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Object-Oriented Classification Approach (OBIA) in Extracting Burial Plot for Muslim Cemeteries Management

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Abstract. In contemporary cemetery management planning, the use of the Object-Oriented Classification Approach (OBIA) stands out as an innovative methodology, providing a sophisticated means of exploring and understanding burial grounds by leveraging high-resolution aerial imagery captured from drones. This study delves into the application of OBIA in the extraction of burial plots, aiming to contribute to the systematic management of a Muslim cemetery area and optimize burial space arrangements. Subsequently, these plots are extracted into GIS software, facilitating a comprehensive spatial analysis. OBIA emerges as an efficient method, outperforming traditional approaches, to identify and classify burial plots. The technique successfully maps intricate burial plot patterns and distributions, providing a detailed overview of the cemetery landscape and enabling the calculation of burial density. Beyond its technological contribution, this research offers practical insights for the enhanced management and planning of Muslim cemeteries, ensuring both respectful and efficient use of these sacred spaces. The success of OBIA suggests its potential integration into broader cemetery management practices, paving the way for automation and contributing to sustainable cemetery space utilization.

Keywords: OBIA, burial plot, Muslim cemeteries, urban planning and low-cost drone

1. Introduction

Cemeteries hold profound cultural and religious significance across societies worldwide as sacred spaces for commemorating the departed and providing solace to their loved ones. Effective cemetery management spaces are crucial to ensure proper allocation of burial plots for ensuring efficient space utilization amidst the land scarcity issues under the development pressure nowadays. In recent years, advancements in geospatial technologies have revolutionized cemetery management practices, offering innovative solutions for mapping and analyzing burial plots with precision and efficiency [1], [2]. Muslim cemeteries, in particular, present unique challenges due to its specific burial customs and traditions according to their belief. As such, the management of Muslim cemeteries requires meticulous attention and sensitivity to cultural and religious practices. Traditional methods for mapping and

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analyzing burial plots often prove inadequate in capturing the complexities of cemetery landscapes and meeting the evolving needs of Muslim communities.

The Object-Oriented Classification Approach (OBIA) emerges as a promising solution to address the complexities inherent in mapping and extracting burial plots in Muslim cemeteries. Unlike traditional pixel-based classification methods, OBIA leverages object-based analysis technique to identify and classify burial plots based on their spatial characteristics, shapes, and contextual relationships [3]. By considering spatial context and spectral properties simultaneously, OBIA offers a more holistic and accurate approach to mapping burial plots in Muslim cemeteries. This paper explores the application of OBIA in extracting burial plots for the management of Muslim cemeteries. It underscores the importance of integrating OBIA into existing cemetery management frameworks, offering practical insights and recommendations for implementing OBIA-based solutions in Muslim cemetery context. Through interdisciplinary collaboration and innovative technological approaches, OBIA holds the promise of revolutionizing cemetery management practices and ensuring the respectful and sustainable stewardship of Muslim cemetery spaces.

2. Theoretical Review

Cemetery management represents a multifaceted challenge influenced by cultural, religious, and spatial considerations. The management of cemeteries is especially crucial in urban areas where land scarcity and competing land use demands pose significant challenges. Like many cities that are experiencing rapid urbanization and population growth, face increasing pressure on land resources, making effective cemetery management essential for sustainable urban development [4]. Cemetery management in Malaysia involves navigating a diverse cultural and religious landscape. With Malaysia being a multiracial and multicultural society, different communities adhere to distinct burial customs and practices [5]. Muslim cemeteries, in particular, follow Islamic principles governing burial rites and land use, necessitating specific considerations in urban planning. As Islam is the predominant religion in Malaysia, the management of Muslim cemeteries is of paramount importance, requiring careful planning and allocation of burial space to accommodate the needs of the Muslim community.

