DRIP: Development of an Advanced Precision Drip Irrigation System for Tree Crops

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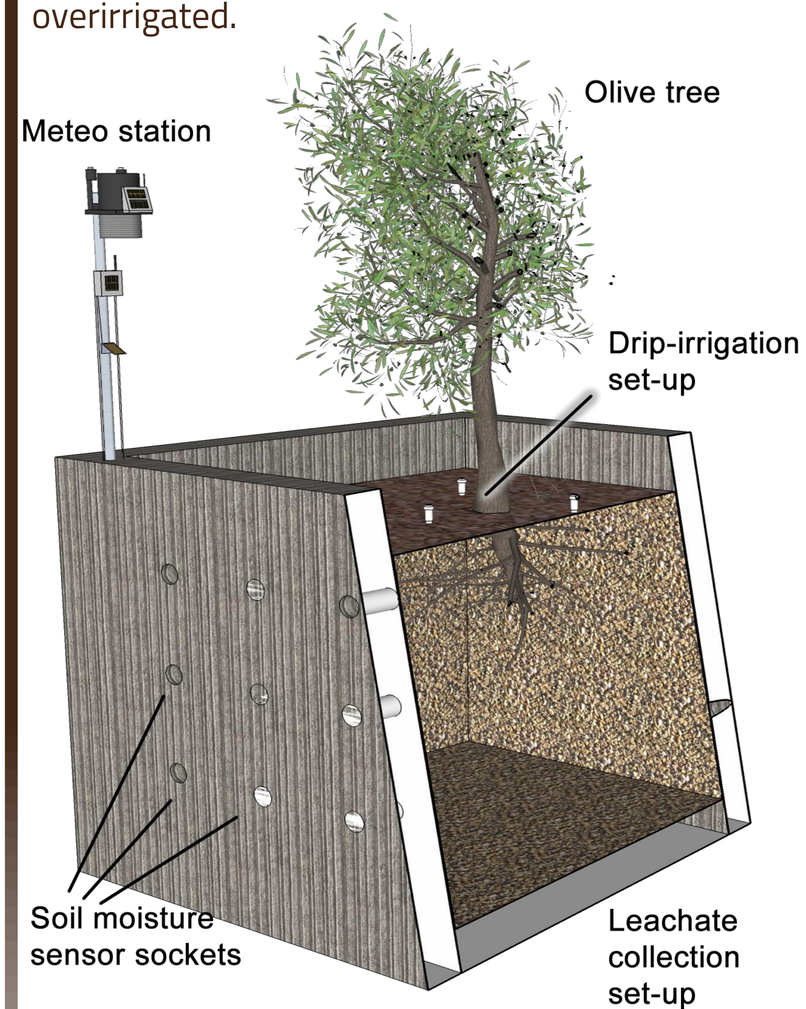
Introduction

Water resources are under constant pressure due to increasing demand, climate change, and water pollution, both globally and locally. In Crete, Greece, irrigation represents 81% of water demand and olive trees are the most abundant crop (64% or 35 Mtrees). It is estimated that only 65% of the irrigated water covers crop demand, whereas 8% is network losses, 7% is lost during application, and 20% evapotranspires, as irrigation is mainly empirical and often without scientific background or professional guidance. This creates a great environmental and financial incentive to increase the efficiency of irrigation systems and the adoption of advanced precision irrigation technologies that incorporate scientific information on soil, plant, and water interactions. DRIP aims to develop an innovative, efficient, and competitive product to reduce irrigation water consumption and promote sustainable water management while supporting and sustaining the agricultural production and the rural economy.

Lysimeters

DRIP will collect experimental data from five free-standing lysimeters, 50 m^3 each. 5-year-old olive trees will be transferred from an experimental olive grove to the lysimeters and undergo different irrigation treatments: Control (covering evapotranspiration requirements), rainfed, two deficit irrigation treatments, and one overirrigated.



Root density and soil parameters will be measured during replanting. Each lysimeter will accommodate a 3x3x4 grid (36) of TDR soil moisture sensors, to achieve exhaustive monitoring. Field measurements will include:

(a) Plant physiology (chlorophyll, micro and macronutrients in leaves, flowering, productivity, yield assessments, etc.)
(b) Soil analysis (pH, EC, micro (K, Mg, Ca) and macro (B, Cu, Zn, Cr, Ni) nutrients, etc.))
(c) Evapotranspiration (direct estimates based on water balance, empirical estimates such as FAO, Penman-Monteith, etc.).

