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ΑΚΑΔΗΜΙΑ ΑΘΗΝΩΝ

High-Resolution Soil Erosion Assessment in Mediterranean Olive Orchards Using Drone-Based Digital Elevation Models and Surface Runoff Monitoring

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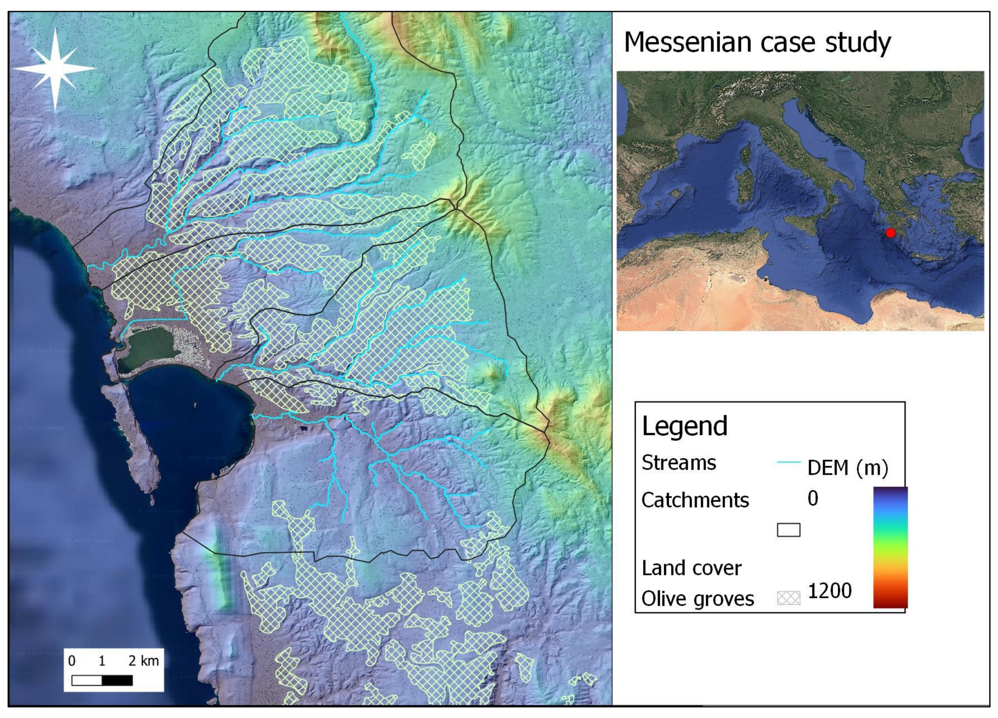
Introduction

Soil erosion is a pressing environmental concern in Mediterranean region, driven by the combined effects of climate change and unsustainable agricultural practices. Intense rainfall events, prolonged droughts, and conventional farming methods contribute significantly to topsoil degradation, posing serious threats to soil fertility and crop productivity. These dynamics result in far-reaching consequences, including land degradation, reduced agricultural yields, and increased flood risk (Firoozi & Firoozi, 2024). In recent years, unmanned aerial vehicles (UAVs) have become valuable tools for analyzing soil erosion due to their ability to capture high-resolution imagery with centimeter-level precision (Medeiros, B.M. et al., 2025). UAVs enable efficient monitoring across both small-scale plots and extensive, topographically complex landscapes, offering detailed insights into erosion patterns, soil loss, and influencing factors such as terrain and human activity. This study aims to assess soil erosion risks in hilly olive orchards using cutting-edge technologies -drone-based digital elevation models (DEMs) in Messenia at the southwestern Peloponnese, Greece.



Data and Methodology

First phase:

- Drone: DJI Phantom 4 (RGB camera); affordable and suitable for low-vegetation areas.
- Study Site: 0.2-hectare newly planted olive orchard located on hilly terrain (18% slope) with sparse tree cover.
- Land management: Conventional tillage.
- Flight Dates: August and December 2024.
- Method: Generated high-resolution DEMs using Agisoft Metashape and applied Difference of DEMs (DoD) analysis for soil displacement.

