Bulletin of the *Transilvania* University of Braşov • Vol. 18(67) No. 2 – 2025
Series I: Engineering Sciences
https://doi.org/10.31926/but.ens.2025.18.67.2.3

IMPROVING FLOOD HAZARD MAPPING IN NISTOREȘTI: A LIDAR-BASED COMPARISON WITH FRMP

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Abstract: *This study analyses the flood hazard limits for the locality of Nistorești, in the Casimcea river basin, based on LiDAR-derived digital terrain models integrated into hydraulic simulations. The results highlight discrepancies between the modelled inundation extents and those currently defined in the Flood Risk Management Plan (FRMP), suggesting that in some areas the official flood boundaries underestimate the actual hazard. These findings underline the importance of incorporating updated topographic data and advanced hydraulic modelling techniques in the revision of flood risk maps, in order to provide more accurate and reliable tools for local risk management and planning in Nistorești.*

Key words: *LiDAR, FRMP, Flood mapping.*

1. Introduction

Floods are among the natural hazards with the highest destructive potential in Romania, exerting significant impacts on physical, economic, and socio-psychological components, while also exhibiting a medium frequency of occurrence, according to a national risk assessment [2]. In the context of ongoing climate change, an increase in the frequency and intensity of flood events is anticipated across numerous river basins [3], particularly during the winter and spring seasons [1].

These changes highlight the growing need for accurate flood risk assessments and updated hazard mapping, based on reliable topographic and hydrological data [6]. In many regions of Romania, existing flood hazard maps—developed as part of the Flood Risk Management Plans (FRMPs)—are based on coarse-resolution topographic datasets that may not adequately represent local terrain variability [7], due to complex geomorphological features or recent land-use changes. Consequently, flood extents delineated using outdated or lower-accuracy datasets are likely to underestimate the actual hazard, particularly in areas where fine-scale topographic variability plays a critical role in flow dynamics.

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This study focuses on the locality of Nistorești, situated within the Casimcea River Basin, and aims to reassess the flood hazard limits using high-resolution LiDAR-derived digital terrain models (DTMs) integrated into hydraulic simulations. By comparing the modelled inundation extents with those defined in the FRMP, the research seeks to identify inconsistencies and evaluate the implications of using updated terrain data and advanced hydraulic modelling techniques for improving flood hazard mapping and local risk management.

2. Materials and Methods

2.1. Study area

The Casimcea River Basin is located within the Dobrogea–Litoral hydrographic network, in southeastern Romania. It is drained by the Casimcea River, which flows across the region along a northwest–southeast direction. The river originates in the Central Dobrogea Plateau (Casimcea Plateau) and discharges into Tașaul Lake.

Covering a total area of approximately 740 km², the Casimcea Basin represents the largest hydrographic basin in Dobrogea, with the main river course extending over about 69 km in length. [5]

2.2. Data collection

Data acquisition was carried out using RTK (Real-Time Kinematic) measurements, which enable the determination of point coordinates with high positional accuracy. The measurements were performed with an advanced Trimble R780 GNSS receiver, ensuring reliable data collection and centimetre-level precision in both horizontal and vertical positioning. The RTK system provided real-time transmission of correction data between the base station and the rover receiver (Figure 1), allowing accurate georeferencing of each surveyed point.

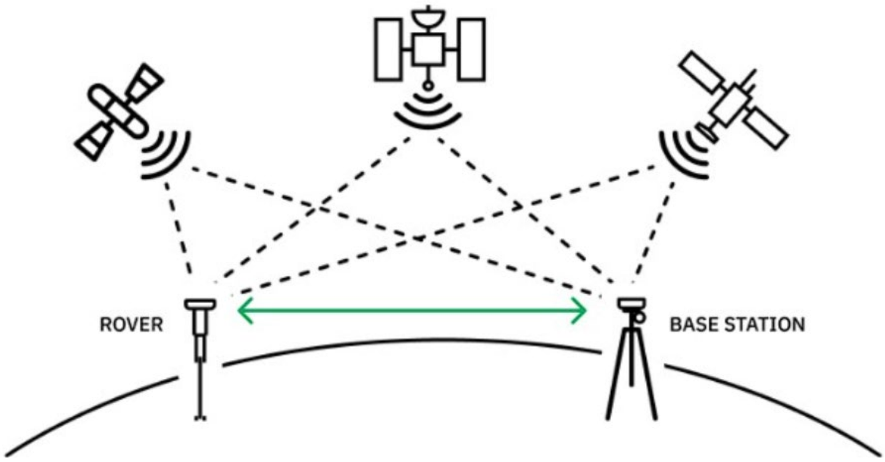

Fig. 1. *Real-time transmission of data in the RTK system* [8]

In addition to ground-based GNSS surveys, aerial data were collected using a DJI Matrice 350 drone equipped with a LiDAR L2 sensor, capable of generating high-density point clouds and capturing fine-scale topographic variations. These datasets provided a detailed and accurate representation of the terrain surface, suitable for subsequent terrain modelling and hydraulic simulations.

