Bulletin of the *Transilvania* University of Braşov • Vol. 16(65) No. 2 – 2023
Series I: Engineering Sciences
https://doi.org/10.31926/but.ens.2023.16.65.2.1

IMPORTANCE OF PHOTOGRAMMETRY IN FLOOD ANALYSIS

C. CERNEAGĂ[1] C. MAFTEI[2]

Abstract: *Floods have always been a natural disaster of immense concern, causing significant damage to both property and human lives. Accurate and timely flood analysis is essential for effective disaster management and response. Drone photogrammetry provides rapid data collection, high-resolution imagery, and 3D modeling capabilities. This technology not only enhances our ability to efficiently understand and respond to floods but also empowers disaster management authorities and researchers to comprehensively grasp, respond to, and prepare for flooding events. This article explores the pivotal role of drone photogrammetry in flood analysis, highlighting its importance, applications, and methodology.*

Key words: *floods, drone photogrammetry, high-resolution imagery.*

1. Introduction

Floods, as one of the most destructive natural disasters, have consistently posed a grave threat to communities worldwide. They not only result in immediate destruction but also have long-term economic, social, and environmental impacts. Timely and accurate flood analysis is, therefore, paramount for disaster preparedness, response, and mitigation efforts. Traditional methods of flood analysis, such as ground surveys and satellite imagery, have their limitations in terms of speed, precision, and accessibility.

Furthermore, climate change is causing more frequent and severe floods, making it essential to adopt advanced technologies to better understand, assess, and mitigate their impacts.

Drone photogrammetry has emerged as a powerful tool for flood analysis, and is a cutting-edge method that utilizes unmanned aerial vehicles (UAVs) equipped with high-resolution cameras to capture images from various angles, creating three-dimensional models of terrain and objects.

The use of photogrammetric techniques allows the generation of dense point clouds whose density is comparable to those acquired by TLS and LiDAR and in which the Ground Sample Distance (GSD), for the same camera, depends on the flight altitude only [8].

In the context of flood analysis, this technology offers numerous advantages that

[1] Ovidius University of Constanta, Doctoral School of Applied Sciences.
[2] Transilvania University of Brasov, Faculty of Civil Engineering, carmen.maftei@unitbv.ro

enhance our understanding of flood events, aid in flood risk assessment, and improve disaster response strategies.

The purpose of this work is to develop a terrain model for the Războieni locality that will be used in a later article to simulate possible disasters in case of a flooding event, considering the results presented also taken into consideration the climate change.

2. Materials and Methods

Study area it’s part of Casimcea river, a sector that include Războieni locality. Casimcea is the most important river in Dobrogea with a basin surface of approximately 742, 33 sq km, and a length of 76,13 km [1]. Casimcea was reported to the EU as one of the 526 areas with a potentially significant flood risk due to the floods in 2002, 2005 and 2010 when Războieni, and other localities located downstream along the river suffered important damages [3].

The application of drone photogrammetry in flood analysis involves a systematic approach that combines technology, data collection, and data processing, offering an overview of the terrestrial situation.

2.1. Drone characteristics

DJI Phantom 4 RTK (Figure 1) is a cutting-edge drone designed for surveying and mapping applications. It boasts a real-time centimetre-level positioning system and a redundant GNSS module for flight stability. The TimeSync system aligns data for precise metadata, while the camera 1-inch, 20-megapixel CMOS sensor, and mechanical shutter ensure high-quality image capture.

Fig. 1. *DJI Phantom 4 UAV with RTK module (top side) and Controller* [9]

The drone offers a Ground Sample Distance (GSD) of 2.74 cm at 100 metres altitude. The GS RTK app provides advanced flight planning options for photogrammetry and waypoint flights. It also supports KML area files, shutter priority mode, and wind alarms.

Compatibility with the DJI Mobile SDK allows customization and automation. The OcuSync transmission system ensures stable HD image and video transmission up to 7 kilometres. The drone seamlessly works with the D-RTK 2 Mobile Station, providing real-time differential data for accurate surveying (Figure 2).