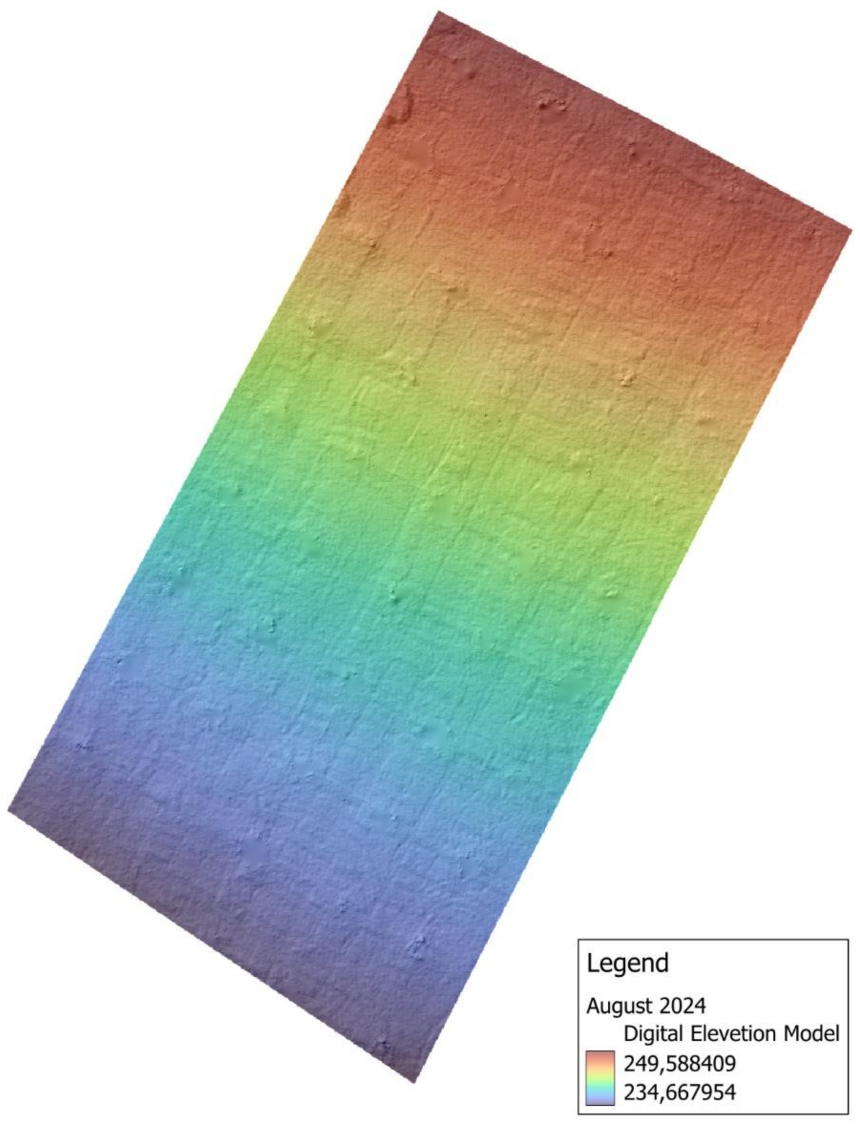
Second phase:

