

Application of unmanned aerial vehicles (UAV) to establish land use map of the Ring Road 2 project in Phuoc Long B ward, Thu Duc city (now Phuoc Long ward), Ho Chi Minh City

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ARTICLE INFO	ABSTRACT
Research Paper Received: May 06, 2025 Revised: September 03, 2025 Accepted: September 10, 2025 Keywords Land use map Site clearance compensation UAV *Corresponding author Le Ngoc Lam Email: lengoclam@hcmuaf.edu.vn	Establishing land use map is a mandatory requirement for all projects involving land use. Mapping the current land use status will use different methods, which depend on factors such as purpose, requirements and scale of the project ... The Ho Chi Minh City Ring Road 2 project passes through many areas from urban to agricultural areas. The scope of the project has a total length of 6 km and a width of 120 m. The total area is more than 61 ha, passing through 6 wards of Thu Duc city, Ho Chi Minh City. The research objective was to establish a high-precision land use status map to serve the work of compensation and site clearance. The study used unmanned aerial vehicle (UAV), which had captured 637 images in the project area with a spatial resolution of 2 cm. The images were combined and adjusted to the VN2000 coordinate system. From the orthomosaic images, the study digitized and directly interpreted the images to extract information about land use layers in the study area. From that result, the study established a map of the current land use status in 2024. The statistical results showed that the total area to be recovered for the project is 17.66 ha, mainly urban residential land.

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1. Introduction

Traditional data collection applying a total station is limited by time and safety and thus often leads to a lack of necessary information for

monitoring and mapping (Nguyen et al., 2020). Unmanned aerial vehicle (UAV) is an important and innovative tool in the field of surveying, measuring and mapping. Currently, traditional measurement methods are often combined with

UAV imagery methods. From there, it will bring high efficiency and accuracy. The result is the creation of digital elevation models or Image maps quickly and accurately. That helps designers choose optimal route options, suitable for site clearance and project proposal preparation (Cao et al., 2016). In the field of cadastral mapping, previous experimental research results show that many land use maps have been created from UAV image data. These maps can meet the accuracy requirements in cadastral mapping in Vietnam according to current regulations. At the same time, land use status maps from UAV images also ensure the criteria of quality, accuracy, and level of detail in land classification for commune level, which are required by Circular 28/2014/TT-BTNMT of the Ministry of Natural Resources and Environment (Phan et al., 2018). The existing map georeferencing method requires longer time, cost and manpower to conduct a survey and produce a map. The output might be inaccurate due to the lower resolution of satellite and cadastral data (Stalin & Gnanaprakasam, 2020). Another study by Phan et al. (2023) on the application of UAVs in map creation for site clearance showed that the quality of the product maps was assessed as satisfactory. Including requirements on form, completeness of content, consistency of land type symbols, accuracy of land plots on the map, and deviation of land area between the map and data in cadastral records. In particular, the results of this topic have contributed to monitoring assets on land, which serves the work of site clearance in the research area (Phan et al., 2023). In addition, with the advantages of high resolution (cm), very small image center error, the use of UAV technology is considered very suitable for establishing cadastral maps in areas with low difficulty levels, especially for agricultural land with annual crops. For residential areas and

areas with higher difficulty levels, it is necessary to combine with other methods such as Global Navigation Satellite System (GNSS) or electronic total stations to bring the best results (Nguyen et al., 2022). High-resolution UAV images show detailed ground objects and should be used to create land use maps and land cover maps. The results show that the images obtained from UAV have a higher level of accuracy with an accuracy of 93,80% compared to 86,67 (IKONOS) and 83,89% (Quickbird). This proves that using UAV to study land use/land cover changes is completely reasonable and highly reliable (Jumaat, 2018). UAV remote sensing is no longer just a cheap substitute for satellite remote sensing in industrial and agricultural applications. Instead, it is now being used to solve problems that were previously difficult to address using satellite remote sensing, thanks to their flight platform and sensor advantages. As a result, non-traditional research fields such as forestry, artificial buildings, precision agriculture, and the natural environment have received increased attention in recent years (Zhang & Zhu, 2023).