The density and accuracy of the acquired points depended primarily on the technology employed, the characteristics of the surveyed terrain, and the flight and acquisition parameters defined during the data collection process (Figure 2).

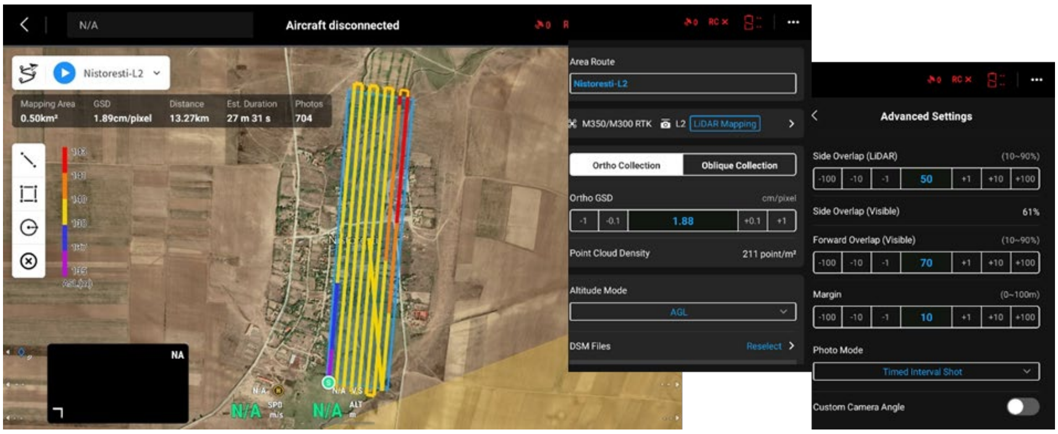

Fig. 2. *Mission planning*

Using corrections from the Istria reference station (RTCM0043), a positional accuracy of 0.012–0.017 m in the horizontal plane and 0.021–0.031 m in the vertical plane was achieved for the study area.

2.3. Data Processing and Terrain Modelling

After field data acquisition, the next step involved data processing, during which measurement errors were corrected, raw data were filtered, and the measured points were interpolated to generate a continuous terrain surface.

This processing stage requires the use of specialized software capable of handling large geospatial datasets. In this study, DJI Terra was employed to process the aerial LiDAR and photogrammetric data, enabling the creation of a high-resolution digital terrain model (DTM). The workflow included point cloud cleaning, noise removal, georeferencing, and interpolation to produce an accurate and detailed representation of the study area's topography.

Following field data acquisition, the LiDAR point cloud served as the primary source for terrain representation, while aerial images were collected to colour and enhance the visualization of the point cloud. The raw data were then subjected to a post-processing stage, during which measurement errors and artificial elements were removed to ensure a more accurate depiction of the terrain.

The processed data were used to generate a Digital Elevation Model (DEM) (Figure 3), which provides a detailed and faithful representation of the natural morphology of the study area. The DEM was constructed using TIN (Triangulated Irregular Network) interpolation, offering precise modelling of irregular surfaces, and also converted into a raster format with a predefined spatial resolution, facilitating its integration into hydraulic simulations.