In urban planning, cemetery management extends beyond land allocation to encompass broader issues such as environmental sustainability, heritage preservation, and community engagement. Sustainable cemetery management practices aim to minimize environmental impact, optimize land use efficiency, and promote biodiversity conservation within cemetery grounds [4], [6]. Community engagement plays a vital role in cemetery management within the Malaysian context. Local communities often have strong emotional and cultural attachments to cemeteries, viewing them as sacred spaces that demand respect and reverence. As such, agencies' involvement in decision-making processes ensures that management practices align with community values and aspirations [7].

2.1. Integration of Object-Oriented Classification Approach in cemetery management

The integration of OBIA technologies marks a significant advancement in cemetery management practices, offering precise and efficient methods for the extraction and analysis of burial plots. One of the primary benefits is the ability to extract burial plot information from high-resolution aerial imagery with unprecedented accuracy and efficiency. OBIA algorithms analyze image data based on object characteristics, such as shape, color, and texture, enabling the automated identification and delineation of burial plots within cemetery landscapes [8]. This automated approach streamlines the process of mapping burial plots, reducing manual labor and potential errors associated with traditional methods of plot identification and demarcation. Furthermore, the integration of OBIA technologies into GIS software can facilitate the comprehensive analysis of cemetery landscapes, enabling stakeholders to assess burial plot distribution patterns, burial density, and spatial relationships within cemetery grounds. By leveraging OBIA-generated data, cemetery managers and urban planners gain valuable insights into burial plot utilization trends, land availability, and infrastructure requirements, supporting informed decision-making and long-term planning strategies [9], [10]. This integrated approach enables planners to explore spatial relationships, identify patterns, and derive meaningful insights that inform strategic decision-making and long-term planning initiatives [11].

2.2. Drones application in cemetery mapping
Drones, also known as Unmanned Aerial Vehicles (UAVs), are equipped with high-resolution cameras and sensors that enable them to capture detailed aerial imagery and geospatial data with unprecedented accuracy and efficiency. It is also rapid and cost-effective acquisition of high-resolution aerial imagery, covering large cemetery areas in a short amount of time [12], [13]. Drones can capture detailed photographs and videos of cemetery grounds from various vantage points and altitudes, providing comprehensive coverage of burial plots, pathways, vegetation, and infrastructure [14], [15]. This aerial imagery serves as a foundational dataset for conducting detailed spatial analyses, identifying spatial patterns, and generating accurate 3D models of cemetery landscapes. In addition to data acquisition, drones play a crucial role in conducting site surveys, topographic mapping, and terrain analysis to assess the topographical features and elevation variations of cemetery landscapes. By capturing high-resolution elevation models and Digital Surface Models (DSMs), drones enable to visualize and analyze the terrain characteristics of cemetery grounds, identify areas prone to erosion or flooding, and optimize the design and placement of burial plots and infrastructure [16]. The aerial imagery serves as the foundational dataset for OBIA analysis, allowing stakeholders to identify, delineate, and classify burial plots and other cemetery features with precision and accuracy. OBIA techniques involve the segmentation of aerial imagery into meaningful objects or image elements based on their spectral, spatial, and contextual characteristics [17], [18]. By leveraging OBIA algorithms, such as feature extraction, classification, and object delineation, drones can systematically analyze cemetery landscapes and extract valuable information about burial plots, pathways, vegetation, infrastructure, and other relevant features.

3. Methodology
The methodology employed in this study combines innovative geospatial technologies with traditional field methods to comprehensively analyze and manage Muslim cemeteries (Figure 1). At the core of the methodology is the integration of OBIA techniques with drone-based aerial mapping, enabling the efficient extraction and analysis of burial plots and other cemetery features. In the initial stage of the data processing, the pre-processing of the data is conducted using software such as Pix4D. This phase begins with the conversion of drone images into an aerial map, which includes the generation of orthophotos and data vectors. These processed data are then imported into GIS software for further analysis. The primary objective of this stage is to transform the raw drone imagery into a format that is compatible with GIS software and suitable for subsequent analysis and interpretation.