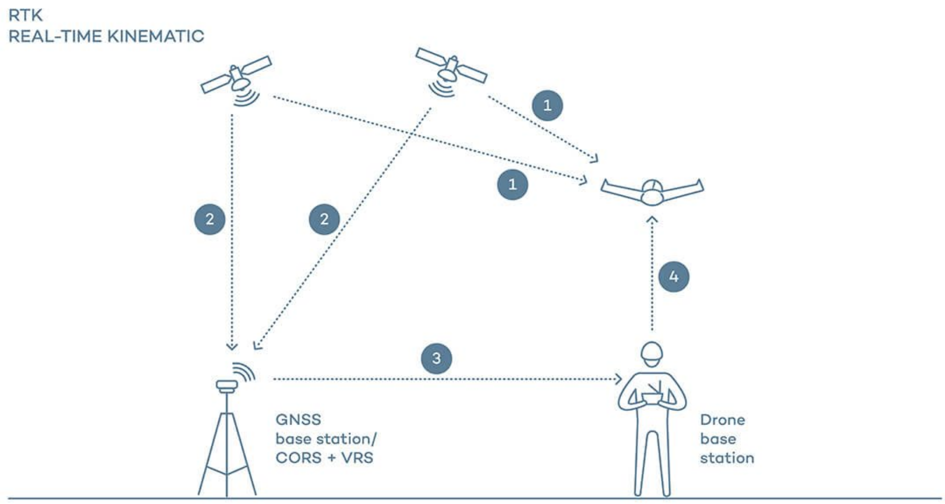

Fig. 2. *Real-Time Kinematic - data transmission* [10]

RTK (Real-time kinematic) positioning is a satellite navigation technique used to enhance the precision of position data derived from satellite-based positioning systems (global navigation satellite systems, GNSS) such as GPS, GLONASS, Galileo, and BeiDou [4].

In Romania, accessing and using GNSS corrections from permanent stations requires access to the ROMPOS state network or another private network from the existing ones. In our case, we used the GNSS corrections received from the ROMPOS network managed by the National Cadastre and Real Estate Advertising Agency (ANCPI).

To improve survey accuracy, we use a GNSS Leica GS12 ROVER with CS15 controller to collect a number of 5 ground control points, with known locations, three on one side and two on the other side of the river.

GCP (ground control point) coordinates. Table 1

GCP No.	North (X)	East (Y)	Elevation (Z)
1 Lt	770337.173	367622.425	199.803
2 Lt	770356.605	367618.049	199.423
3 Lt	770371.743	367618.145	199.314
4 Rt	771200.201	368343.222	232.401
5 Rt	771220.156	368353.948	232.929

Both the number and the position of the ground control points (GCPs) were chosen considering the specialized literature, which suggest that for relatively small study sites the vertical error stabilizes after 5 or 6 GCPs and the horizontal error after 5 GCPs [5, 6].

2.2. Software

Pix4D Mapper software is a leading solution for processing drone-captured imagery into accurate 2D and 3D maps. Its advanced algorithms generate orthomosaic, point clouds, and DSMs/ DEMs, enhancing flood analysis accuracy. During processing, one can access and improve project quality with the aid of quality reports regarding the generated results, calibration details, etc. Once the data is processed, from the digital model it becomes possible to extract distances, areas, volumes, elevation profiles, contours, etc.

The main advantages of the software used are as follows:

- Automatic point classification with a revolutionary algorithm that uses machine learning.
- Surface finishing and automatic filling of voids.
- Easy measurement of distance, areas, elevation and volumes, directly on the digital model.
- Inspection and marking of project elements both local and remote.
- Fast and secure sharing of project data as well as a possibility of collaboration in the editing of data.

Pix4D Mapper can process data from images taken from any camera, any drone and any kind of image: RGB images, drone images, multi-spectral images, thermal images, “fisheye” (ultra-wide angle) images, 360° images and videos.

3. Results and discussions

One of the most noteworthy achievements of drone photogrammetry is its unparalleled precision in spatial data capture. This technology can be applied to create detailed topographic maps, highly accurate 3D models of structures, and digital elevation models. Traditional surveying and mapping methods are often characterized by their time-consuming nature and high costs. Drone photogrammetry presents a transformative solution, substantially reducing the time and expenses associated with data collection and processing.

Furthermore, drone photogrammetry's capacity to access remote or hazardous locations is one of its most compelling attributes. This capability can be invaluable for various applications, including environmental monitoring, disaster assessment, archaeological research, and infrastructure inspection. By sending a drone into areas where human access is limited or unsafe, we can gather crucial data without jeopardizing human safety [7].

In this study we combine the DJI Phantom 4 RTK drone with Pix4D Mapper software, leading us to a high-resolution DSM (Figure 3) and orthomosaic (Figure 4) created from 1076 calibrated images covering 1.28 sq km with an average Ground Sampling Distance (GSD) of 4.47 cm.

