ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Vol 10, Issue 11, November 2023

Urban Land-Cover Classification Utilizing Sentinel 2 Data for Landscape Planning and Management in Vietnam

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Abstract*— The Copernicus Sentinel 2 data could be essential for an effective land-cover classification for urban policymakers. While huge expenses and complicated post-processing issues are well-recognized by the city authorities, a convenient approach is hardly available to apply with other commercially available data sources. Freely available Sentinel 2 data, even with 10–60 m resolution, could be an essential addition for policymakers, especially for classifying urban landscapes. Here, the Geographic Object-based Image Analysis (GEOBIA) approach has been applied in the eCognition platform utilizing a Sentinel 2 image for the urban land-cover classification in Hue, Vietnam. Currently, four different classes, i.e., streets, buildings, vegetation, and water resources, have been applying the GEOBIA approach. Concerning the data availability and post-processing approach, this study could be a way out for urban policymakers due to the convenience and simplicity of the applied algorithms. So, this study will certainly assist city planners either in the case of developed or third-world developing ones, where it is much more necessary for efficient urban space management.

Index Terms — Urban land-cover, GEOBIA, Sentinel 2 data.

I. INTRODUCTION

An efficient and convenient land cover classification approach is one of the paramount prerequisites to introducing a sustainable monitoring and management system. For city planners and researchers, convenience is always a massive matter of confrontation when introducing remote-sensing data-based approaches and their applications. Even though the most recent features of Remote Sensing (RS), such as hyperspectral imagery and high spatial resolution satellite imagery, are being utilised as more effective tools regarding classification and monitoring the urban land cover, ensuring better accuracy than those of the traditional ones. While RS data provides a massive amount of information about terrestrial and land cover data, the tools and techniques are very inconvenient, either concerning processing skills or expenses. Regarding computing and data acquisition costs, RS-based approaches prod the applications of machine learning algorithms like Geographic Object-based Image Analysis (GEOBIA) freely accessible multispectral remote sensing data, i.e., Sentinel 2. The Sentinel mission was sent off in April 2014 by the European Space Organization (ESA) to improve Copernicus program applications that primarily plan to screen the world's territory surface and its current circumstances. The Sentinel mission comprises two satellites (Sentinel 2A and 2B) to upgrade the visit and bring about dependable information accessibility. The polar-orbiting multispectral imaging mission known as Sentinel 2 consists of Sentinel 2A, which was launched on June 23, 2015, and Sentinel 2B, which was found on March 7, 2017. The onboard multispectral imaging device has a revisit time of five days and a width of 290 kilometres, which covers the earth's land surface from 560 S to 840 N. It produces 13 otherworldly groups of various goals in 10 m to 60 m[1]. Even though the resolution is an issue, this study suggests a GEOBIA approach applied to Sentinel 2 image data for the urban land cover classification for Hue City in Vietnam. The approach has assisted city policymakers in introducing a convenient method to ensure a sustainable landscape management system.

A. Research objectives and methodology

Several studies were found focusing on remote sensing approaches and their applications. In contrast, most of the reflections on Vietnam were done to predict or map out the natural disaster-prone areas and vegetation, insisting on landscape change detections and forest monitoring. The main idea was to introduce an efficient classification approach considering the complex urban environment, which will initiate better scopes for the city authority to identify and monitor the landscape features covering the central, provincial area considering the classes like streets, buildings, vegetation, rivers, and so the other water resources. The Trimble eCognition Developer® 10.2 platform (Trimble, Munich, Germany)[2] has been utilised to apply GEOBIA for the classification, where the Sentinel 2 image data were preprocessed on QGIS.

ISSN (Online) 2456 -1304

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II. METHODOLOGY

A. Data set

Fig. 1. The study area at Hue City, Vietnam

For the landscape classification, the study area (Figure 1) has been considered to cover the urban area of Hue City. Sentinel 2 image data (Figure 2) was acquired on November 21, 2021, and has been downloaded utilising the Semi-Automatic Classification Plugin (SCP) [3] in QGIS. The Sentinel 2 image data comprises 13 spectral bands ranging from 10 to 60-meter pixel size (Table I).

