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A comparative study of mass movement morphometry in two adjacent watersheds of southern Italy

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Abstract— **This study examines the integration of geomorphometric and geological data to understand landslide dynamics in the Bradano and Basento river basins in southern Italy. Despite their proximity and shared climatic conditions, these basins display distinct geomorphological and lithological features, making them ideal for a comparative analysis.**

High-resolution digital elevation models (DEMs) and landslide data from official databases were combined with key geomorphometric indices. This approach allowed a detailed assessment of mass movement distributions and their relationships with geological and morphological factors. Results reveal substantial differences between the basins. Furthermore, significant variability inside the same basin was observed, with landslides unevenly distributed across lithological units and valley sides.

This research underlines the value of integrating geomorphometric and geological analyses to identify patterns in landslide susceptibility and spatial variability. The findings highlight the critical role of local geological settings in shaping mass movement dynamics and stress the need for basin-specific strategies for risk assessment and land-use planning. Future work will refine this integrated methodology and explore predictive models to evaluate the potential impacts of climate change on landslide activity in the region's diverse landscapes.

I. Introduction

This study focuses on two adjacent fluvial basins, the Bradano and Basento river catchments, significatively different from geological and geomorphological viewpoints. Such basins are located astride the border between Lucanian and Apulian regions in the case of the Bradano River catchment [1], and entirely in Basilicata in the case of the southernmost Basento basin. Both are in southern Italy and therefore share similar climatic conditions [2, 3], but their divergent topographical and geological attributes make them the ideal candidates for this kind of investigation, aiming to stress the different mass movement arrangement eventually linked to local control factors. As a matter of fact, landslides represent the expression of a cumulative geomorphological vulnerability, influenced by climatic, geomorphometric and geological factors [4, 5, 6, among others]. Although it is not possible, in many cases, to precisely date landslide events, multi-temporal climate analysis provides valuable information on predisposing conditions and potential climate-related triggers by the identification of climate trends and critical rainfall thresholds [7, 8, 9]. On the other hand, the morphometric comparison between two basins under the same climatic forcing may furnish the keys for a better comprehension of spatial distributions of gravitative events [6].

The study area is characterized by a complex setting, hosting river basins with distinct lithological, structural, and morphological features, whose watercourses cut geological units of both the orogenic chain and foredeep domain. The increasing frequency of extreme weather events, driven by climate change, necessitates a deeper understanding of how these phenomena manifest in regions with varying geomorphological characteristics.

II. Methodology

High-resolution digital elevation models (DEMs) integrated by new field data were employed to analyse the spatial distribution and characteristics of landslides in the two basins. Landslide data were acquired and processed from official databases, including PAI (*Piano Assetto Idrogeologico*) and IFFI (*Inventario dei Fenomeni Franosi in Italia*), besides from published and/or original geothematic maps and geodatabases of

the authors. Key geomorphometric indices [10] were calculated to provide a quantitative comparison of the two basins, including Asymmetry Factor (Af); Transverse Topographic Symmetry Factor (T); Valley Floor Width-to-Height Ratio (Vf). In addition, more landslide-related parameters were calculated in function of different geological and morphological zonation of the study area.

III. DATA ANALYSIS AND PRELIMINARY REMARKS

The comparative analysis revealed significant differences in the frequency, type, and spatial distribution of mass movements between the two basins. As Fig. 1 shows, in the Bradano river basin (covering an area of 2.846,51 km²), 14.569 landslide bodies were identified, corresponding to 278,12 km² of landslide-affected area (about 9,77% of the total basin area). In contrast, the Basento river catchment (1.537,45 km²) exhibited 16.356 landslides, affecting 263,7 km² (about 17,2% of the basin's area).

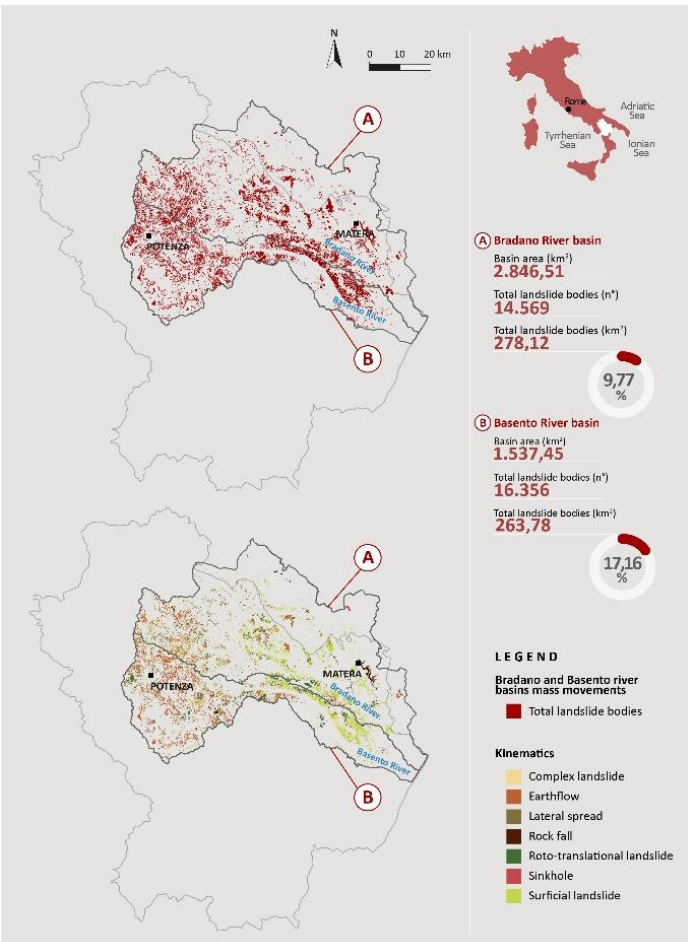

Figure 1. Data comparison of mass movements of the Bradano and Basento river basins.