The Ring Road 2 project in Thu Duc city, Ho Chi Minh City with a total length of 6.04 km. The project is 120 m wide with an area of 61.15 ha, which passes through 6 wards with three main intersections. The research area has places that are difficult to access from the ground surface. The project route passes through many prime areas, so the inventory of current status is very important. At the same time, the map results require high accuracy and are implemented in a short time to serve as a basis for compensation and site clearance for project implementation. In this study, unmanned aerial vehicles (UAVs) were used to create a map of current land use status of the Ring Road 2 project in Phuoc Long B ward, Thu Duc city (now Phuoc Long ward). The study

aimed to effectively support compensation and site clearance for Ho Chi Minh City.

2. Equipment and Methods

2.1. Equipment

This study used the DJI Mavic 3 drone (Figure 1). The DJI Mavic 3 is one of DJI's most advanced drone lines, with some features: Flight

range of 15 km; camera model M3E (12.29 mm); resolution 5280 x 3956; focal length 12.29 mm; pixel size 3.36 x 3.36 μm .

Thanks to the integration of many modern technologies, the Mavic 3 has improved accuracy to the centimeter (cm) level. At the same time, with the ability to capture images in real time, it ensures accuracy and is suitable for research areas with high population density.



Figure 1. DJI Mavic 3 enterprise drone.

2.2. Methods

Data collection survey method: Many data, documents, map data, survey data to serve as input data for the study. Data sources were collected from the Department of Natural Resources and Environment of Thu Duc City, the Compensation and Site Clearance Board, the People's Committee of Phuoc Long B ward (now Phuoc Long ward, Figure 2).

Image processing method: Images created after the UAV flight will be processed according to the image processing process using Agisoft Metashape software. The steps include: Creating

an image project; correcting image blocks; converting the coordinates of the center of the image to the VN2000 system; establishing a point cloud; creating a digital elevation model and creating an image map.

Methods for creating land use status maps: Digitize imagegrammetry, correct errors, create regions, assign land type attributes, edit land use status maps, calculate areas and statistics of land types. At the same time, the study also collects and processes relevant maps including: cadastral maps, previous land use status maps (2019), planning maps and other types of maps for additional comparison.

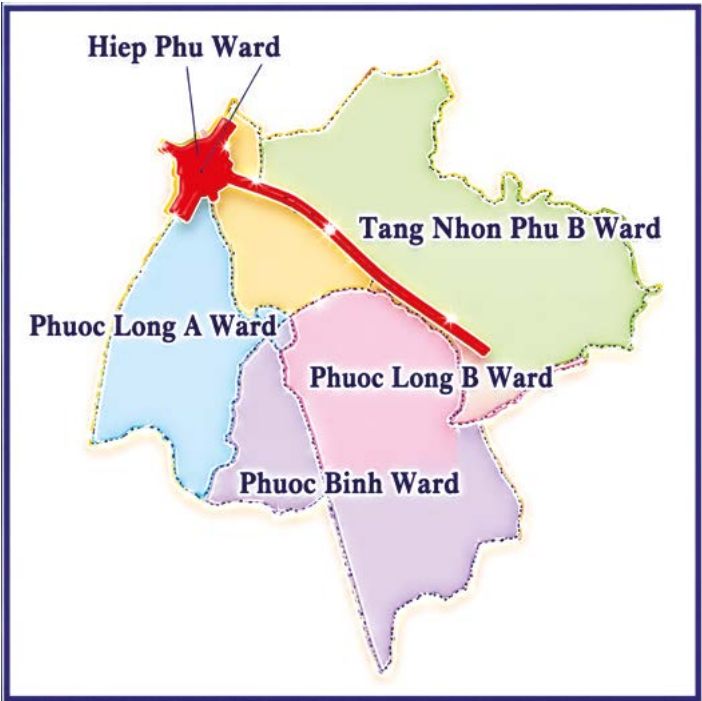


Figure 2. Study area location.

The process of establishing a land use status map was applied according to Circular 07/2021/TT-BTNMT of the Ministry of Natural Resources and Environment, which regulates the techniques for collecting and processing digital image data from unmanned aerial vehicles. At

the same time, the study also applies Circular 08/2024/TT-BTNMT of the Ministry of Natural Resources and Environment, which regulates land statistics, inventory and mapping of land use status (Figure 3).