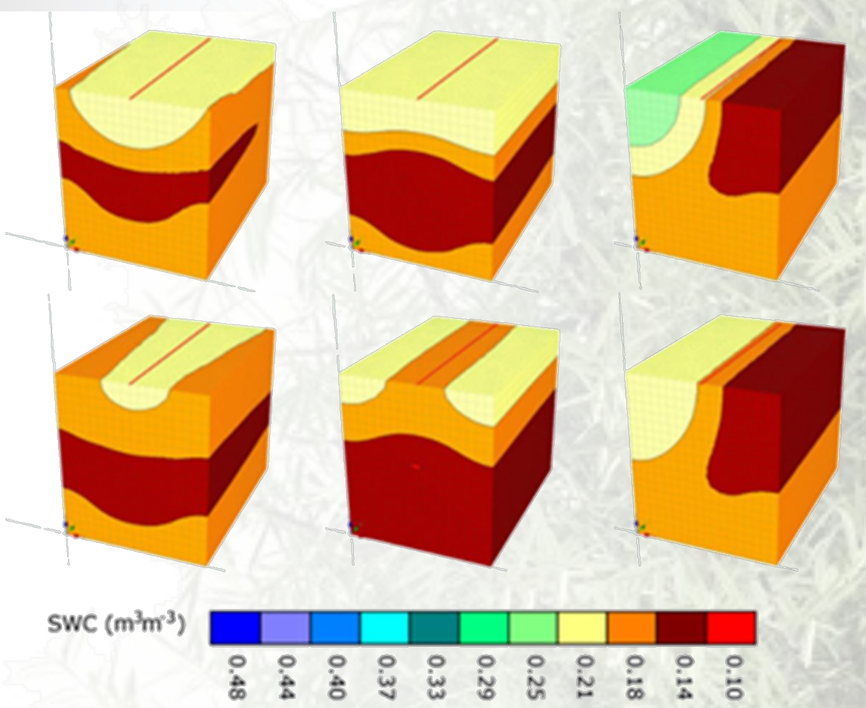
The lysimeters will also facilitate other non-obstructive experiments (e.g. microfauna).

Soil Moisture Modeling

Collected data will be use to calibrate the state-of-the-art soil moisture model HYDRYS 2D/3D. The goal is to create a testbed for:

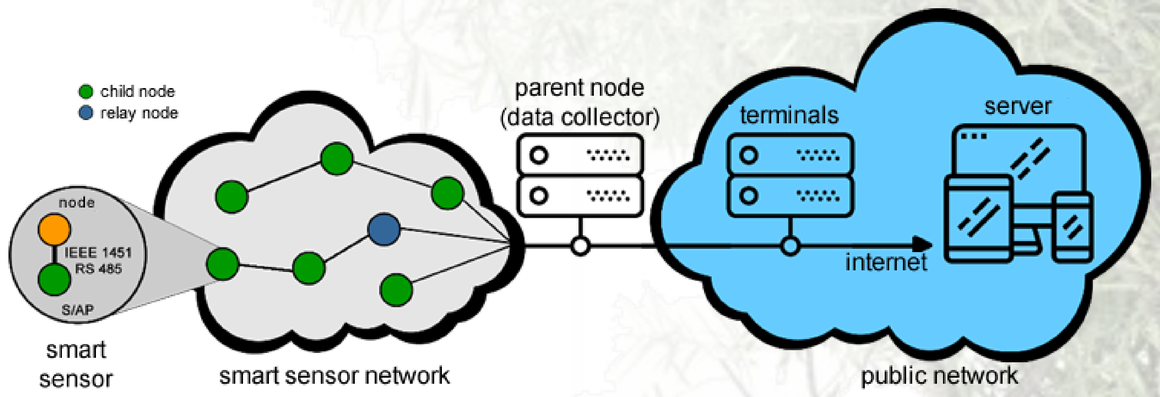
(a) parameters that can't be controlled in the lysimeters (e.g. soil type, climate)
(b) values that may stress the vegetation beyond its limits (e.g. minimum irrigation, poor water quality)
(c) optimizing parameters that can be controlled (e.g. irrigation, evapotranspiration by pruning).

The model will also facilitate the identification of the optimum TDR sensor installation scheme to minimize their number and therefore the total cost of the DRIP system under operational conditions.



Internet-of-Things (IoT)

Measurements will be relayed through an IoT sensor network to a cloud server. From there, users will monitor environmental conditions and manage drip-irrigation scheduling through electronic valves, also controlled remotely.



Experimental olive grove

DRIP will also collect data from the experimental olive grove which sourced the five replanted trees. Here the goal is to install IoT TDR sensors in a less dense but strategically selected pattern to maximize the cost-effectiveness of the monitoring scheme and to demonstrate the feasibility of DRIP:
Based on the developed soil moisture model, DRIP will integrate a decision support tool for optimal sensor placement.
Also, drip emitters with integrated IoT control valves will be scheduled in real-time to fit individual tree assessed requirements.
Crop productivity will be compared against lysimeter measurements, models, and conventional farming systems to assess the feasibility of the DRIP system in real world applications.

Expected results

1. The installation of five state-of-the-art experimental lysimeters, fully automated, with infrastructure for different interventions and measurements, on a variety of irrigation treatment for tree crops.
2. An IoT system that can operate in the agricultural/productive environment, allowing for the collection, transfer, analysis, and exploitation of a multitude of data in real-time, which can be used for other future applications such as harvesting, plant protection, fertilization, etc.
3. An extremely detailed simulation of soil moisture and the development of a prediction and monitoring system, exploiting IoT systems.
4. An integrated state-of-the-art high precision drip-irrigation system that can significantly reduce water losses when irrigating tree crops by watering each tree according to its needs.
5. A detailed feasibility study of the exploitation of the DRIP system at commercial scale.

DRIP is coordinated by TEI of Crete with the co-funding of Greece and the European Union.

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Poster · February 2018

DOI: 10.13140/RG.2.2.33390.10566

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