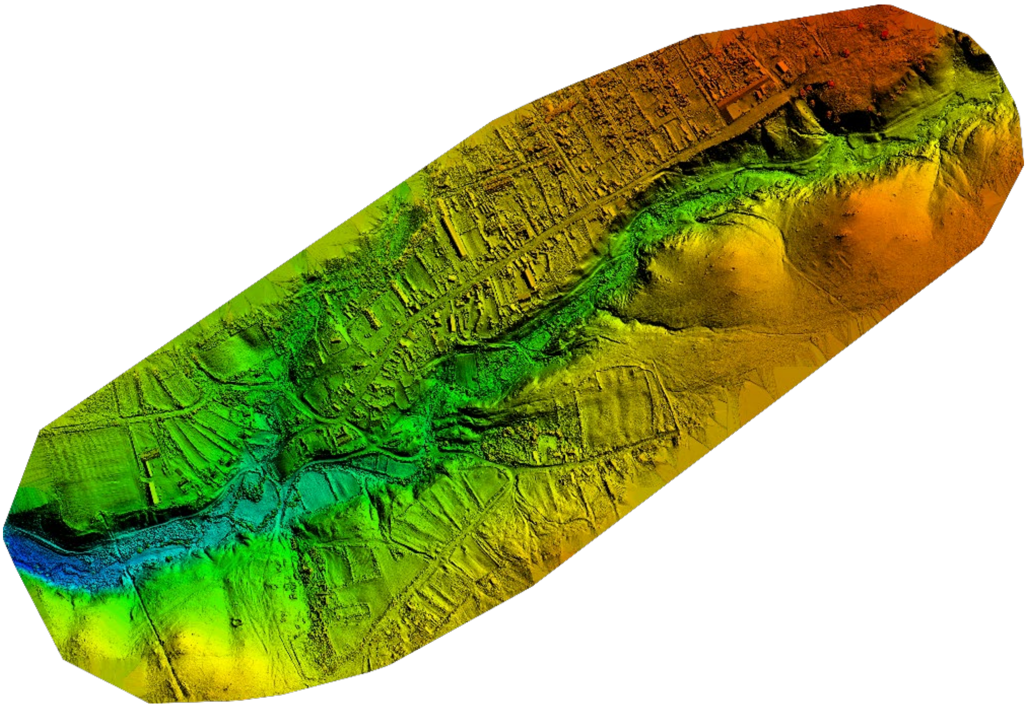

Fig. 3. *Digital Surface Model*

Fig. 3. *Orthomosaic*

According to the Flood Hazard Maps and Plan for the Prevention, Protection, and Mitigation of Flood Effects in the Dobrogea-Litoral Hydrographic Area - Stage report, a digital elevation model was generated using LiDAR technology with a detailed level of scanning (10 points/ sq metre), vertical resolution ranging from 10 to 20 cm, and horizontal resolution of 10 cm [2].

4. Conclusions

Drone photogrammetry has emerged as a powerful tool in flood analysis. This methodology allows for rapid, accurate, and detailed data collection, enabling authorities and researchers to better understand and respond to flooding events. As technology continues to advance, drone photogrammetry will play an increasingly vital role in improving flood management, reducing risks, and safeguarding vulnerable communities.

While the potential of drone photogrammetry is undeniable, it is not without its limitations and challenges. Adverse weather conditions, stringent airspace regulations, and the need for skilled operators are main factors that must be navigated.

References

1. Cerneagă, C., Dobrică, G., Maftei, C.: *Hydraulic Modeling with HEC-RAS 2D in the Urban Area of Casimcea (Romania) Catchment.* In: Chenchouni, H., et al. New Prospects in Environmental Geosciences and Hydrogeosciences. CAJG 2019. Advances in Science, Technology & Innovation. Springer, 2022.
2. *Flood Hazard Maps and PPPMFP.* ROMAIR, 2012, p. 6.
3. *Flood Risk Management Plan - National synthesis,* Ministry of the Environment, Waters and Forests - National Administration „Romanian Waters", 2023, p. 17.
4. Li, X., Zhang, X., Ren, X. et al.: *Precise positioning with current multi-constellation Global Navigation Satellite Systems: GPS, GLONASS, Galileo and BeiDou.* In: Scientific Reports 5 (2015), 8328; https://doi.org/10.1038/srep08328
5. Manfreda, S.; Dvorak, P.; Mullerova, J.; Herban, S.; Vuono, P.; Arranz Justel, J.; Perks, M.: *Assessing the Accuracy of Digital Surface Models Derived from Optical Imagery Acquired with Unmanned Aerial Systems.* In: MDPI, Drones 3(15) (2019), p. 1-14.
6. Mesas-Carrascosa, F.J., Torres-Sánchez, J., Clavero-Rumbao, I., García-Ferrer, A., Peña, J.M.; Borra-Serrano, I.; López-Granados, F.: *Assessing optimal flight parameters for generating accurate multispectral orthomosaicks by uav to support site-specific crop management.* In: Remote Sensing, 7 (2015), p. 1-3.
7. Mohsan, S.A.H., Othman, N.Q.H., Li, Y. et al.: *Unmanned aerial vehicles (UAVs): practical aspects, applications, open challenges, security issues, and future trends.* In: Intelligent Service Robotics 16 (2023), p. 109-137.
8. Taddia, Y., Stecchi, F., Pellegrinelli, A.: *Coastal Mapping Using DJI Phantom 4 RTK in Post-Processing Kinematic Mode.* In: MDPI, Drones 4(9) (2020).
9. https://enterprise.dji.com/phantom-4-rtk?site=enterprise&from=nav. Accessed: 30.10.2023.
10. https://wingtra.com/ppk-drones-vs-rtk-drones/. Accessed: 30.10.2023.