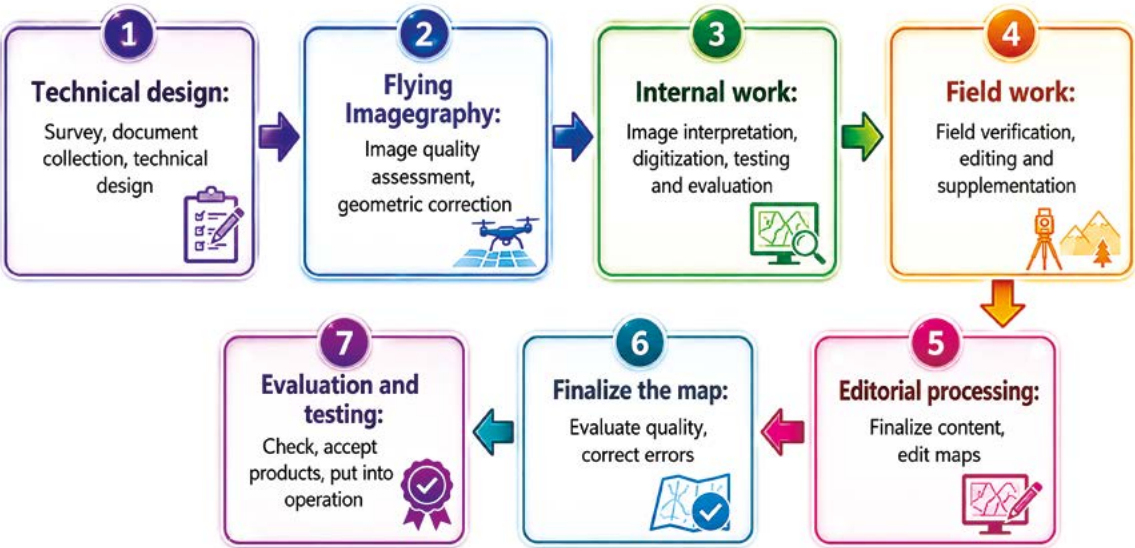


Figure 3. Mapping process using unmanned aerial vehicle in the research area.

3. Results and Discussion

3.1. Technical design and processing of flight results

3.1.1. Technical design

The survey area had a relatively flat terrain, so the grid flight mode (mapping) was selected. In this study, the coverage was selected at the following level: vertical coverage 70%

and horizontal coverage 60% (AEROTAS, 2020). The selected flight altitude was 74.5 m, corresponding to a ground image resolution of 2 cm. The measurement area was 0.554 km², with a linear shape of 2 km. Therefore, the total number of selected ground control points (GCPs) is 6 points and 2 base station points (Figure 4). The locations of the GCPs are shown in Figure 3. The coordinates of the GCPs are shown in Table 1.

Table 1. Coordinates of ground control points (GCPs)

Point ID	X Coordinate	Y Coordinate	Z Elevation
GCP-01	1198823,933	611195,262	11,982
GCP-02	1198405,186	610924,810	5,976
GCP-03	1198359,700	611252,437	6,857
GCP-04	1198255,128	611504,397	7,944
GCP-05	1197954,360	612013,889	7,756
GCP-06	1197696,455	612418,559	4,978
Base-01	1198351,434	611258,568	6,590
Base-02	1197694,311	612421,682	4,983

