Application of images from UAV to create cadastral map in Mekong Delta (VietNam)

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Abstract. Research topic: "Application of images from UAV (Unmanned Aerial Vehicle) to create a 1:2000 cadastral map in Hoa Khanh Tay commune - Duc Hoa district - Long An province". The project was conducted in Hoa Khanh Tay commune, Duc Hoa district, Long An province from August 2017 to December 2018 with the goal of testing the establishment of 1:2000 cadastral map from UAV images, with Trimble UX5 HP aircraft and SONY a7R camera; The purpose of the paper is to assess the accuracy when using digital images taken from UAV to create large scale cadastral maps for state management of land. The project carried out through steps: designing flight imagegraphy, measuring grid control coordinates by static GPS technology, processing images, digitizing, drawing pictures, surveying information and additional measurements by total stationary method in the field, editing and perfecting the cadastral map according to current regulations. Based on the results of the project: evaluation of the accuracy and applicability of UAV images in mapping.

1. Introduction
Cadastral map showing current land use status, showing land plot or non-plots of land parcels, subjects occupying land but not forming land plots, approved planning elements, elements geographically relevant. Cadastral maps are made by region within one or several administrative units of commune level.[1].

Cadastral map is an important document to serve the state management of land.

Purpose of making cadastral map:
- Land allocation, registration of statistics, land acquisition, and issuance of land use right certificates.
- Confirm the current status of administrative boundaries at all levels, showing the fluctuations of the land types in each administrative unit at the communal level.
- As a basis for planning, land use plans.
- Inspection of land use situation and settlement of land disputes.
- Serving the adjustment of land changes.
- Building a land database.

Methods for making cadastral maps:
- Create a map by the method of direct measurement on the ground, also known as direct field measurement.
- Making cadastral map using GNSS technology.
Establishment of cadastral map by the method of using aviation images in combination with direct field measurement.

In this paper, the authors used the method of creating cadastral maps using the method of using images from UAV combined with the method of direct field measurement.

Mathematical foundations of Map:
- VN-2000 national coordinate reference system and Hon Dau - Hai Phong elevation
- Cadastral map is built according to VN-2000 reference system and national coordinate system.

With the meridian axis projection 30 appropriate to each locality.

- The scale of map
  The selection of the scale of map measurement must be based on the purpose, requirements and tasks of land management, the economic value of the land parcel, the difficulty level of each region, and the average density of such land plots in 1 hectare, Mt, equipment, and financial resources to select the appropriate measurement and mapping scale.
  + The scale of map 1: 200 is applicable to urban areas of special grade urban areas Mt ≥60.
  + The scale of map 1: 500 is applicable to areas with Mt ≥ 25 of urban land, urban land, and rural residential areas of urban form; Mt ≥ 30 belonging to the remaining residential area.
  + The scale of map 1: 1000 is applicable to the following cases:
    a) Areas with Mt ≥ 10 in residential land;
    b) Areas with Mt ≥ 20 in agricultural land in the form of narrow, extended parcels; agricultural land in wards, townships and communes in adjacent districts and communes in provincial towns and cities;
    c) Concentrated agricultural land areas with Mt ≥ 40.
  + The scale of map 1: 2000 is applicable to the following cases:
    a) Areas with Mt ≥ 5 belonging to agricultural land;
    b) Areas with Mt < 10 in residential land.
  + The scale of map 1: 5000 is applicable to the following cases:
    a) Areas with Mt ≤ 1 belonging to areas of agricultural production, aquaculture, salt production and other agricultural land;
    b) Areas with Mt ≥ 0.2 belonging to the forestry land area.
  + The scale of map 1: 10000 is applicable to the following cases:
    a) Forest land with Mt <0.2;
    b) Unused land, land with water surface have a large area in case of necessity to draw drawings to close the administrative boundary. [2]

2. Relevant researches in the world and in Vietnam

2.1. In the world

Many researches and applications in other countries in the application of UAV (Unmanned Aerial Vehicle) to take images for mapping purposes in many fields: cadastral, topographic, geological and urban planning, environment ...

In some studies, topographic mapping from UAV images is used, for example:

A 10-cm aviation imagegraphy project creates orthogonal and stereoscopic images with an area of 45,000 km² in the Netherlands to create orthogonal image maps and image triangles for the creation of topographic maps, DEM model ... projects in 3 years 2009-2011.