The second stage is the main processing, where the core analysis of the data takes place. This phase involves the implementation of data sampling techniques to select representative samples from the dataset. These samples are then subjected to data classification procedures to categorize them into four main categories; burial plots, buildings and infrastructure, vegetation, and roads and pathways. The main processing stage is crucial for identifying and delineating the different features present within the cemetery area, with a particular focus on extracting burial plots as the primary target of the analysis.

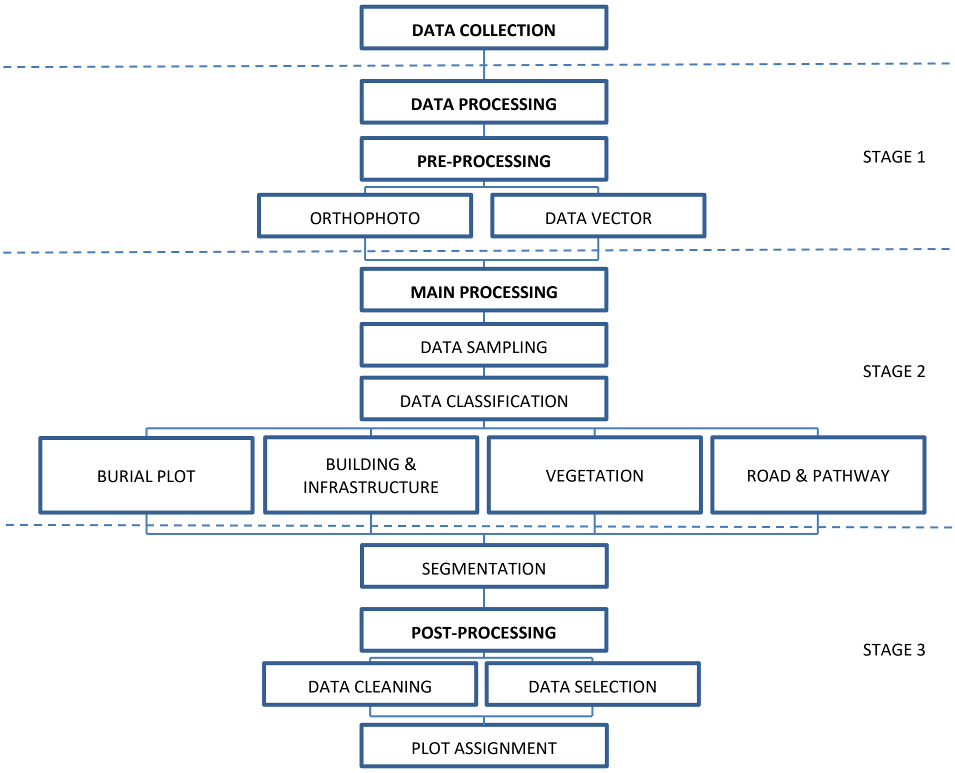

Figure 1. Study framework

The final stage of the methodology is the post-processing, which encompasses segmentation and data cleaning processes. Segmentation involves partitioning the dataset into distinct segments based on predefined criteria, such as spectral and spatial attributes. Following segmentation, post-processing activities involve data cleaning and selection to refine the dataset and isolate the necessary data for analysis. In this case, the focus is on retaining only the burial plot data while removing extraneous information. The burial plots are then assigned plot designations, enabling the determination of burial density within the cemetery area. The post-processing phase is essential for the relevance of the final analysis results.

4. Analysis and Result

4.1. Pre-processing

The pre-processing process lays the foundation for the subsequent stages of data analysis and interpretation. In this phase, the raw drone imagery is subjected to a series of preprocessing steps to enhance its quality and suitability for further analysis. One of the key aspects of the pre-processing stage involves the correction of image distortions and anomalies. This includes the removal of lens distortions, sensor noise, and other artifacts that may affect the accuracy of the imagery. Through advanced image processing techniques, such as geometric correction and radiometric calibration, the raw drone images are transformed into accurate representations of the study area. The drone imageries are georeferenced to establish its spatial coordinates relative to the Earth's surface. Georeferencing is essential for aligning the imagery with existing geographic datasets and ensuring spatial accuracy in subsequent analyses. Through the use of ground control points and GPS data, the drone images are accurately positioned within the GIS environment, enabling precise spatial analysis and interpretation.