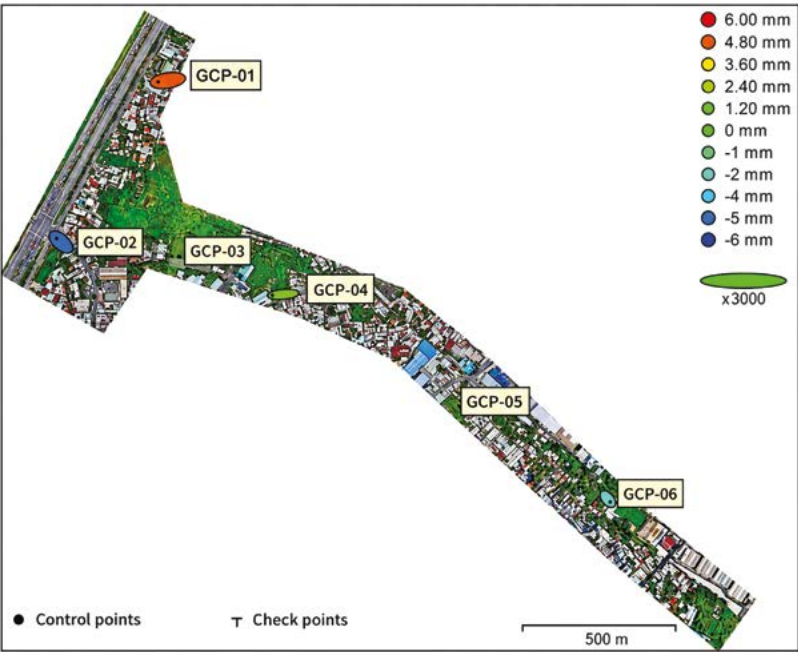


Figure 4. Location of ground control points (GCP).

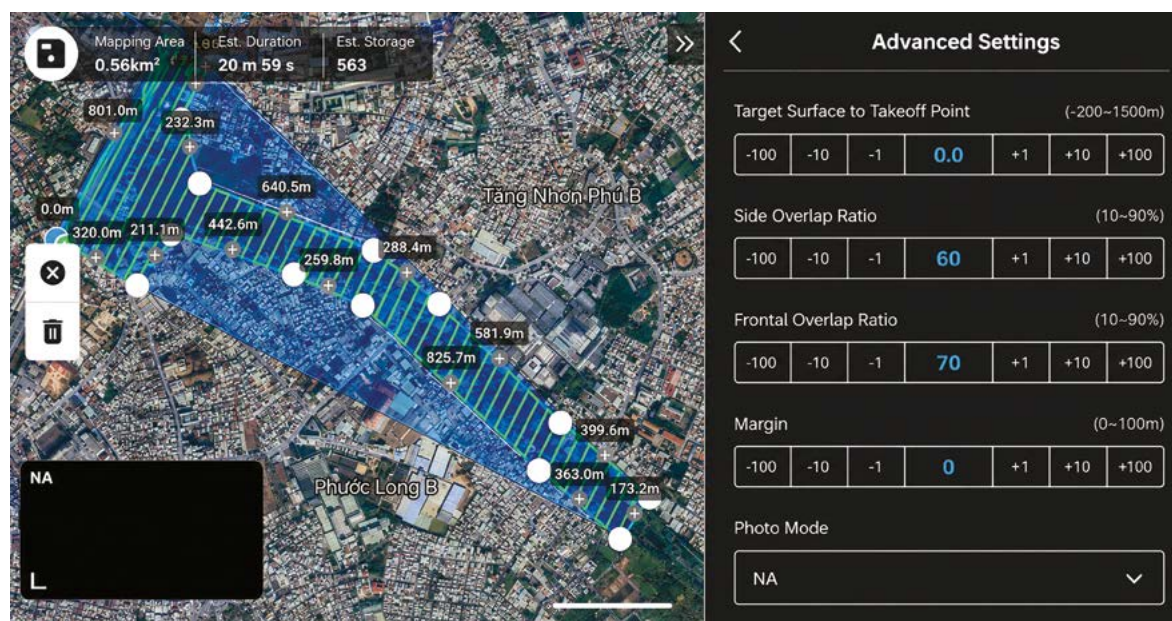


Figure 5. Flight diagram of the study area.

3.1.2. Mapping flight

The mapping flight was conducted at 9:00 on August 23, 2024, with the flight diagram shown in Figure 5. The parameters were set and calculated on the DJI Flot 2 flight control software. Continuous capture mode was used in this study. The flight time estimated by the software was 22 min. The flight was carried out in accordance with flight safety standards and the flight plan designed according to Circular 07/2021-BTNMT. The mapping flight resulted in 637 images, those in *.JPG format covered the flight diagram as designed.

