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Low-cost soil moisture monitoring: experiences from a technology transfer project for small farms

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The importance of irrigation water management has increased in recent years with the declining summer availability due to climate change, especially for surface waters. The diffusion of pressure irrigation systems has led to higher water efficiency exploiting a demand-based irrigation, overcoming the turn-based limitation of classical flood irrigation. GUARDIANS project (https://guardians-project.eu/), funded by the Horizon Europe program and involving 22 partners from 9 countries, has the goal to transfer this approach shift in the context of small farms, developing and demonstrating IT technologies in several study areas. One of these case studies is the irrigation reservoir of Rivoira (Boves, Piedmont, NW Italy), built in 2017 and having a capacity of 42000 m^3. The reservoir is connected to a pressure irrigation network serving about 300 ha of cropfields mainly owned by small farmers.

To improve water management in the study area based on actual soil moisture readings, low-cost sensors were tested for ground-based measurement of volumetric water content (VWC). Their affordability makes them suitable for small farms, while remote data transmission enables continuous monitoring across multiple points within the same field.

These sensors, however, present several challenges. Calibration procedures that balance accuracy and simplicity are essential: for example, the choice is between calibrating each sensor or deriving a calibration formula that applies to all of them, or between calibrating sensors for each soil type or with a formula that works for all types. Furthermore, practical considerations for field installation and reliable long-term data transmission are crucial. Measurement quality must also be carefully evaluated, making sensor redundancy important to compensate for devices that may go offline or produce anomalous readings over time.

This work focuses on operational challenges and solutions adopted during calibration, installation, and data management of low-cost soil moisture sensors in the context of seven small farms. The comparison with meteorological data and recorded irrigation events makes it possible to check the performance of the sensors installed during the previous irrigation season, thereby allowing conclusions to be drawn about the reliability of sensors. In particular, the field monitoring

campaign revealed similar dynamic behaviour among sensors, which correctly responded to irrigation and rainfall events; however, significant offsets in their absolute VWC values were observed. These discrepancies may be attributed to spatial heterogeneity in field VWC distribution, as well as to sensor drift over time, and deserve particular consideration.

Overall, low-cost sensors can play an important role in improving irrigation management, but several operational challenges need to be addressed to fully exploit their potential.

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