The main output from the pre-processing process is the orthomosaic image, which serves as a stitched-together, georeferenced representation of the study area. This image is created by integrating numerous aerial images captured during the drone flight, providing a comprehensive and detailed view of the landscape. The orthomosaic image encapsulates information about the land surface, infrastructure, and other objects present within the study area. Subsequently, the orthomosaic can be imported into GIS software and overlaid with open-source maps to seamlessly integrate with its surrounding context, facilitating comprehensive spatial analysis and interpretation.

a) Orthophoto output from Pix4D processing result *b) Orthophoto overlay with open-source map*

Figure 2. Orthomosaic photo generated from the drone images

4.2. Main-processing

This process aimed at analyzing and classifying the data obtained from the pre-processed drone imagery. Through data sampling and classification techniques, the imagery data were systematically analyzed to categorize them into four main classes; burial plots, buildings and infrastructure, vegetation, and roads and pathways. Each class was assigned specific attributes based on its characteristics and spatial distribution within the study area. This comprehensive classification process provided valuable insights into the composition and layout of the cemetery landscape, allowing for a detailed assessment of burial plot distribution, vegetation coverage, and infrastructural elements. These datasets served as valuable resources for visualizing and interpreting the spatial patterns and relationships between different elements within the cemetery landscape.

Table 1. The details of Classification

Types	**Details**
Grave	The grave classification involves distinguishing and categorizing different types of burial plots based on their attributes. This can include differentiating between traditional graves, well-built graves, and any other structures associated

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	with burial sites. Accurate grave classification is essential for understanding the spatial distribution of burial plots, aiding in cemetery planning and management. Classifying graves based on their characteristics, such as size, shape, or markers (e.g., headstones), is crucial.
Vegetation	The vegetation category focuses on identifying and classifying greenery within the cemetery area. This includes trees, bushes, and other types of vegetation that contribute to the overall landscape by distinguishing between different types of vegetation (trees, shrubs, grass) and cemetery infrastructure (paths, buildings, fences).
Roads and Pathway	Roads and pathways form a critical part of the cemetery infrastructure. Accurate classification of these features helps in assessing the overall layout of the cemetery. It provides valuable information for optimizing pathways for visitors and facilitating efficient maintenance and management.
Infrastructure and Buildings	This category involves identifying and classifying any man-made structures within the cemetery, such as administrative buildings, prayer halls, or other infrastructure. Understanding the distribution of these elements contributes to efficient management practices, ensuring that facilities are appropriately located and accessible.