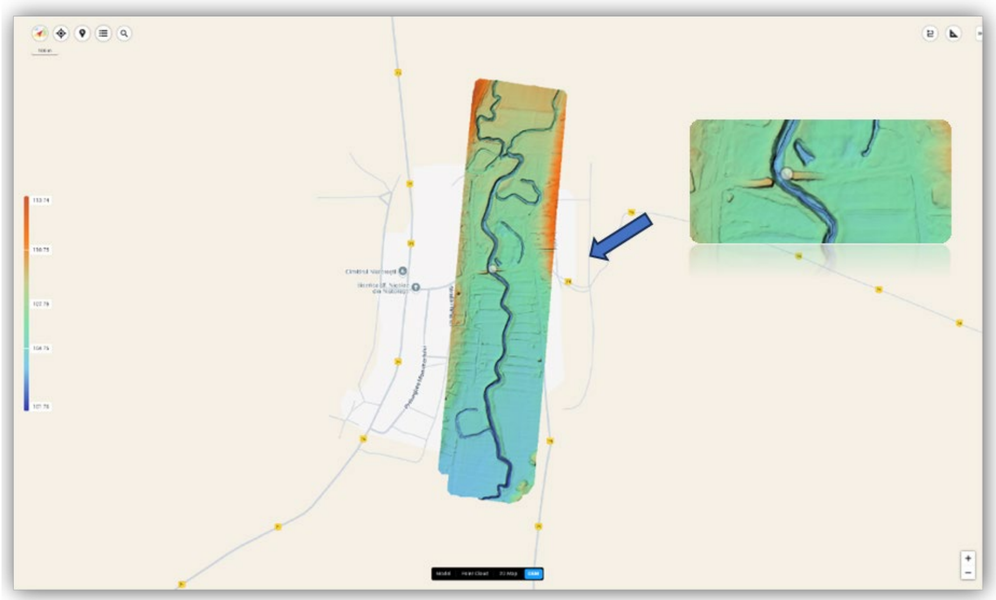

Fig. 3. *Digital Elevation Model (DEM)*

This final DEM represents the most refined product of the data processing workflow and is fully suitable for subsequent hydraulic modelling, forming the basis for simulating flood events in the Nistorești area.

2.4. 2D Hydraulic Modelling

A two-dimensional (2D) hydraulic model was developed in HEC-RAS for the Nistorești sector, enabling simulation of water flow in both longitudinal and lateral directions. The model uses the previously generated DEM and a 10 × 10 m computational mesh, refined along the main channel (thalweg) to capture detailed flow patterns (Figure 4).

Artificial elements were removed during preprocessing, and Manning's roughness coefficients were assigned based on land-use classes from Corine Land Cover, adapted to local terrain characteristics.

Boundary conditions were defined upstream using the hydrograph from the 2002 extreme event, which had a peak flow of 398 m^3/s, while downstream conditions were specified separately for the minor channel and for the left and right major channels, ensuring that no intersections occurred with the computational mesh. This 2D modelling approach provides a realistic representation of flood extent, depth, and flow distribution, suitable for comparison with existing flood hazard limits and supporting local flood risk management.

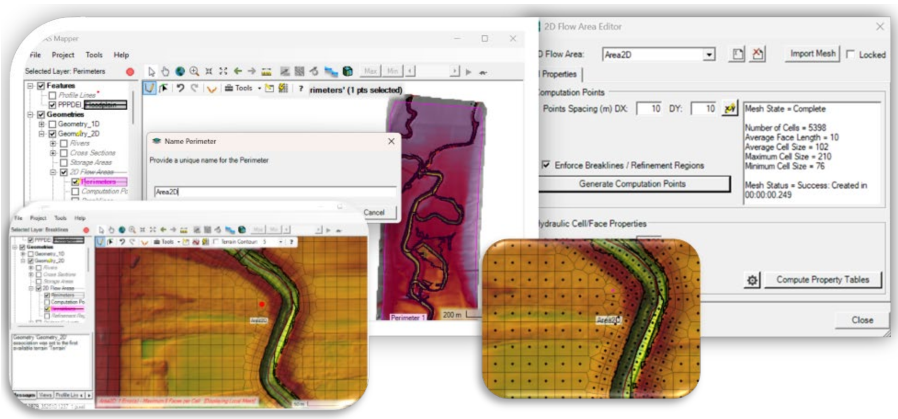

Fig. 4. *2D Geometry and Computational Surface Refinement*

3. Results and Discussion

3.1. Drone Survey and Data Processing

The drone survey over the Nistorești area was conducted to obtain high-precision topographic data required for detailed hydraulic analysis. The survey covered a total area of 0.504 km², with an effective flight time of 25 minutes and 23 seconds.

The data processing phase lasted approximately 4 hours and 25 minutes, generating an orthophoto with a ground sampling distance (GSD) of 2.09 cm/pixel and a LiDAR point cloud with an average density of 584 points/m². These parameters ensured a detailed representation of both the micro-topography and the larger geomorphological structures relevant to hydraulic modelling.