The quantitative geomorphic analysis of landslides and their morphometric parameters showed that significant differences exist also inside the same catchment, such as unequal distributions of mass movements in the left and right orographic side of the main valleys. The right orographic sides of the Bradano and Basento river basins show similar patterns in terms of landslide density, but the percentage of landslide-affected area is higher in the Basento river valley (7,66% vs. 4,67%). The left orographic side of the Basento watershed, despite its smaller area compared to the left side of the Bradano ones (Fig. 2), shows a significantly higher percentage of landslide-affected area (9,49% vs. 5,10%). Overall, the Basento fluvial basin is more prone to landslides, with nearly double the percentage of landslide-affected area compared to the Bradano basin (17,15% vs. 9,77%). These findings underline how landslide distribution is strongly influenced by the morphology, lithology, and local control factors specific to each orographic side and orographic basin. The high density and extent of landslides on the left side of the Basento river valley suggest particularly predisposing geomorphological and geological conditions to be investigated (Table 1). Calculations of morphotectonic indices, in progress, will help to detect the recent to present deformational behaviour of the basins.

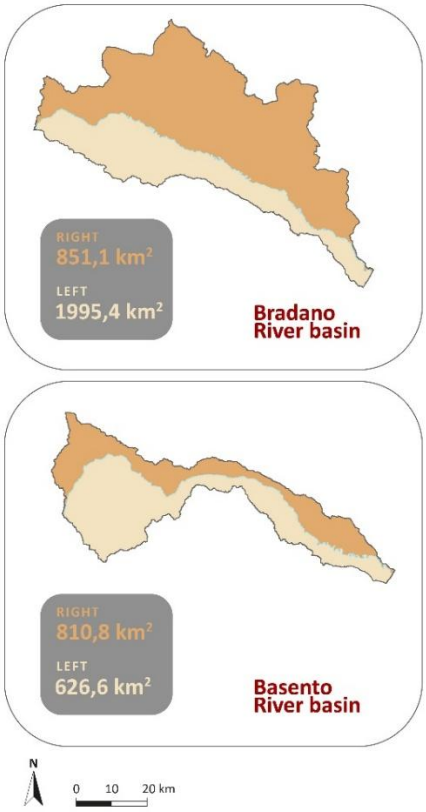

Figure 2. Right and left orographic side areas (km²) comparison of Bradano and Basento river basins.

The analysis of the single lithological units shows percentage peaks of landslides in the arenaceous and clayey units of the foredeep, whereas in the Apennine chain higher percentages (up to 30% ca.) are recorded for the clay-dominant formations (deep-water units) and marly-arenaceous stratigraphic successions (mainly Miocene flysch units). In relation to the kinematics, in the entire study area the flows are the landslides that offer a greater contribution, followed by the roto-translational slides (Table 2).

This study highlights the importance of integrating geomorphometric and geological data to understand the arrangement and dynamics of mass movements in diverse landscape units.

TABLE I. DATA COMPARISON OF MASS MOVEMENTS IN THE RIGHT AND LEFT OROGRAPHIC SIDE OF THE BRADANO AND BASENTO RIVER VALLEYS.

Right and Left orographic side				
Bradano River valley				
	Area (sq.km)	***N. landslide bodies***	***Landslide area (sq.km)***	***%***
Right	851,1	8509	132,89	4,67
Left	1995,41	6113	145,23	5,10
Total	2846,51	14622	278,12	**9,77**
Basento River valley				
	Area (sq.km)	***N. landslide bodies***	***Landslide area (sq.km)***	***%***
Right	910,8	7371	117,80	7,66
Left	626,65	9017	145,94	9,49
Total	1537,45	16388	263,74	**17,15**

TABLE II. DISTRIBUTION OF LANDSLIDE BODIES AND RELATED KINEMATICS IN THE ENTIRE STUDY AREA OF THE BRADANO AND BASENTO RIVER BASINS (4383,96 KM²).

Bradano and Basento river valleys landslide types			
Kinematics	***N. landslide bodies***	***Area (sq.km)***	***%***
Complex landslide	503	11,77	**0,27**
Earthflow	16307	205,95	**4,70**
Lateral spread	16	0,61	**0,01**
Rock fall	545	14,54	**0,33**
Roto-translational landslide	6211	72,43	**1,65**
Sinkhole	86	1,52	**0,03**
Surficial landslide	7257	235,06	**5,36**
Total	30925	541,87	**12,36**

The findings emphasize the need for tailored risk management strategies [11], considering the complex interplay among landslide-triggering factors of each basin, and represent the grounds for the construction of geomorphic susceptibility maps and related predictive scenarios under a changing climate.

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