[https://doi.org/10.69646/aob241223]
[Poster]

Innovative UAV Approaches for Monitoring Riverbank Erosion and Lateral Channel Migration Processes

Marko Langović[1*] and Slavoljub Dragićević[1]

[1] University of Belgrade, Faculty of Geography, Serbia

*Correspondence: marko.langovic@gef.bg.ac.rs

Abstract: Modern physical-geographical research encompasses a comprehensive examination of the intensity and dynamics of natural processes, among which the processes of riverbank erosion and lateral channel migration stand out as particularly significant. The use of modern technologies (remote sensing, unmanned aerial vehicles and GIS software) provides new possibilities for fluvial geomorphology research, particularly with regard to accuracy, detail and visual representation. The aim of this article is therefore to point out the importance of the use of innovative UAV technology in the investigation of riverbank erosion process on the examples of the Kolubara and South Morava rivers in Serbia. The obtained results could be valuable for river channel management, water management, spatial end environmental planners and policy makers, etc.

Keywords: Riverbank erosion, UAV, drones, Lateral channel migration

Introduction

Riverbank erosion represents a component of lateral channel migration and is therefore recognised as a constant, active and most important geomorphological process in floodplains (Menting & Meijles, 2019; Sylvester et al., 2019; Hooke 2023). Lateral bank erosion of meandering rivers is responsible for extensive destruction of

agricultural lands and landscape degradation and usually has very severe ecological and economic consequences (Langović et al., 2024). Furthermore, understanding and managing riverbank erosion is crucial to achieve a balance between ecological conservation, economic and sustainable development (Dragicevic et al., 2017). In the era of intense climate change as a direct determinant of hydrological variability and changes in the river regime, knowledge of the recent dynamics of the intensity of the above-mentioned processes is of great importance.

In addition, contemporary and observational research into the process of lateral channel migration and riverbank erosion employs numerous technical innovations that enable more precise and appropriate fieldwork and quantitative calculation of the intensity of the process, as well as its analysis and interpretation. In this context, the use of unmanned aerial vehicles (UAVs) is of particular importance for this type of research, as they allow constant observation of the Earth's surface in real time and its dynamics. The advances in photogrammetry and the availability of lightweight unmanned aerial vehicles or drones offer an advantageous alternative for the acquisition and creation of orthophoto images of the Earth's surface as well as secondary digital models of the topographic surface with high temporal and spatial resolution (Long et al., 2016, Dragićević et al., 2024).

The aim of this paper is to illustrate the possibilities of using modern unmanned aerial vehicles in the study of riverbank erosion and lateral channel migration in Serbia. The results of studies that implemented mentioned modern technologies (conducted on the Kolubara and South Morava rivers), have improved the possibilities of observing and quantifying these processes and facilitated field research.

Methods and data

The use of modern field survey methods was reviewed on the example of the meandering sections of the Kolubara and South Morava rivers from 2014. The use of drones has enabled the quantification of changes that have occurred in particular before and after extreme climatic-hydrological events. To date, monitoring of the riverbanks of the Kolubara and South Morava rivers has been carried out using unmanned aerial vehicles, which have different technical competences and different optical and flight capabilities. The first surveys were carried out in 2014 (June and December) with the SenseFly eBee aircraft and covered certain sections of the Kolubara River (total length of 7.5 km) (Dragićević et al., 2015; Dragićević et al., 2017). In the period 2019-2023, the surveys were carried out on the South Morava River (total length of 7.2 km) using several drones: Phantom 4 pro, Parrot ANAFI Work and DJI Air 2s drones (Langović, 2022). During the same period, surveys were also carried out on the individual meanders of the Kolubara River using Parrot Anafi Work and Dji Mini Pro 4 drones. All recordings were made from an altitude of 40-55 metres along a previously planned route, i.e. special software for planned terrain recordings (Pix4D Capture) was used. WebODM and the Pix4D Capture software were used for the subsequent processing of a large number of images, with the ultimate goal of obtaining clear orthophoto images of all surveyed sectors.

The resolution of the processed orthophotos was 4 cm/pixel. In the same way, digital relief models of the study areas were created, which were later used for a more detailed analysis of bank heights and changes in vegetation cover. Based on the data obtained, an analysis of the basic morphometric indicators was carried out, namely the sinusoidality and geometric elements of the meander curves, etc.

Results and discussion

The most important results of conducted research are singled out in this segment. Considering that one of the most important factors influencing the evolution of river channels is the occurrence of extreme hydrological events on the Kolubara River, the highest values of bank erosion intensity were recorded in 2014 (between 2.2 and 11.2 m depending on the defined meander) (Figure 1). A comparison of the results with previous studies on the riverbanks of the Kolubara River indicates a significant loss of soil in the period December 2013 - June 2014, when an intensity 2-3 times higher than in previous periods was recorded. In the Kolubara River Basin, riverbank erosion of 7.1 m occurred during the four-day passage of a flood wave (May 2014), which corresponds to 30.3 % of soil loss in four years of observation (2010–2014) (Dragićević et al., 2017).