Validation against six ground control points (GCPs) demonstrated high accuracy, with an average flight altitude of 75.6 m and a mean flight speed of 8.61 m/s. The mean vertical error (Z) was −0.107 m, the absolute mean error 0.107 m, and the root mean square error (RMSE) 0.1181 m. The standard deviation of elevation differences was 0.1181 m, while the maximum observed error was −0.140 m. These results confirm that the LiDAR-derived dataset is highly reliable for generating a high-resolution digital elevation model (DEM) suitable for advanced hydrodynamic simulations.

3.2. Two-Dimensional Hydraulic Modelling

The two-dimensional (2D) hydraulic modelling for the Nistorești area was performed using the high-resolution DEM obtained from LiDAR and photogrammetric processing. Implemented in HEC-RAS 2D, the model provides a realistic simulation of flood propagation by accounting for both longitudinal and lateral water movement across the floodplain.

Following the methodological steps applied in the previous modelling stages, the analysis for the Nistorești area was further developed by expanding the computational domain of the 2D simulation. A new simulation area was defined with a cell size of 100 × 100 m, compared to the 10 × 10 m grid used in the earlier model. This configuration enabled a comparative assessment between fine- and coarse-resolution meshes, balancing computational efficiency with the level of hydraulic detail required for the study.

Under unsteady flow conditions, the 2D simulation revealed notable spatial and temporal variations in flow velocity and discharge distribution across the Nistorești floodplain. Within the main channel, water velocities exceeded 3.8 m/s in certain cross sections, indicating localized accelerations generated by discharge variations and the propagation of the flood wave through the channel system.

In the inundated areas, the flow pattern showed active involvement of the lateral floodplain zones. On the left bank, flow velocities generally ranged between 0.6 and 1.4 m/s, while on the right bank, local peaks of up to 1.5 m/s were observed. These differences illustrate the hydraulic connectivity between the channel and adjacent floodplain areas, confirming that the lateral zones play an active role in the overall conveyance process during transient conditions.

The total discharge across the model domain varied between 330 and 370 m^3/s, reflecting a dynamic flow regime influenced by temporary water storage and redistribution processes. During the flood peak, the discharge within the main channel remained relatively low—rarely exceeding 180 m^3/s in the central sector—suggesting a significant transfer of flow toward the overbank zones.

On the left floodplain, the conveyed discharge decreased below 100 m^3/s, while on the right side it fluctuated within a similar range but with greater variability. These differences highlight the asymmetric behaviour of lateral flow paths, driven by local morphological features and temporal variations in water level. Overall, the results emphasize the capacity of the 2D model to reproduce the complex spatial redistribution of flow during the flood event and to capture the interaction between the river channel and its adjacent floodplain.

3.3. Comparison with Official Flood Hazard Maps (PPPDEI and FRMP Frameworks)

A crucial part of the analysis involved comparing the newly modelled flood extents with those delineated in the PPPDEI (Plan for Prevention, Protection and Mitigation of Flood Effects). This national-level plan formed the technical basis for the first Flood Risk Management Plan (FRMP – Cycle I) and was subsequently referenced and partially maintained in the FRMP – Cycle II. Therefore, any identified inconsistencies between the current results and the FRMP delineations hold significant implications for national flood risk assessment practices.

The comparison revealed notable discrepancies between the 2D model results and the official flood boundaries. Even without a detailed spatial overlay, these differences clearly indicate that earlier flood maps were generated using coarser-resolution terrain data and simplified hydraulic models, which may have underestimated the true flood hazard in certain sectors. The integration of LiDAR-derived elevation data in the present study provides a much finer depiction of surface morphology and drainage patterns, resulting in a more accurate and physically consistent simulation of flood dynamics.

These findings (Figure 5) underscore the necessity of revising and updating the official flood hazard boundaries within future PMRI cycles, in accordance with the most recent topographic and hydraulic datasets. The use of updated 2D modelling, grounded in high-resolution LiDAR data, enables the production of more realistic flood hazard and risk maps. This improvement is crucial for evidence-based decision-making, territorial planning, and local risk management in the Nistorești area and, by extension, throughout the Casimcea River Basin.