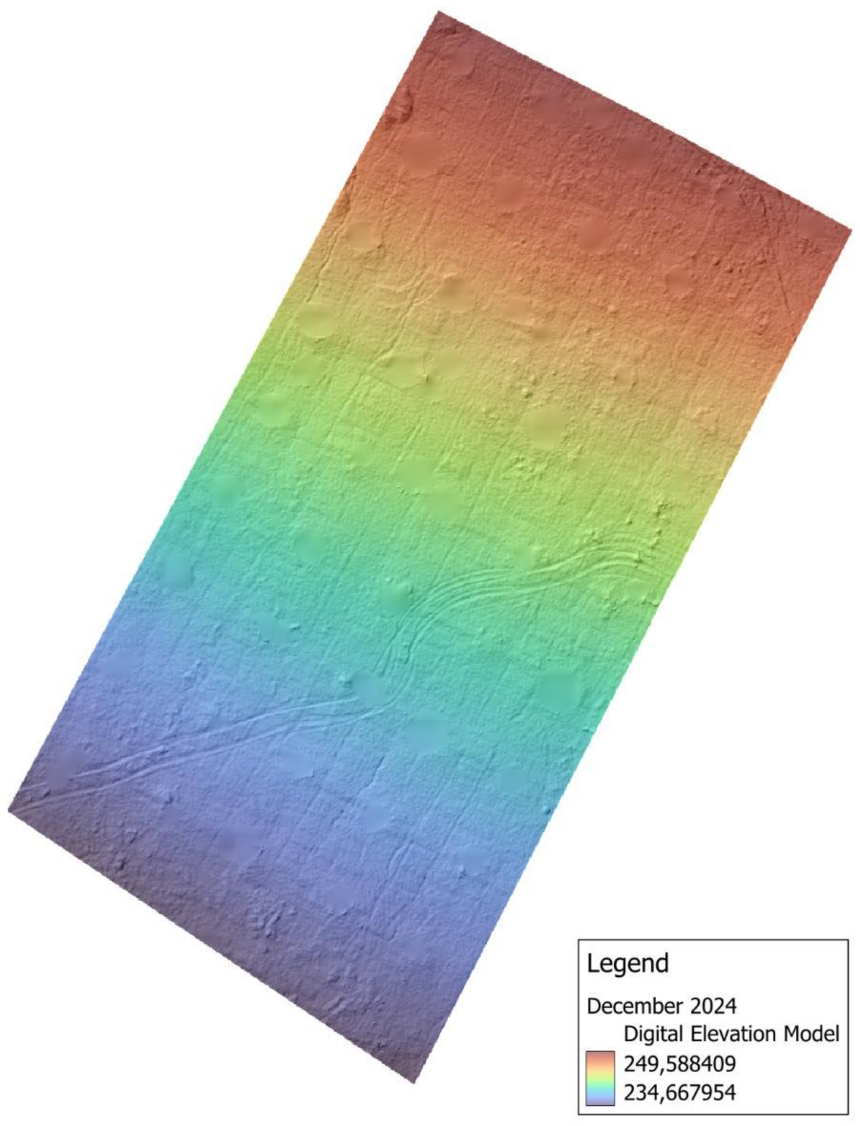
- Drone: DJI Matrice 350 RTK (LiDAR sensor); advanced UAV for high-resolution terrain modeling.
- Study Site: Olive orchard in hilly terrain with 15% slope (different from Phase 1).
- Land management: Mowing of natural vegetation.
- Flight Dates: December 2024 and March 2025.
- Method: High-resolution digital elevation models (DEMs) generated for erosion monitoring using DJI TERRA software.