3.1.3. Post-flight image processing

Image quality was evaluated using Agisoft Metashape software. Accuracy estimation was based on the Estimate Quality images tool. The test results showed that 637/637 images were of good quality (100%). The images were linked into image blocks with a mean square error of 2.01 pixels. The coordinates of the photo center were converted to the VN2000 coordinate system with a 3-degree projection zone. The Ho Chi Minh City axis meridian was 105°45'. The mean square error of the field Ground Control Points involved in the processing was 0,015 m, which ensured accuracy. The number of point clouds in the flight area was 2.5 billion points (Figure 5). From the point cloud set, the classification results are shown in Figure 6.

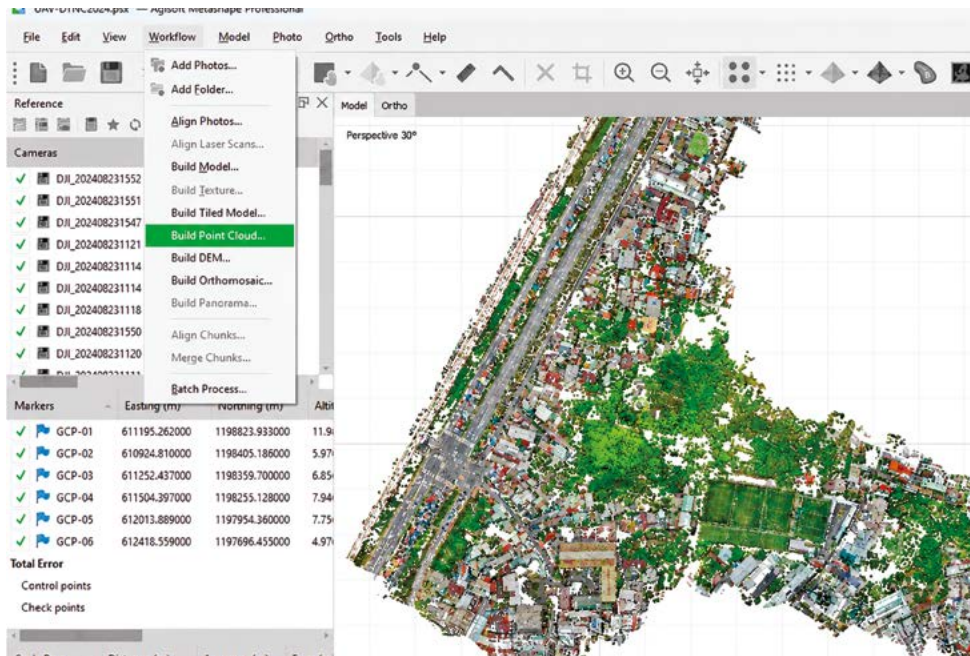


Figure 6. Point cloud creation.

3.2. Establishing maps from images

After the images were processed to ensure the required accuracy, the study digitized them according to the interpretation boundaries on the images. At the same time, the field investigation was combined to accurately determine the types

of land in the study area (Figure 7). The results digitized 415 land plots, located on 14 maps at a scale of 1/500. Finally, the study established a land demarcation map. This was the basis for statistical analysis on the area of land use types and for editing the current land use map (Figure 8).