April 2010 scientist S.Kuscu, M.S. Ayık, E. Can reported at FIG Congress Facing the Challenges – Sydney (2010). The project "Project For The Producing Of 1/1000 Scale Base Maps From Colorful Images With Taken Digital Camera in Bursa Metropolitan Area in Turkey", the authors has created a large 1: 1000 scale basemap in the Bursa Metropolitan Turkey from image data digital aviation with high resolution.

In December 2011, scientist Joachim Hohle of Aalborg University - Denmak (Joachim Hohle 2011) published the project "On the Potential of New Digital Aerial Cameras for Dem Generation", [2]
the authors gave data as well as compared on Ground resolution and accuracy of digital aviation camera lines in establishing an elevation digital model.

In December 2014, scientists J. Narendran, P. Srinivas, M. Udayalakshmi, S. Muralikrishnan of National Remote Sensing Center and Indian Space Research Organization - India. Published the project "Quality Metrics of Semi Automatic DTM from Large Format Digital Camera" in this work, the authors evaluates the accuracy of the establishment of surface model from machine data of Large format image Ultracam - D.

Comment: In general, the above topics mainly use high-resolution digital aviation images and digital image processing stations to establish DEM, DTM and topographic maps.

2.2. In the VietNam

Some works of applying UAV drones in Vietnam in the fields of topographic and cadastral mapping, surveying and planning in construction fields such as:

+ In 2011, flying to create a 3D terrain map at 1: 2000 scale of Vietnam - Cambodia border.
+ In 2012 Establishment of topographic map to adjust the detailed construction planning of the area around West Lake, the rate of 1/2000.
+ 2013 Establishment of topographic map for Dao Me planning project - Thanh Hoa province, scale 1/2000.
+ Postgraduate project of University of Mining and Geology "Evaluation of accuracy of large-scale map established from aviation imagegraphic data taken with Vecxel Ultracam XP W \ A camera". However, in this topic, the authors uses digital image measurement stations to perform.

According to the current trend of technology development in our country, there are also research projects on the application of unmanned aerial vehicles (UAV-Unmanned Aerial Vehicle) in the making of maps: Assoc. Le Van Trung, Director of the Center for Geoinformatics, Vietnam National University, Ho Chi Minh City presented the study "Acquisition of images by unmanned aircraft for mapping work". Preliminary research results are highly appreciated, especially UAVs can take off and land on a small area and use GPS system and IMU device to determine the image center coordinates during flight.

Comment: In general, the application of digital aviation images mainly establishes topographic maps, image maps serving the planning survey. The establishment of large topographic maps in our country is less common, just research, while the current urgent need for speeding up the creation of topographic maps as well as reducing prices. products, improve product quality.

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3. Materials and methods

3.1. Materials

In this study, the authorss used images from UAV in August 2017. These images were processed and created as orthogonal images

Technological process of creating cadastral maps from image UAV.
3.2. Methods
In this study, the following methods are used:
- Methods of collecting documents and secondary data: Gathering information on creating topographic maps, theoretical and theoretical bases at home and in the world. Documents about technology of measuring images, using aviation images, UAV images to create topographic maps of paper and digital ratios and on the Internet ...
- Conducting field surveys and surveying of flying areas, building of image control points and measuring and controlling grid. Take a field trip to sample for image interpretation, digitizing image sheets in the room. At the same time, measuring the contents of topographic maps in areas that are hidden on the image and adjusting the field control, checking samples to improve the accuracy when making the map.
- Methods of interpretation and drawing (UAV).
- Map method and GIS tool
  The map method is used in the process of designing a fly map, digitizing the imagery map and additionally measuring and drawing in the field. In addition, the above method is also used to make editing and perfecting, showing the results of cadastral maps of the study area.
  Application of GIS tools in flight planning, image processing and digitalization of cadastral map editing. Using Microstation software to design the flight zone. FME2013 software for transferring design results to WGS84 coordinate system. Using PosTrack-Tracker32, POSAV 510 software to design and navigate the flight, Camera Operation Software (COS) 3.60 software to control the camera. After taking flight results using Ultramap 2.1.2 software to process and adjust to improve image quality. Use DIPEdit Ver 5.0 program to create Overview of digital image. Use Aerial Triangulation to increase image control. Then use the Ortho Vista 4.6 program to evenly color the image and the ImageStation OrthoPro Ver 4.03 program running on Geomedia Professional level automatically and merge image maps from the image data has been thickened.
- Total station method
  Using electronic total stations to measure and determine the points of the land plot and the above objects on the hidden area, which cannot be seen clearly on the image plan.
- Comparative statistical method
  This method is used to collect and summarize all land statistics documents, data related to mapping. Comparing errors and assessing the accuracy of the map established between the results of the thesis and traditional measurement data.