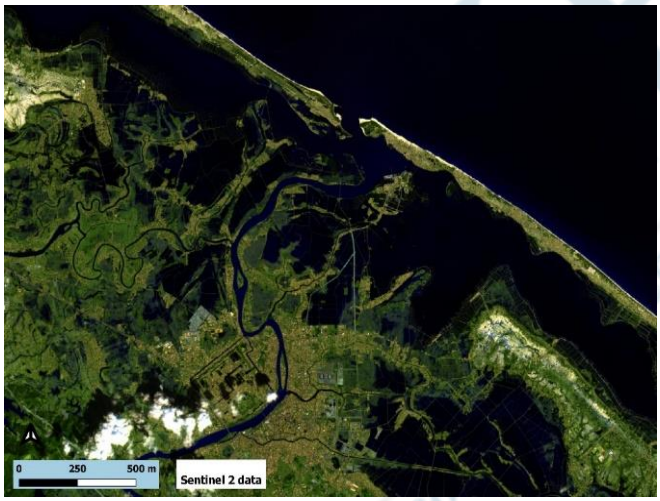

Fig. 2. The Sentinel 2 image data of Hue City, Vietnam

TABE I. 13 spectral bands ranging from 10 to 60-meter pixel size of the Sentinel 2 image data

Sentinel 2 Bands	Band parameters		
	Central Wavelength (nm)	***Description***	***Resolution (m)***
B1	443	Ultra Blue	60
B2	490	Blue	10
B3	560	Green	10
B4	665	Red	10
B5	705	Visible and Near Infrared (VNIR)	20
B6	740	VNIR	20
B7	783	VNIR	20
B8	842	VNIR	10
B8a	865	VNIR	20
B9	940	Short Wave Infrared (SWIR)	60
B10	1375	SWIR	60
B11	1610	SWIR	20
B12	2190	SWIR	20

Later, the image was exported in eCognition(Trimble, Munich, Germany) [2], where the GEOBIA was introduced to extract the information for each landscape feature. The GEOBIA method does not include only the spectral information but also the other added information such as context, texture, geometry, and spatial features[4], [5], which can minimise the number of units to be considered for the classification[6]. Segmentation is the critical procedure of dividing the image into different significant objects where the spectral and spatial features will be computed. The segmentation procedure divides the image into spatially continuous and homogeneous regions [7] and limits the local spectral variation[8], [9].

B. Methodology

Concerning the classification of eCognition, the chessboard segmentation [10]–[12] has been introduced to initiate the OBIA classification approach (Figure 3). After that, the well-known multiresolution segmentation was performed to group contiguous pixels into areas or segments that are homogenous, which is composed of parameters such as the "smoothness/compactness" that determines the preferred shape of parts and the "colour/shape" parameter that controls the weights of spectral and profile information in the calculation of segments' heterogeneity [13]–[15]. After several attempts, the ideal values utilised for segmentation were found as scale parameter = 20, shape = 0.5, and compactness = 0.5.

Later, three parameters were calibrated, which can be defined as follows,

Normalised Difference Vegetation Index,

NDVI = (NIR-RED) / (NIR+RED)

Normalised Difference Water Index,

NDWI = (NIR - SWIR) / (NIR + SWIR)

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Bare Soil Index,

BSI = ((Red + SWIR) – (NIR + Blue)) / ((Red + SWIR) + (NIR + Blue))

Where, NIR = Near Infrared, SWIR = Short Wave Infrared

These parameters have been calibrated to develop the rule set to extract spectral information for each class. For instance, BSI-customized feature values have been utilised to identify lower to higher-bared soil areas. For each parameter, the values have been tested using the "Update range" option on the object feature algorithm on eCognition. Successively, the pixel-based values have been tested for each object belonging to the different classes. The "Assign class" algorithm has been applied later based on the feature value range for each object. Finally, the main courses were identified as follows-

- Wet and turbid soil/rice cultivated area
- Clouds
- Streets and buildings
- Vegetation
- Water resources