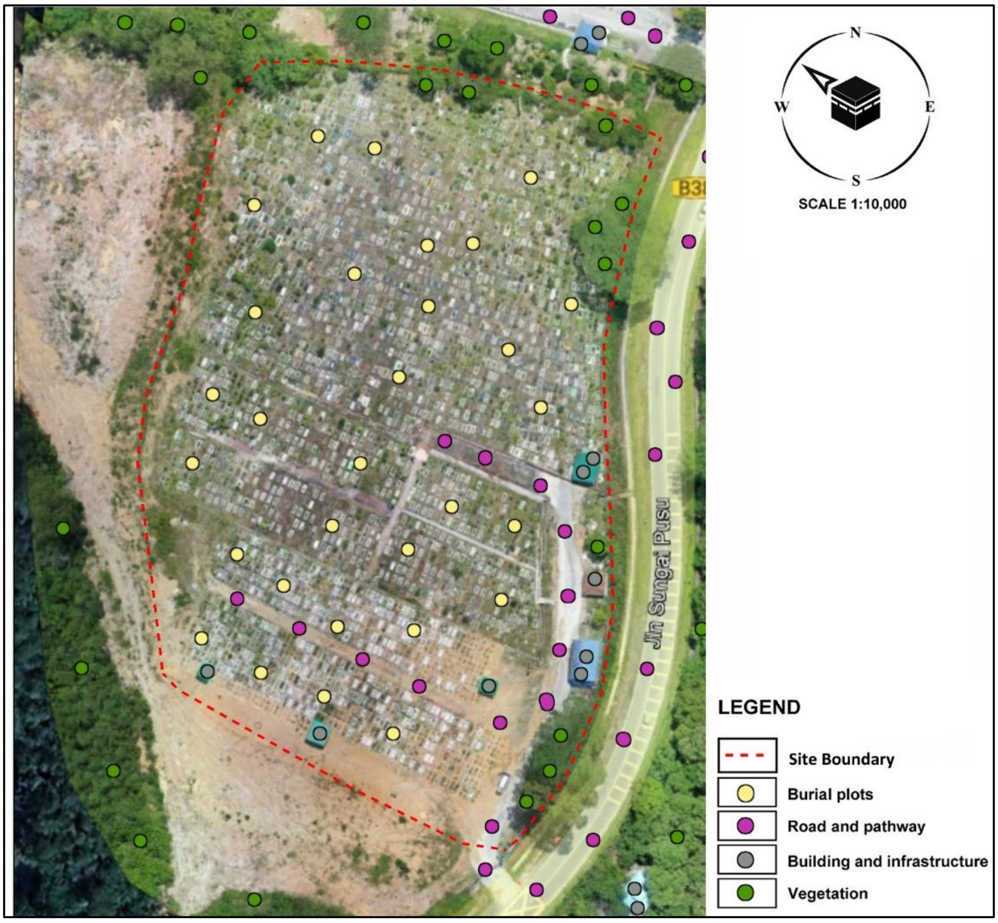

Figure 3. The training data samples within the classification process

4.3. Post-processing

This stage primarily involved two key processes: data cleaning and data selection, aimed at enhancing the accuracy and relevance of the final segmentation output. During the data cleaning process, the dataset underwent a manual inspection and validation ensuring the integrity and reliability of the final dataset. Following this, the data selection process focused on isolating and retaining only the relevant information necessary for the study objectives. In the context of cemetery management, this primarily involved selecting and retaining data related to burial plots while discarding extraneous or non-essential features. Through careful data selection, the study aimed to streamline the dataset and focus exclusively on the burial plots within the cemetery landscape.

