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IRRITRE: TOOLS AND INFRASTRUCTURES FOR IRRIGATION IN TRENTINO (IT)

IRRITRE: INFRASTRUTTURA E STRUMENTI PER L'IRRIGAZIONE IN TRENTINO

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Abstract

Sustainable water management in agriculture and the maintenance of current crop quantity and quality standards are pivotal elements of agricultural policy at global and local levels. One pressing issue is the concurrent use of water resources for irrigation alongside hydropower, tourism, industrial, and civil purposes. This issue is becoming increasingly urgent in the Alps due to changes in winter precipitation patterns, which affect summer water supplies. To monitor the water consumption for irrigation at provincial level, the Autonomous Province of Trento has established and leads the IRRITRE project in collaboration with Fondazione Bruno Kessler, Fondazione Edmund Mach, and Trentino Digitale S.p.A. for the technological aspects. The initiative was launched in the Summer of 2023 and aims to provide the public administrators with real-time monitoring tools to track agricultural water usage. Additionally, it will equip Irrigation Consortia with an irrigation advisory system to optimize water consumption and irrigation automation at hydraulic valve le-level by using Artificial Intelligence. The project incorporates the creation of the digital infrastructure and the deployment of humidity probes in the soil. Currently, IRRITRE is being piloted in three significant agricultural areas of the Trentino region—cultivated with grapevines, apples, and olives—with plans to expand to other irrigation consortia.

Parole chiave: irrigazione, LoRA, sensori di umidità del terreno, consiglio irriguo
Keywords: irrigation, LoRA, soil moisture probes, irrigation advisory system

Introduction

Agriculture is nowadays one of the main sectors affected by Climate Change. The increasing temperatures and the imbalance of the yearly water regime are posing serious problems in terms of water use efficiency for the maintenance of crop production and high yield quality standards (Malhi et al., 2021). In the Province of Trento the high added value of primary productions, particularly in wine grapes and apples, are a crucial aspect of the primary sector to be preserved. Moreover, another pressing issue is the concurrent use of water resources for irrigation alongside hydropower, tourism, industrial, and civil purposes.

Precision Agriculture aims to rationalize the input of resources for plant nutrition and protection against biotic and abiotic stresses, in order to overcome the water consumption issue by enhancing a more efficient use of the water resource, Precision Irrigation practices in water management should be steered and implemented at regional level and enforced to the irrigation consortia depending on the local environmental characteristics, and the cultivated crops (Bwambale et al., 2022).

The irrigation strategy known as Deficit Irrigation which views the soil-atmosphere-plant system as a continuum, has already been implemented in both viticulture and fruit cultivation (Unesco, 2015). This approach has proven not only to sustain yield levels but also to enhance several aspects of quality (Van Leeuwen et al., 2009; Liao et al., 2021). Through careful management of water stress, Deficit Irrigation can optimize the trade-offs between resource use and crop quality, offering a sustainable solution to resource-intensive agricultural practices (FAO, 2002).

The Internet of Things technology (IoT) offers nowadays low cost and powerful tools for the real time crop monitoring, collection of data and automation of agricultural processes (Quy et al., 2022) At crop level soil moisture instruments give a picture of the amount of humidity in the soil (Thalheimer, 2013), meteorological data describe the actual status of the atmosphere and plant tensiometers give an overview of the water status of the plants (Lakso et al., 2022). Using IoT applications, this information is collected in real time, through LoRa modulation, and stored in TD's

data center, facilitating a more complete analysis in the perspective of crop monitoring.
The setup of a distributed network of sensors and data collectors facilitates the development of the automation of irrigation at hydraulic valve-level using Artificial Intelligence with the goal of both monitoring the irrigation water consumption and preserving the top-quality standards of primary production.