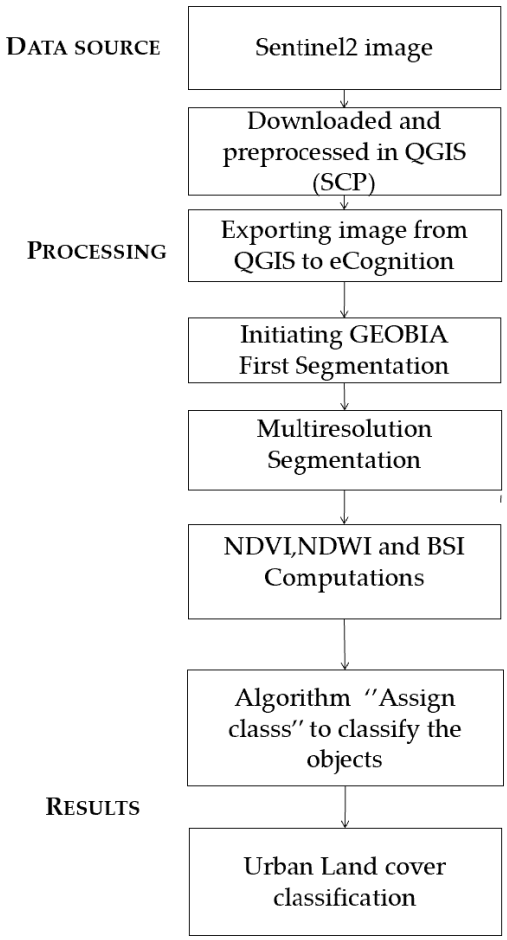

Fig. 3. The Flowchart of the GEOBIA approach applied to eCognition.

III. RESULTS

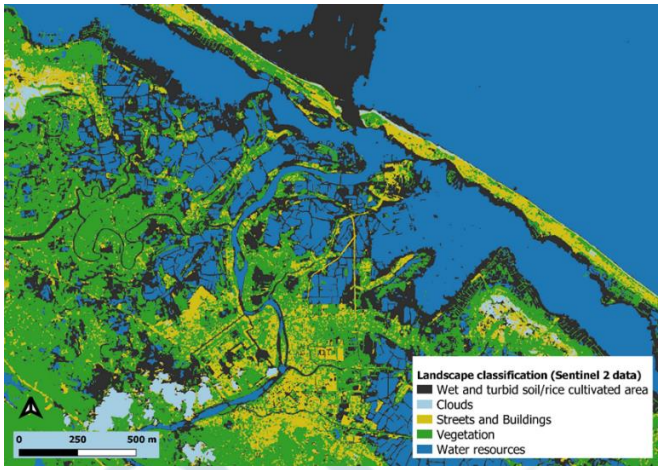

Fig. 4. Urban landscape classification utilising Sentinel 2 data in eCognition

The GEOBIA approach applied in this study has been used as an efficient technique even in the case of the Sentinel 2 data having a cloud coverage of almost 30%, with a coarse resolution. The classification outcomes (Figure 3) for landscape features like Vegetation and Water resources were more significant than the other classes. For instance, the streets and buildings were classified as unique objects, where it was not certainly more accessible to extract two different classes. These classification issues recognise the facts of utilising Sentinel 2 data, which are more applicable in the case of landscape monitoring and change detection considering a particular timeframe.

IV. DISCUSSION

This classification will be strong evidence of the prospects of applying a similar approach in the case of utilising either Sentinel 2 image data or other commercially available data with better resolution. This could assist the city authorities in coming up with a convenient policy where this kind of outcome will be a fundamental web-based database for the planning and regular monitoring of the landscape features because this kind of free data-based approach does compensate for the costs associated with the data collection and stable monitoring system increasing the management efficiency that leads to increased income based on improved decision making. That is why the utilisation and application of this GEOBIA-based approach will undoubtedly assist the planners in determining the purpose, economic feasibility, and prospects of the resulting outcomes concerning a sustainable policy.

V. CONCLUSION

The proposed methodology would be an adequate solution considering efficient land cover mapping for complex urban areas. This study was designed to understand and explore the feasibility of the proposed mapping approach, while an efficient validation process will be done after acquiring the

ground truth data. It could be an efficient way out for policymakers in the case of land cover classification as well as the probable mapping of urban features over traditional methods. Especially for developing countries or where the application of data sources like LiDAR or other commercially available data sources is hardly known, this mapping approach will show the alters with Sentinel 2 image data. Thus, the outcomes of this study will assist researchers and city planners in employing and implementing advanced methods in future applications with further investigations on freely available data sources like Copernicus from the European Space Agency (ESA).

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