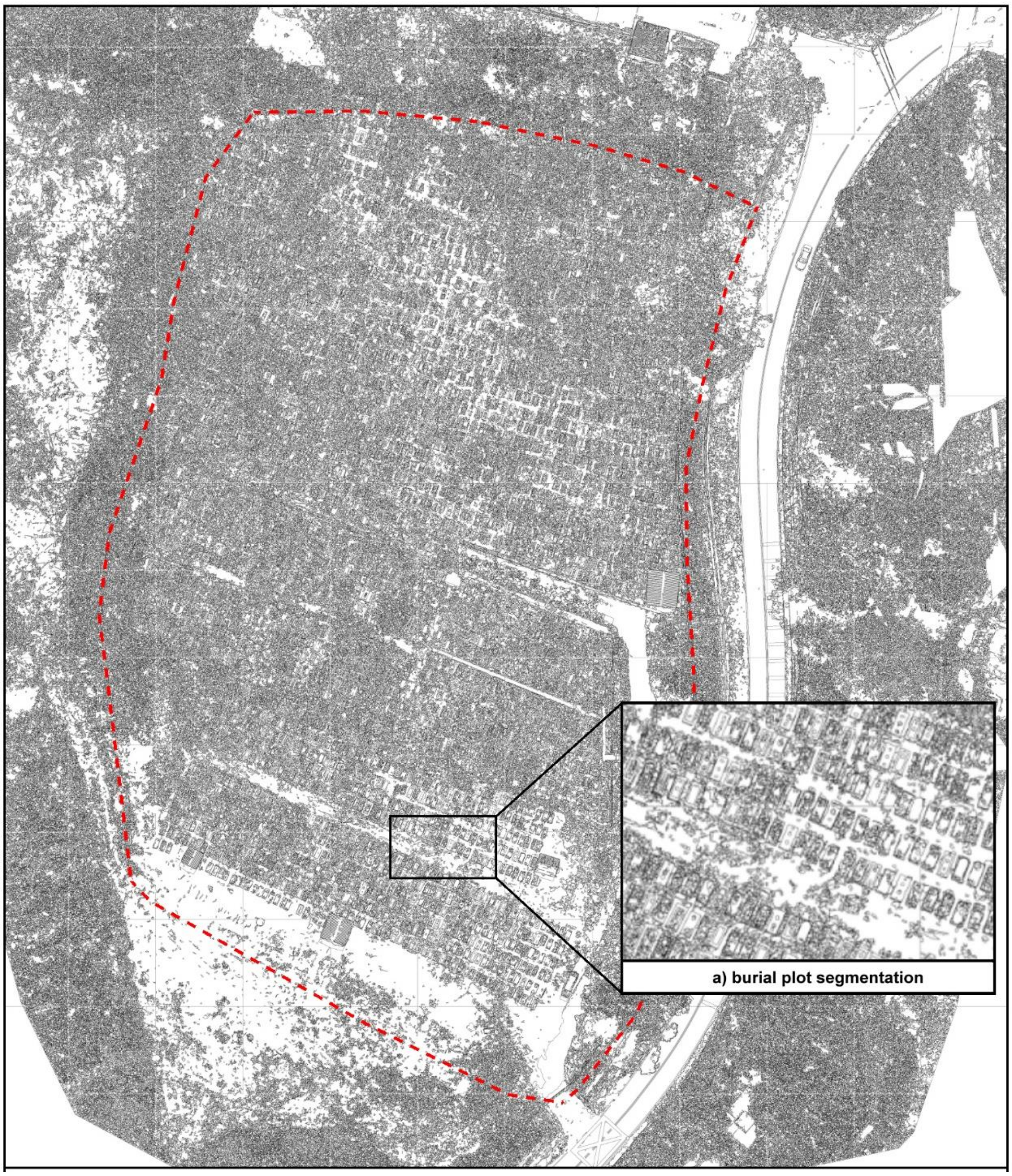

Figure 4. Image segmentation process

The final process is the assignment of plot attributes to the selected burial plots, providing additional context and information about each plot. This included assigning unique identifiers or attributes to individual plots, such as plot size, orientation, and spatial coordinates. By assigning plot attributes, the study aimed to facilitate further analysis and interpretation of the burial plot data, enabling stakeholders to gain deeper insights into burial density and spatial distribution patterns within the cemetery.