3.3. Research facilities
In this paper, the authors used Trimble UX5 HP aircraft and SONY a7R camera
  Introduction of UAV:
  - UAV (Unmanned Aerial Vehicle) is a drone. In its true sense, there is absolutely no pilot that can be remotely controlled or can fly on a set schedule.

4. Results and discussion
4.1. Research area - Hoa Khanh Tay commune
The study area in Hoa Khanh Tay commune is located in the southwest of Duc Hoa district, Long An province.
  - Terrain: Hoa Khanh Tay commune has a common feature of the Mekong Delta, with a flat topography. The whole measuring area has an average height above the sea level, about 1.5 - 2.0 m. Slope is small, most of the existing residential land is not flooded, scattered with low-lying areas along the banks of rivers and canals flooded in the rainy season.
  - Geophysical: In general, the terrain is mainly concentrated in the central area of the commune, sparse and distributed along waterway and road roads, industrial parks, residential areas and headquarters areas of administrative agencies, including: houses, post offices, schools ... This is convenient in identifying and digitizing objects on the image.
  - Food cover: The area is mainly cultivated with two- or three-season wet rice, vegetables, vegetables, short-term industrial crops, coconut trees, fruit trees, mainly dragon fruits. This is convenient for interpreting, recognizing and distinguishing boundaries when digitizing and drawing pictures.
  - Transport - Hydrology: Road DT823 runs in the northeast direction connecting from Tra Cu ferry to NH N2 road. There are also concreted inter-commune and inter-hamlet roads, large and small dirt roads running across and along residential areas and along canals and ditches such as Xang 1 canal (Cau Duyen), Thay An canal, Khang Chien canal, Chua canal ... Hydrology has Vam Co Dong River running through Hoa Khanh Tay commune about 10 km wide, average from 150 m to 160 m, average depth is about 15 m.
  - Climate: Hoa Khanh Tay commune is influenced by tropical monsoon and humid climate. Abundant temperature and radiation, average annual temperature is about 27°C to 27.7°C. The average daily lighting time is from 6.8-7.5 hours / day and the annual average is from 2500-2800 hours. The dry season from November to April has the northeast wind, frequency of 60-70%. Rainy season from May to October has southwest wind with a frequency of 70%.

With the above climate, the suitable area is mainly developed for growing rice, dragon fruits and crops. With such plants, it is convenient to see from the aerial image that can distinguish and identify clear boundaries.

Comment: Through analysis of the above mentioned natural conditions, in general, the study area with flat terrain, the difference is not significant. The terrain is sparsely distributed and mainly along traffic axes. At the same time, the area covered with low cover, the research area of cultivation is mainly wet rice, vegetables and dragon fruits ... Hoa Khanh Tay commune is an agricultural, socio-economic development medium. The urbanization rate is slow, there is little change in infrastructure. This is convenient in interpreting, identifying and clearly distinguishing objects on the image.

With the above conditions, in the study, the authors chose the map ratio of 1: 2000 and flew UAV to shoot image the ground in August 2017.
4.2. Process of flight and shooting UAV image

Flight and shooting UAV image processing:

- Flight design and management
  The flight is conducted directly at the measurement site. The imagegraphic flight was conducted on 08/2017 by "Geodetic - Map" Co., Ltd. of the Cartography Department - General Staff Department (Ministry of Defense).
  + Area and flight area: 50 km².
  + Maximum battery usage: 35 °/ 1 flight;
  + Image coverage: 80 x 80;
  + Ground resolution 15 cm.
  - Using eMotion2 sensefly software to design and manage flight. The design results on the software show:
    + Flight altitude: 530 m above terrain;
    + The number of flight: 46 flights;
    + Number of flight days: 08 days.

![Figure 2. Model of flight range when UAV fly up, during flight and landing](image-url)

Designing the location of the outdoor image control point including 10 points, made of iron poles and reflective paint, setting in the field before taking flight and determining coordinates and exact height by static GPS measurement method, the point of origin has coordinates and heights with an accuracy of grade IV or higher.