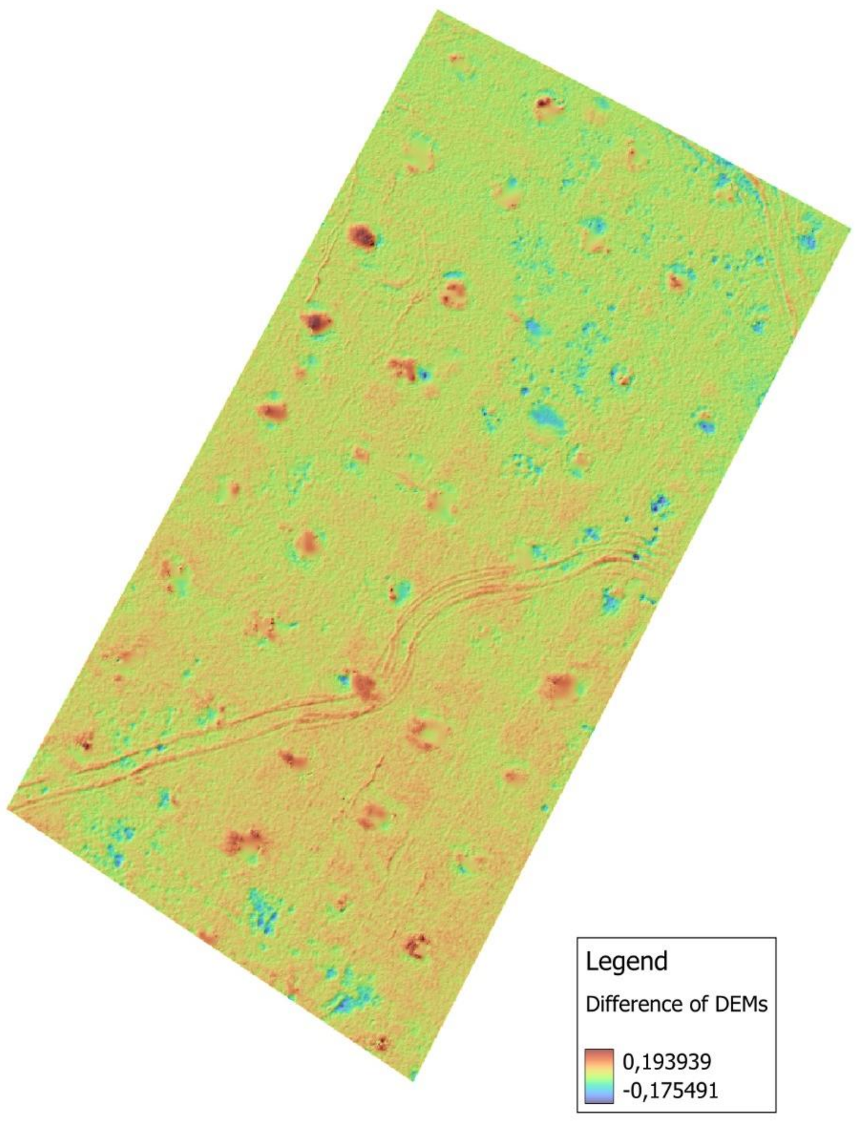
Results

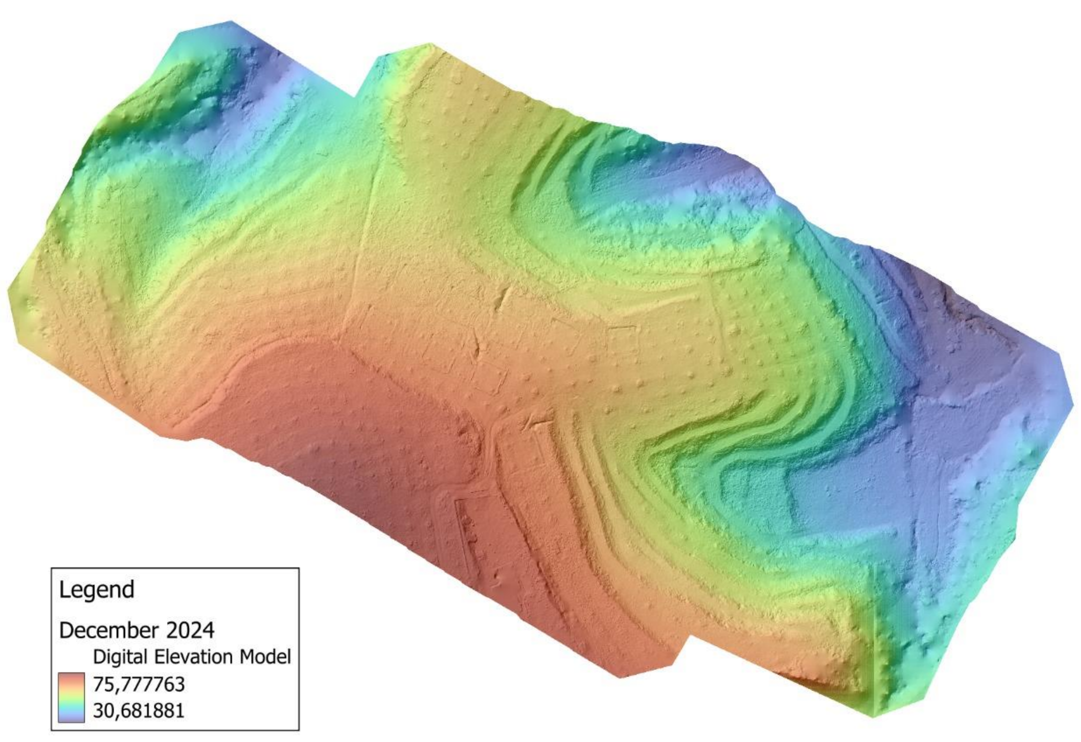
Preliminary results of the first phase indicate that tractor operations such as tillage and plowing, combined with intense rainfall events, led to an estimated soil displacement of approximately 0.001 m^3/m^2. The site will be re-surveyed at the end of the rainy season in late spring to assess additional erosion.