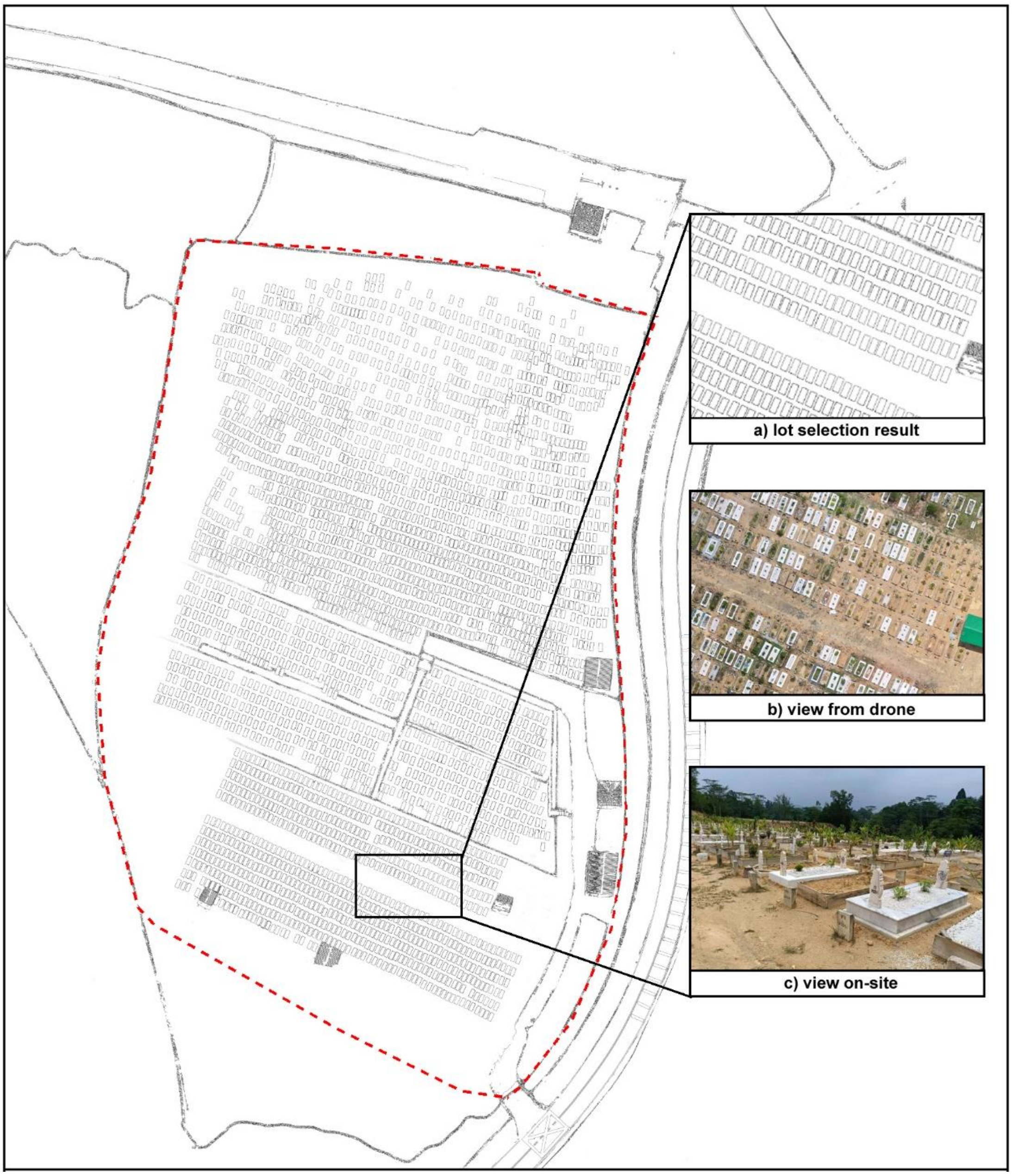

Figure 5. Data cleaning and plot assignment result

5. Conclusion

In conclusion, the application of the Object-Oriented Classification Approach combined with drone technology has demonstrated significant potential for enhancing the management and planning of Muslim cemeteries. Through a comprehensive methodology encompassing pre-processing, main-processing, and post-processing stages, the study is proven to successfully extract and analyze burial plot data, providing valuable insights into cemetery spatial characteristics and distribution patterns. The analysis revealed a nuanced understanding of burial plot distribution and density within the study area, offering insights that can inform more effective cemetery management strategies. The utilization of OBIA technique enabled the accurate delineation and classification of burial plots, facilitating detailed spatial analysis and visualization of cemetery landscapes. By leveraging high-resolution aerial imagery captured by drones, the study achieved a level of detail and accuracy previously unattainable through traditional methods. This integration paves the way for more sustainable and efficient cemetery management practices and highlights the transformative potential of geospatial technologies in the management and planning of Muslim cemeteries. By combining innovative methodologies with cutting-edge technology, planners can enhance their capacity to optimize resource allocation and ensure the sustainable management of sacred spaces for generations to come. As technology continues to evolve, the study sets the stage for ongoing advancements in cemetery management practices, paving the way for a more informed and efficient approach to honoring the departed.

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