Similar results were obtained for the South Morava River. The highest intensity of riverbank erosion of the South Morava River over a two-year research period (November 2019 - November 2021) was recorded on one of the meanders and amounted to 104.8 metres (4.3 m/month) (Figure 1). In the same period, the degradation of riverbank zone was 4.66 ha (Langović, 2022). However, the intra-annual analysis showed that the extreme hydrological event of January 2021 had the greatest impact on the intensity of the bank erosion process (over 50% of the total bank erosion for the observed period of only three months compared to the two-year study period. The importance of this process is also evidenced by the fact that most of the lost land belongs to agriculturally fertile land.

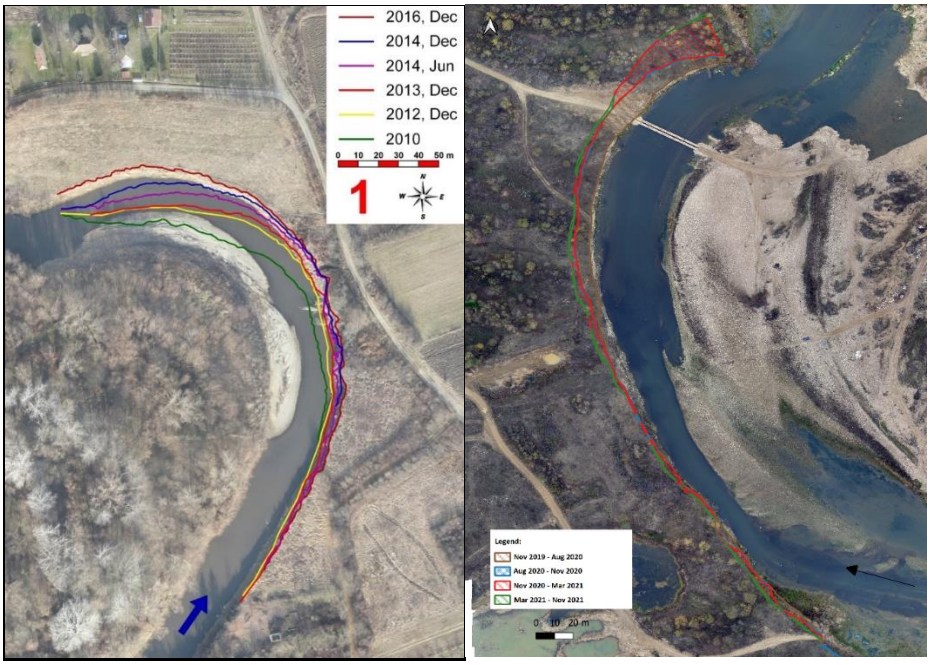

Figure 1. Examples of two meanders characterised by intensive riverbank erosion in recent times: Kolubara River (left) and South Morava River (right)

Conclusions

With the development of easily accessible unmanned aerial vehicles or drones for aerial photography, the precise positioning of riverbanks and the detailed research of their recent evolution and dynamics became possible. The use of these technologies and the associated software has proven to be very reliable and applicable and has opened up new possibilities and new fields of research in the geosciences, especially in fluvial geomorphology. Future work includes the use of even more advanced unmanned devices with improved optical equipment, sensors and numerous capabilities (Dji mavic 3M with multispectral camera).

References

Dragićević, S., Živković, N., Roksandić, M., Luković, J. & Kostadinov, S. (2015). *Recent state, intensity and consequences of the riverbank degradation of Kolubara River (Obrenovac Municipality)]*. Belgrade: University of Belgrade, Faculty of Geography.

Dragićević, S., Pripužić, M., Živković, N., Novković, I., Kostadinov, S., Langović, M., Milojković, B. & Čvorović, Z. (2017). Spatial and Temporal Variability of Bank Erosion during the Period 1930–2016: Case Study—Kolubara River Basin (Serbia). *Water*, 9, 748.

Dragićević, S., Langović, M., Lovrić, N., Milevski, I. & Tošić, R. (2024). The use of new technologies in the research of the fluvio-denudation process]. *Collection of papers VI congress of geographers "Where is geography going"*, Zlatibor, August 2024., 32-41. doi: 10.5937/KonGef24003D.

Hooke, J. (2023). Morphodynamics of active meandering rivers reviewed in a hierarchy of spatial and temporal scales. *Geomorphology*, 439(5), 108825.

Langović, M. (2022). Spatial and temporal dynamics of river bank erosion process (South Morava River). *Doctoral dissertation*. University of Belgrade, Faculty of Geography.

Langović, M., Popović, S., Dragićević, S., Stojanović, Ž. & Manić, E. (2024). Assessment of the Economic Consequences of Riverbank Erosion: The Case of the South Morava River, Serbia. *Water Economics and Policy*, doi: 10.1142/S2382624X24500036.

Long, N., Millescamps, B., Guillot, B., Pouget, F. & Bertin, X. (2016): Monitoring the topography of a dynamic tidal inlet using UAV imagery. *Remote Sensing,* https:// doi. org/ 10. 3390/ rs805 0387.

Menting, F. & Meijles, E. (2019). Local Factors Determining Spatially Heterogeneous Channel Migration in a Low-Energy Stream. *Water*, 11, 2149. DOI: doi:10.3390/w11102149.

Sylvester, Z., Durkin, P. & Covault, J. (2019). High curvatures drive river meandering. *Geology*, 47(3).