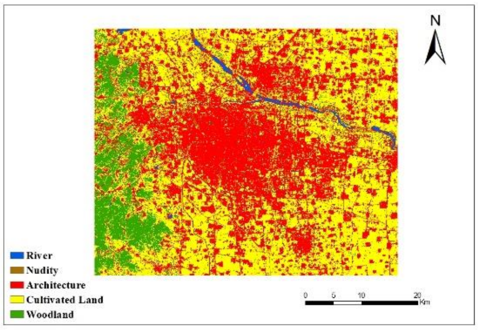
(a) 2019 classification of land



(b) 2020 classification of land



(c) 2021 classification of land



(d) 2022 classification of land

Figure 3: The result of classification

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4.2 Analysis of Changes

Figure 4 reflects the proportion of various types of land use in Shijiazhuang City in four years:

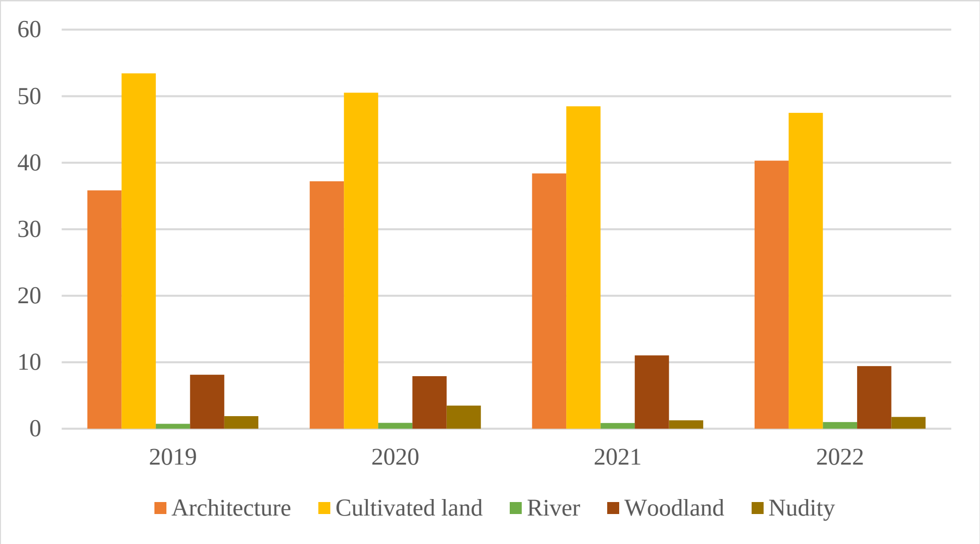

Figure 4: Land use type change

The land use situation in Shijiazhuang City is shown in Table 2: construction area of 2019 is 847.12km^2, occupying the land area of the study area 35.84 %; cultivated area is 1262.52km^2; occupying the land area of the study area 53.42%, occupy the largest proportion; river area is 17.56km^2, occupying the land area of the study area 0.74%; woodland area is 191.70km^2, occupying the land area of the study area 8.11%; nudity area is 44.50km^2, occupying the land area of the study area 1.88%. With the continuous development and urbanization of Shijiazhuang, by 2022, construction area becomes 952.63km^2, increased 4.46%; cultivated land becomes 1122.61km^2, decreased 5.92%; river area becomes 23.58km^2, increased 0.25%; woodland area becomes 222.44km^2, increased 1.30%; nudity area becomes 42.15km^2, decreased 0.10%.

Table 2: City center of gravity

Land use type	2019	2022	Variation/km^2	Dynamic degree/%
architecture	847.12	952.63	105.51	3.11
cultivated land	1262.52	1122.61	-139.91	-2.77
river	17.56	23.58	6.02	8.57
woodland	191.70	222.44	30.74	4.01
nudity	44.50	42.15	-2.35	-1.32

This study uses Arcgis to process the raster data of land use types in Shijiazhuang City from 2019 to 2022 to obtain the land use transfer matrix. It can be seen from Table 3 that the conversion between land use types is complicated, the most obvious one is the area conversion between cultivated land and construction land, 74.29% of the reduced cultivated land was converted to construction land, and 85.36% of the increased construction land came from cultivated land. The area of forest land increased, of which 92.10% came from cultivated land, and 6.50% came from construction land. The area of the river and the area of the bare land did not change much.

Table 3: Land use change transfer matrix from 2019 to 2022

Unit: Km^2

2019	2022					
	River	**Nudity**	**Architecture**	**Cultivated land**	**Woodland**	**All**
River	14.58	0.07	2.65	0.18	0.09	17.56
Nudity	1.86	5.46	26.05	10.44	0.69	44.50
Architecture	3.94	24.71	732.86	82.04	3.57	847.12
Cultivated land	2.87	11.43	187.60	1010.00	50.61	1262.52
Woodland	0.33	0.48	3.46	19.95	167.48	191.70
All	23.58	42.15	952.63	1122.61	222.44	2363.41

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Analyze the spatial concentration and direction change trend of the architectural complexes in Shijiazhuang City, connect the obtained urban centers of gravity in the four periods, and draw the standard deviation ellipse, as shown in Figure 5, the center of gravity coordinates and migration distance information are shown in Table 4. From the point of view of the longitude of the center of gravity, the longitude will not change significantly from 2019 to 2022. From the perspective of latitude, the latitude will increase from 2020 to 2022, which is manifested by the city's northward development. On the whole, the center of gravity of the city will move to the southwest from 2019 to 2020; the center of gravity will move to the north from 2020 to 2022.