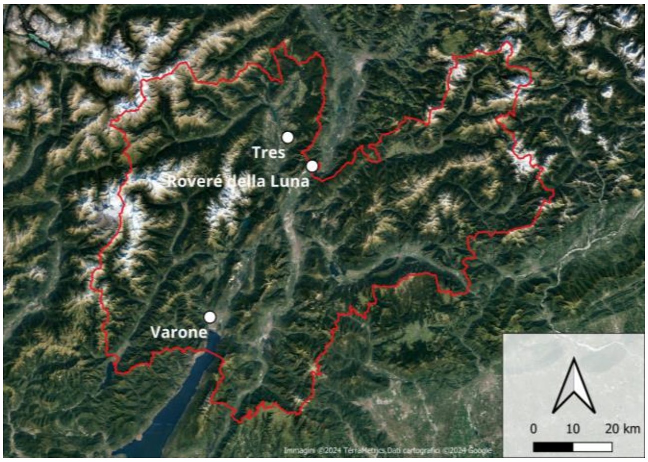

Fig.1: Map of the Autonomous Province of Trento (red contour) and location of the three selected irrigation consortia (white dots): Tres, Roveré della Luna and Varone. (Base map: Imagery ©2024 TerraMetrics, Map Data ©2024 Google)
Fig.1: Mappa della Provincia Autonoma di Trento (linea rossa) e dei tre consorzi irrigui scelti come areee pilota del progetto (punti bianchi): Tres, Roveré della Luna e Varone. (Base map: Immagini ©2024 TerraMetrics, Dati cartografici ©2024 Google)

Materials and methods

The IRRITRE project was launched in the Summer of 2023 and it is led by The Autonomous Province of Trento (PAT), in partnership with Fondazione Edmund Mach (FEM), Fondazione Bruno Kessler (FBK) and Trentino Digitale (TD). The project is aimed to offer a decision support tool to irrigation consortia for the management of irrigation scheduling following the effective water needs of the crops. To achieve the set goals the selected areas were infrastructured with a digital wireless network (LoRaWAN) in order to collect and send the data in real time to the operational entities. We decided to choose three different facilities particularly vocated for the main cultivated cultures in Trentino: “Piana Rotaliana” for wine and grape production, “Val di Non” for apples and “Garda Trentino” for olive for olive oil, as shown in Fig.1. In each of these areas, different kinds of soil moisture probes were installed, varying both in the physical principles of measurement and in the manufacturers' brands. Also, we installed flowmeters on the valves and on the drip lines to calculate the water volume utilized during irrigation. Furthermore, we used meteorological data collected by FEM agrometeorological stations in the surroundings to improve the results and to facilitate the water needs calculation. The collected data coming from the soil probes and the atmospheric variables have been used to formulate the irrigation advice thanks to the SWAB model (Soil Water Atmosphere advanced Budget), which integrates water requirements of crops, soil types, and meteorological conditions. The measures and the irrigation advice will be available on a digital interface (developed by TD) where the irrigation consortia will be able to see the daily irrigation advice and the daily measured water consumption.

Results and discussion

In the first year of the IRRITRE project, we conducted a comprehensive analysis to effectively develop the infrastructure across three chosen irrigation consortia, each distinguished by its type of cultivation (Fig.1). The orchards of “Consorzio di Miglioramento Fondiario di Tres”, located in Val di Non, are dedicated exclusively to apple production, while the “Consorzio Irriguo di Roverè della Luna” focuses on viticulture. Both had a previously installed sensor infrastructure for measuring irrigation flow and soil moisture due to prior projects. In orchards, the use of tensiometers for soil moisture measurement proved effective. However, in the conoidal areas of the vineyards in Piana Rotaliana, these instruments were less effective, necessitating the deployment of alternative sensors (both resistive and capacitive) to better monitor soil water availability for grapevines.
The third pilot site, the “Consorzio di Migliormento Fondiario e Irriguo del Varone” presents a greater complexity due to its heterogeneous agricultural production with the irrigation sectors that differ from homogeneous cultivated areas. Olive trees were selected as the reference crop here, but no dedicated irrigation water distribution valves are entirely devoted to olive cultivation, making it challenging to evaluate the appropriateness of the water distributed versus the water needs of the plants. Additionally, this consortium lacked an existing network for measuring soil moisture, relying instead on measurement points installed individually by farmers using various technologies and suppliers. This site was particularly challenging due to the conflicting demands on water resources, especially from tourism, municipal needs for land protection, and agriculture.

A critical development in the project has been the creation of a data communication infrastructure based on LoRa technology, which could potentially be extended throughout the province for multiple uses. Previous experiences at the Roverè della Luna and Tres consortia have shown good performance; however, these were based on individual projects and had not been tested for scalability. Therefore, the goal for the first year was to design a scalable network suitable for multiple applications, not just agriculture.

Conclusions

With the objective of monitoring the water consumption for irrigation at a regional level and providing a decision-support system to rationalize water consumption at a local level, the Province of Trento launched the IRRITRE project. In these initial months, three facilities (irrigation consortia) were selected to deploy the project's infrastructure, which includes a network of soil sensors for monitoring soil moisture and a LoRa communication network for data transmission. This setup facilitates the automation of irrigation at hydraulic-valve level by the use of Artificial Intelligence. These initiatives mark a significant advancement in managing agricultural water resources effectively and sustainably within the region.

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