

Summary

In recent decades, the intensification of agricultural practices has raised major environmental concerns, particularly regarding soil and water conservation, biodiversity, sustainability, and ecosystem services. Growing recognition of soil as a non-renewable resource—and of its key role in climate-change mitigation—has strengthened global efforts to promote sustainable soil management across a range of agri-ecosystems, including viticulture.

This thesis evaluates the effects of introducing conservation-oriented soil management in hilly vineyards of North-West Italy, with the aim of mitigating soil degradation processes such as erosion and compaction. While maintaining grape quality and yield, the work focuses on three complementary innovations: (i) improved soil management practices, (ii) agro-meteorological monitoring of water and soil dynamics, and (iii) ICT tools for data management and field observations to support farmers in vineyard management and soil–water conservation. Overall, the research investigates how soil management in sloping vineyards can increase soil water content, reduce runoff and erosion, and improve water and nutrient availability for vines. In addition, it examines how repeated vehicle traffic affects soil compaction and hydrological conditions.

The second part of the thesis introduces advanced technologies alongside traditional methods within a joint measurement campaign aimed at characterizing water, soil, and energy dynamics in a sloping vineyard. A W-band radar, a coupled microwave–optical scintillometer, and a cosmic-ray neutron sensing (CRNS) system were deployed in an experimental vineyard where both current and long-term monitoring of soil moisture, erosion, and water dynamics is available. These proximal sensing techniques help overcome the limitations of point-scale measurements by providing estimates of precipitation characteristics, surface energy fluxes, and soil moisture at temporal and spatial scales not accessible to conventional sensors.

Overall, this work represents an initial attempt to apply such technologies in a complex environment such as sloping vineyards under different soil management practices. It provides a framework for collecting field- and landscape-scale data on water and energy fluxes and supports decision-making for sustainable agricultural land management.