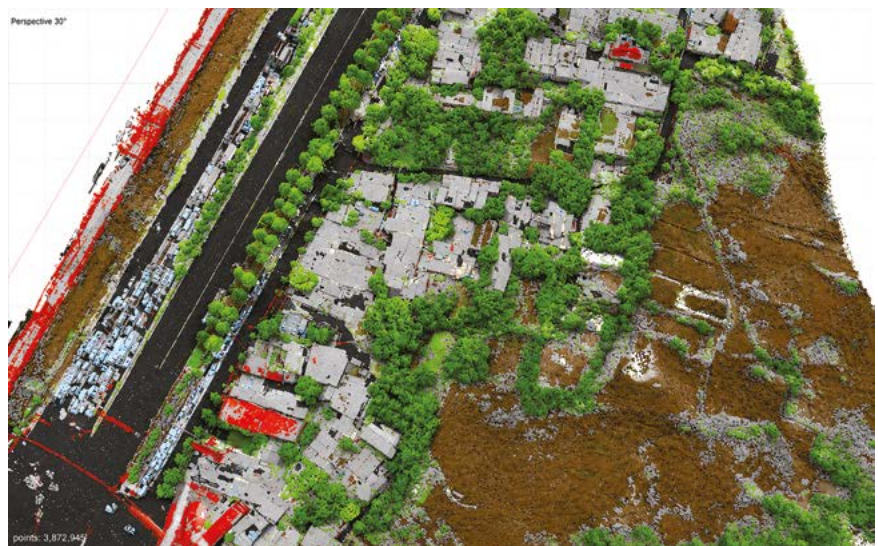


Figure 8. Digitization of land boundaries and structures on land.



Figure 9. Land use map of Ring road 2.

3.3. Land area statistics

Based on the land use map, the land use types are automatically counted on the Gcadas software. The statistical results showed that

within the project, there were 7 types of land that need to be recovered. Specifically, the land types were shown in Table 2. In the total current measured area of 17,66 hectares, it was mainly urban residential land (ODT).

Table 2. Area of land types

STT	Symbol	Land type	Area (ha)
1	CLN	Land for perennial crops	3.79
2	DGT	Traffic land	1.23
3	DTL	Irrigation land	0.03
4	SKC	Land for non-agricultural production facilities	0.08
5	HNK	Other annual crop land	4.55
6	NTD	Cemetery or graveyard land	0.12
7	ODT	Urban residential land	11.62
Total			17.66

3.4. Map quality assessment and discussion

The results of image block processing show that the mean square error is 2,01 pixels. The mean square error of field ground control points was 0.015 m. This result ensures the accuracy according to the regulations in Circular 07/2021/TT-BTNMT. The results of establishing the current land use map of the study area ensure compliance with the regulations according to Circular 08/2024/TT-BTNMT. The map meets the requirements on: presentation form, symbols of land types, and completeness of information. The results of field comparison show that 415/415 land plots ensure the accuracy of land types and plot boundaries. From there, it showed that the current land use map of the Ring Road 2 project in Phuoc Long B ward (now Phuoc Long ward) ensured quality, which can serve the work of compensation and site clearance.

Using UAVs provided better support for land clearance compensation. Instead of having to walk to each parcel, the survey team can collect comprehensive aerial data. This not only shortens the project implementation time but also limits errors due to human. The images and coordinate data obtained from UAVs are a solid basis for mapping the land use types and valuing assets fairly and transparently. The application of UAVs significantly reduces labor costs and field time. Instead of having to mobilize a large team for survey work, only a few technicians can operate UAVs to collect data. This is especially useful for areas with complex, difficult-to-access terrain, or large-scale and fast-implementation projects such as the Ring Road 2 project. The cost of operating a UAV is also much lower than using other traditional means of transport. The image and video data obtained from the UAV is visual, irrefutable evidence of the current condition of

the property before clearance. This helps people easily check and compare information, ensuring that compensation is carried out in accordance with reality. It also helps local management agencies closely monitor the process, prevent fraudulent and negative behaviors, thereby increasing people's trust in the government.

4. Conclusions

The study applied UAV technology to establish a 1/500 scale land use status map, which is within the boundary of Ring Road 2 in Phuoc Long B ward, Thu Duc City (now Phuoc Long ward). The research results showed that the land use status map was of good quality, which complied with the technical standards prescribed by the Ministry of Natural Resources and Environment. The results of the study confirmed that UAV technology can be applied in the establishment of large-scale maps. It was especially effective in areas that were difficult to access. Through the study, it can be seen that the application of UAV technology for ground monitoring had advantages such as: shortening the time to establish maps, ensuring high accuracy and limiting errors. Through the research process, it shows that the higher the image resolution, the longer the image processing time and the higher the computer configuration requirements. Therefore, depending on the purpose of using the image and the accuracy requirements, the researcher needs to choose the appropriate image resolution.

Conflict of interest

All authors declare that they have no conflicts of interest.

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