![Figure 3. The choice control points in field (a) and The product of this process is orthogonal images (b)](image-url)
4.3. Create and accuracy evaluation cadastral map from image of UAV

4.3.1. Create cadastral map from image of UAV.

Measuring and drawing boundaries of land plots from aviation image data/ After UAV image data has been processed and received the product is each orthogonal image map according to fragmentation of each cadastral map as prescribed, using Microstation v8i software to digitize images, at the same time, combined with the use of Mircosotion v7, Mapping Office, Famis and Vietmap to edit and improve the cadastral map. This digitization is based on the clear boundaries defined on the image such as farmland, canals, roads, etc. In residential areas and land plots with unclear boundaries or being obscured, additional measurement in the field shall be carried out in the field by means of direct drawing with electronic total station.

Based on the data of the project after digitizing and editing, the 1: 2000 cadastral map is completed at 18 Hoa Khanh Tay commune - Duc Hoa district - Long An province. The statistics of the area of digitization on the image and the compensation area are shown in Table 1.

| Table 1. Measuring area of each method |
|----------------------------------------|
| Content of the work                  | Area (ha) | %   |
| Additional measurement               | 13,75     | 13,75 |
| Digitize the map sheet                | 86,23     | 86,25 |
| Complete of map 18                   | 99,98     | 100,0 |

According to the statistics of the project, the workload performed between the UAV image method and the total measurement method is shown in Table 2 and Table 3

| Table 2. Date of implementation of Total measurement method |
|-----------------------------------------------------------|
| Content of the work                  | Date of implementation | Total |
| Grid of control points               | 3                      |       |
| Detailed measurement                | 15                     | 26    |
| Processing calculations and drawings | 5                      |       |
| Collection of land parcel information| 3                      |       |

(Source: "Geodetic - Map" Co., Ltd. of the Cartography Department - General Staff Department (Ministry of Defense)

| Table 3. Date of implementation of method of UAV image |
|-------------------------------------------------------|
| Content of the work                  | Date of implementation | Total |
| Digitizing images                    | 1                      |       |
| Additional measurement               | 3                      | 8     |
| Processing calculations and drawings | 2                      |       |
| Collection of land parcel information| 2                      |       |

The local economy of Hoa Khanh Tay commune - agricultural development, mainly growing rice and vegetables. The population is concentrated along the roads and canals, so the image usability rate reaches 86.25%. Total date of implementation created cadastral map by method of UAV image in 31 % of total measurement method.

4.3.2. Accuracy evaluation cadastral map from image of UAV

- Check coordinates of the corner of the land plot

  From the image control points and ground control grid of theodolite 1, (KV1-9, KV1-10 and KV1-11) established in the measurement area, using electronic total stations to conduct measurements. Check the coordinates of the boundaries of the land plot in map sheet 18.

  The results of detailed point measurements were calculated and transferred to the cadastral map that was established from UAV images.
Number of detail points for measuring the corner inspection of the land plot: 80 points. The maximum and minimum differences are shown in Table 4.

Position error calculated by the formula:

\[ \Delta S = \sqrt{\Delta X^2 + \Delta Y^2} \]  

\((1)\)

| No. points | X(m) | Y(m) | X(m) | Y(m) | ΔX(m) | ΔY(m) | ΔS(m) | Note |
|------------|------|------|------|------|-------|-------|-------|------|
| KT6        | 1201584.870 | 568951.539 | 1201584.942 | 568951.485 | -0.072 | -0.054 | 0.09  | Min  |
| KT34       | 1201465.395 | 569204.895 | 1201465.312 | 569204.931 | -0.083 | 0.036  | 0.09  | Min  |
| KT56       | 1201289.497 | 569399.947 | 1201289.425 | 569399.892 | -0.072 | -0.055 | 0.09  | Min  |
| KT12       | 1201575.274 | 569211.784 | 1201575.025 | 569211.967 | -0.249 | 0.183  | 0.31  | Max  |
| KT55       | 1201321.507 | 569379.478 | 1201321.784 | 569379.625 | 0.277  | 0.147  | 0.31  | Max  |
| KT79       | 1201122.541 | 569282.783 | 1201122.349 | 569282.600 | -0.192 | -0.183 | 0.27  | ΔY_Min |
| KT12       | 1201575.274 | 569211.784 | 1201575.025 | 569211.967 | -0.249 | 0.183  | 0.31  | ΔY_Max |
| KT55       | 1201389.318 | 569291.988 | 1201389.510 | 569292.171 | 0.192  | 0.183  | 0.27  | ΔY_Max |
| KT17       | 1201630.911 | 569298.960 | 1201630.617 | 569298.902 | -0.294 | -0.058 | 0.30  | ΔX_Min |
| KT39       | 1201543.005 | 569319.426 | 1201542.711 | 569319.368 | -0.294 | -0.058 | 0.30  | ΔX_Min |
| KT80       | 1201181.111 | 569239.218 | 1201181.398 | 569239.141 | 0.287  | -0.077 | 0.30  | ΔX_Max |