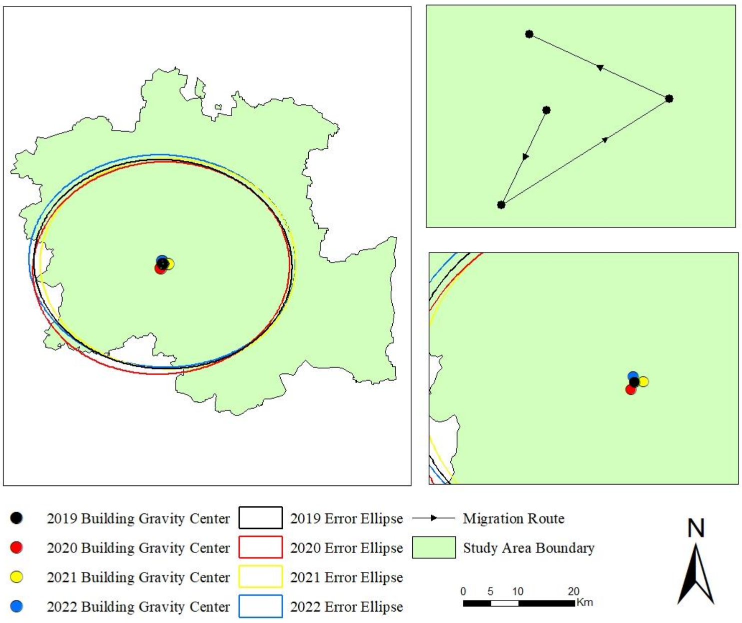

Figure 5: Center of gravity shift and standard deviation ellipse

Table 4: City center of gravity

Year	Longitude/E	Latitude/N	Direction of migration	Distance of deviation
2019	114°30′21.80″	38°2′14.24″	/	/
2020	114°30′8.83″	38°1′51.28″	southwest	775m
2021	114°30′58.69″	38°2′17.89″	northeast	1467m
2022	114°30′15.94″	38°2′32.44″	northwest	1135m

5. Conclusion

This study takes Shijiazhuang City as the research area, based on the four-year land use classification data from 2019 to 2022, using land dynamics, land use transfer matrix and urban center of gravity migration model to reveal the change of land use types in Shijiazhuang City, and draw the following conclusions:

(1) During the four-year period, the building land area increased year by year, and the cultivated land area decreased year by year. Among them, 85.36% of the increased construction land area came from cultivated land; 74.29% of the decreased cultivated land area was converted into construction land. The area of forest land increased by 16.03%, and the area of rivers and bare land did not change significantly.

(2) During the four-year period, the center of gravity of the city will move to the southwest; from 2020 to 2022, the center of gravity will move to the north. From the perspective of migration distance, the migration range of the urban center of gravity has not changed much.

The data source year of this study is limited, and the time phase of remote sensing images also has a certain impact on the monitoring results. However, this study can provide data support for Shijiazhuang's modernization construction and provide reference for rational land use.

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References

[1] Lin Y, Liu B, Lu Y, et al. Correlating analysis on spatio-temporal variation of LUCC and water resources based on remote sensing data[C]// Remote Sensing of the Environment: 18th National Symposium on Remote Sensing of China. International Society for Optics and Photonics, 2014.
[2] Song Y Q, Pan Z K, Liu Y L, et al. Monitoring of Inefficient Land Use with High Resolution Remote Sensing Image in a Chinese Mega-City[C]// IEEE International Conference on Computational Science & Engineering. IEEE, 2017.
[3] Gao X, Wang J, Li C, et al. Land use change simulation and spatial analysis of ecosystem service value in Shijiazhuang under multi-scenarios[J]. Environmental Science and Pollution Research, 2021(1):1-16.
[4] Saleem M S, Ahmad S R, Shafiq-Ur-Rehman, et al. Impact assessment of urban development patterns on land surface temperature by using remote sensing techniques: a case study of Lahore, Faisalabad and Multan district[J]. Environmental Science and Pollution Research, 2020, 27(32):1-14.
[5] Kai L, Hongbo S, Lifu Z, et al. Analysis of the Urban Heat Island Effect in Shijiazhuang, China Using Satellite and Airborne Data[J]. Remote Sensing, 2015, 7(4):4804-4833.
[6] Hua, DING, Ru, et al. Research on Land Use Changes in Panjin City Basing on Remote Sensing Data[C]// 2018.
[7] An H. Research on Remote Sensing Monitoring of City Land Use Change of Qixingguan District Based on GIS[J]. Heilongjiang Environmental Journal, 2016.
[8] Lou S, Liu Y, Ren C, et al. Study on the first pollution process in autumn-winter of 2017 in Shijiazhuang City based on satellite remote sensing and SPAMS[J]. Hebei Journal of Industrial Science and Technology, 2018.
[9] Zhao Q, Zhao X, Liu Z. Change of Land Use and Its Response of Ecological Service Function in Shijiazhuang City[J]. Bulletin of Soil and Water Conservation, 2015.
[10] Du Y K, Yan Q, Luo C F. Monitoring and predicting the changes of vegetation coverage in Shijiazhuang from 1995 to 2015[C]// IGARSS 2016 - 2016 IEEE International Geoscience and Remote Sensing Symposium. IEEE, 2016.
[11] Jia B Q, Qiu E F. Vegetation changes and its driving factors in Shijiazhuang City from 2004 to 2010 based on Landsat TM imagine[J]. Arid Land Geography, 2014.