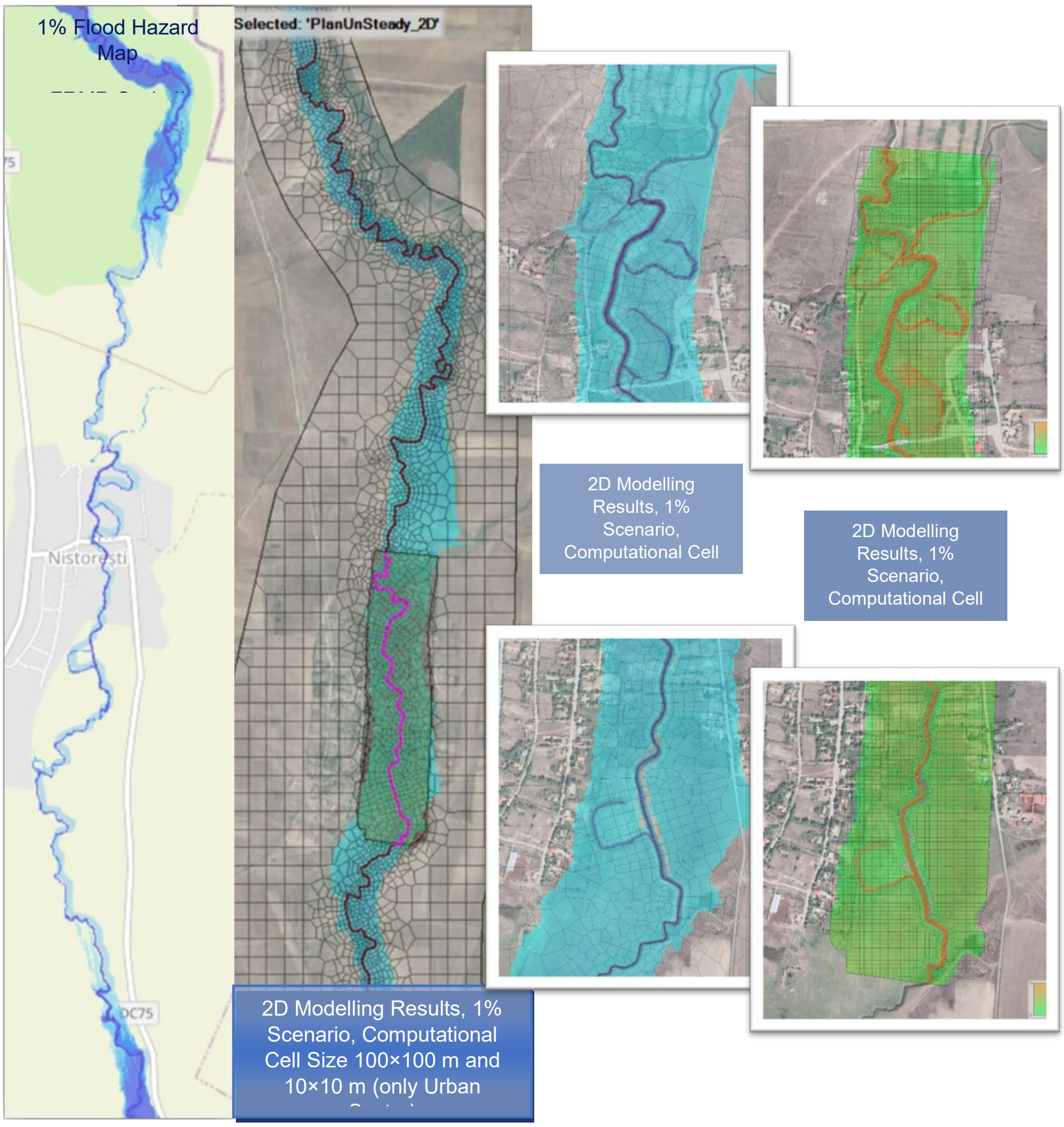

Fig. 5. *Map comparison*

4. Conclusions

The high-resolution LiDAR-based DEM enabled accurate 2D hydraulic simulations, capturing fine-scale topographic variations across the Nistorești floodplain.

Results showed consistent model stability and realistic flow distribution, confirming the quality and precision of the collected GNSS and UAV datasets.

The simulated inundation extent and water depths differ substantially from those delineated in the official FRMP maps.

These discrepancies suggest that previous studies relied on coarse or outdated topographic inputs, leading to potential underestimations of flood risk.

The updated 2D modelling highlights the need to revise and modernize the flood hazard boundaries using current high-resolution terrain and hydraulic data.

Overall, the refined 2D modelling outputs demonstrate that high-resolution, accurately calibrated topographic and hydraulic datasets are essential for reliably characterising flood dynamics and for supporting evidence-based decision-making in the design and implementation of effective flood protection measures.

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