According to Circular 25 [2]: The error of the position of any point on the boundary of the land plot to the position of the nearest control point \( \leq \pm 30 \text{ cm} \) for cadastral maps of 1: 2000 scale. For agricultural land measuring cadastral maps at the scale of 1: 1000, 1: 2000, the reciprocal error of the position of any two points above may be increased by 1.5 times. In this study, the scale of the map needed to be established is 1: 2000, this area is agricultural land so the corresponding error will be 0.45 m. Thus, the error is within the permissible limits.

- **Check length of the land plot**

  The number of edges tested is 69. The maximum and minimum differences are shown in Table 5.

![Figure 4](image.png)

**Figure 4.** The position of two checked edges have the maximum and minimum differences.
Table 5. The lengths have maximum and minimum differences

| No. the edge | The length of the edge is measured by the total method | The length of the edge is measured by UAV imaging | Length difference | Note |
|------------|-------------------------------------------------------|-------------------------------------------------|-------------------|-----|
| KT65-KT66 | 44.44                                                 | 44.44                                           | 0.00              | Min |
| KT79-KT80 | 73.00                                                 | 73.38                                           | 0.38              | Max |

According to Circular 25 [2]: The reciprocal error of the position of any two points on the boundary of the land plot indicated on the digital cadastral map compared to the distance on the field directly or indirectly measured from the same workstation does not exceed 0.2 mm according to the scale of the map to be established.

For agricultural land measuring cadastral maps at the scale of 1: 1000, 1: 2000, the reciprocal error of the position of any two points above may be increased by 1.5 times. In this study, the scale of the map needed to be established is 1: 2000, this area is agricultural land so the corresponding error will be 0.6 m. Thus, the error is within the permissible limits.

- Check acreage
  Conduct overlapping of maps between results maps using UAV image method and cadastral map that local competent authorities have just accepted and published to use in December 2018. In order to compare the land areas, the authors has calculate the area of the land plot on two cadastral maps and using Excel software calculate the difference and compare with the limit value, which is calculated using the following formula (2).

\[
\Delta P = \pm \frac{0.04 M}{100} \sqrt{P}
\]  

In which: M is the denominator of the map scale; P is the area of land plot.

The land plot has the largest and smallest area difference, with the percentage of the largest and smallest difference is shown in Table 6.

Table 6. Difference of the area of the land plot

| No. of land plot | Acreage measured by the total method (m²) | Acreage measured by UAV image method (m²) | Acreage difference ΔP (m²) | Acreage difference limits (m²) | % | Note |
|-----------------|-----------------------------------------|-----------------------------------------|---------------------------|--------------------------------|----|------|
| 13              | 7740,8                                 | 7737,3                                 | -3,5                      | 70,4                           | 0,05 | % Min |
| 328             | 60,1                                   | 54,3                                   | -5,8                      | 6,2                            | 10,1 | % Max |
| 315             | 158,5                                  | 160,1                                  | 1,6                       | 10,1                           | 1,00 | Min |
| 16              | 11917                                  | 11987,4                                | 70,6                      | 87,3                           | 0,59 | Max |

The error is within the permissible limits.

Comment: Thus, UAV images fully meet the requirements of geometric accuracy for large scale database and cadastral maps.

5. Conclusions

More research in this area is needed to draw accurate conclusions, which can then be converted into normative regulations in the use of UAV image data for other industries.

In order to reduce costs as well as labor, the Ministry of Natural Resources and Environment and the Department of Natural Resources and Environment should encourage and boldly apply the measurement of mapping using UAV image technology into production practice.
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