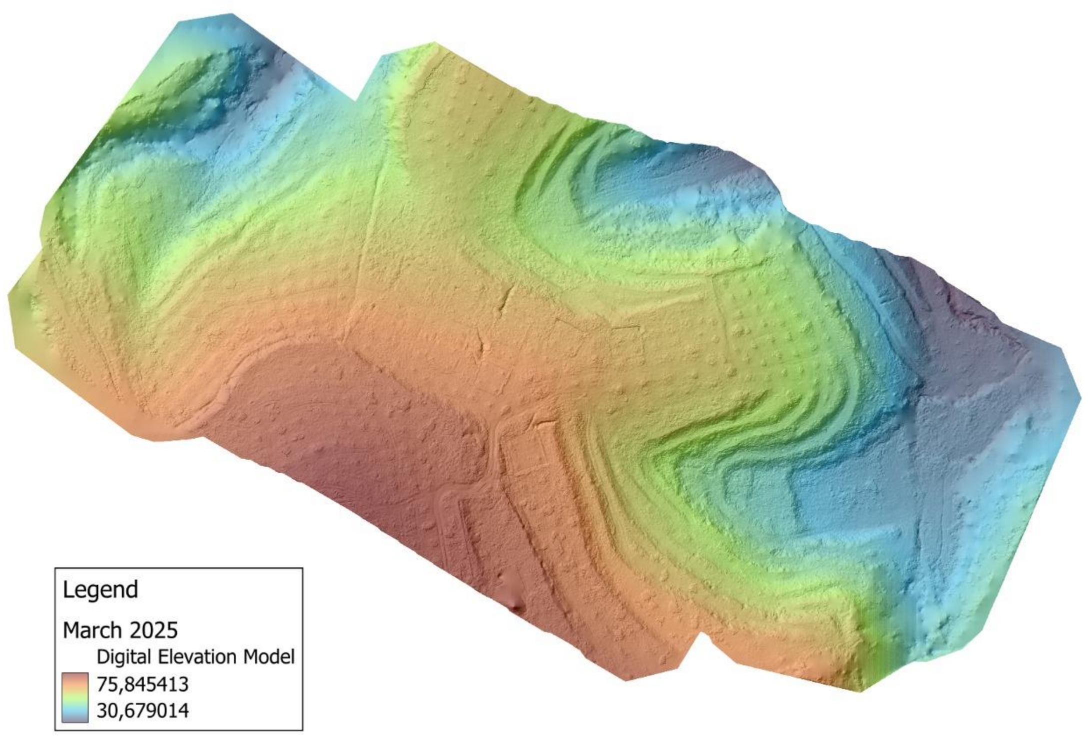
As far as phase two is converned, due to the short interval and limited rainfall between these two flights, no significant soil displacement could be detected. A third LiDAR survey is planned for the end of the rainy season to extend the observation period and enable more robust erosion estimates.

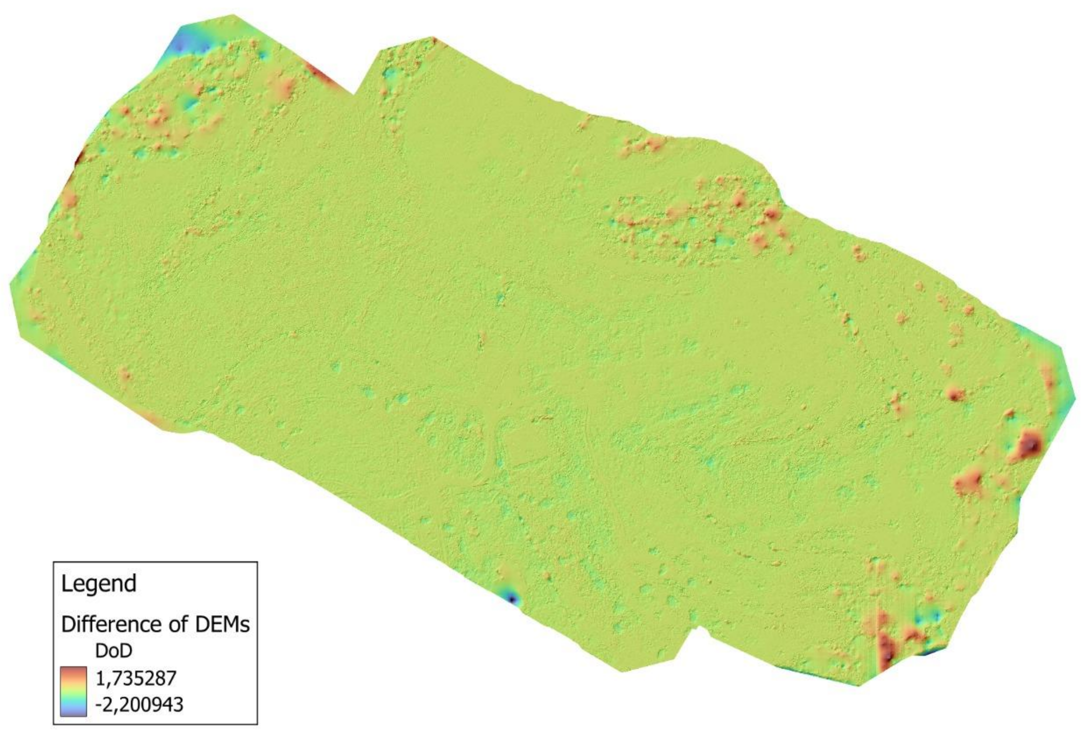












Key Findings

- ❖ DJI Phantom 4 cannot distinguish vegetation from bare soil, so trees had to be manually removed from the DEM to ensure accurate ground surface modeling.
- ❖ DJI Matrice 350 RTK penetrates vegetation and generates accurate bare-soil surface models without manual editing.

References

- Firoozi, A. A., & Firoozi, A. A. (2024). Water erosion processes: Mechanisms, impact, and management strategies. 24. https://doi.org/10.1016/j.rineng.2024.103237
- Medeiros, B. M., Cândido, B., Jimenez, P. A. J., Avanzi, J. C., & Silva, M. L. N. (2025). UAV-Based Soil Water Erosion Monitoring: Current Status and Trends. *Drones*, *9*(4), 305. https://doi.org/10.3390/drones9040305

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