# Development of a soil-crop water status Wireless Sensor Network to support the agrohydrological approach in the drought audit processes: first setups in Chianti terroir

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## RESEARCH MOTIVATION AND STUDY OBJECTIVES

Vineyards registered under Controlled Designation of Origin (CDO), such as Chianti (Tuscany, Italy), are subjected to a certification aimed to verify that the product quality, dependent on natural and human factors, meets the conditions requested from the respective regulations. Despite dry farming is usually practiced in Chianti region, supplemental irrigation (SI) could be necessary after prolonged drought periods to support the functioning of the vineyard. Supplemental irrigation and other agronomic practices connected with soil water status (e.g. cover crops) are in fact suggested from the disciplinary of production. Monitoring of the soil and crop water status in Chianti region can therefore represent an innovative practice to support the audits of drought characterizing the wine terroir of Central Italy. In this context, innovative tools are needed to implement and schedule SI, which among those is the wireless sensor network.

In this study, we developed a wireless sensor network (WSN) in two similar organic vineyards in Chianti region, (namely Montevertine, MV, and San Giusto a Rentennano, SG) to support and monitoring the audit process of the drought phenomena. WSN can be used: i) to provide farmers with a management tool to support supplemental irrigation and defining the time and amount of watering and ii) to offer to the policy makers a tool for environmental analysis, with the aim to assess objectively the occurrence of drought periods.

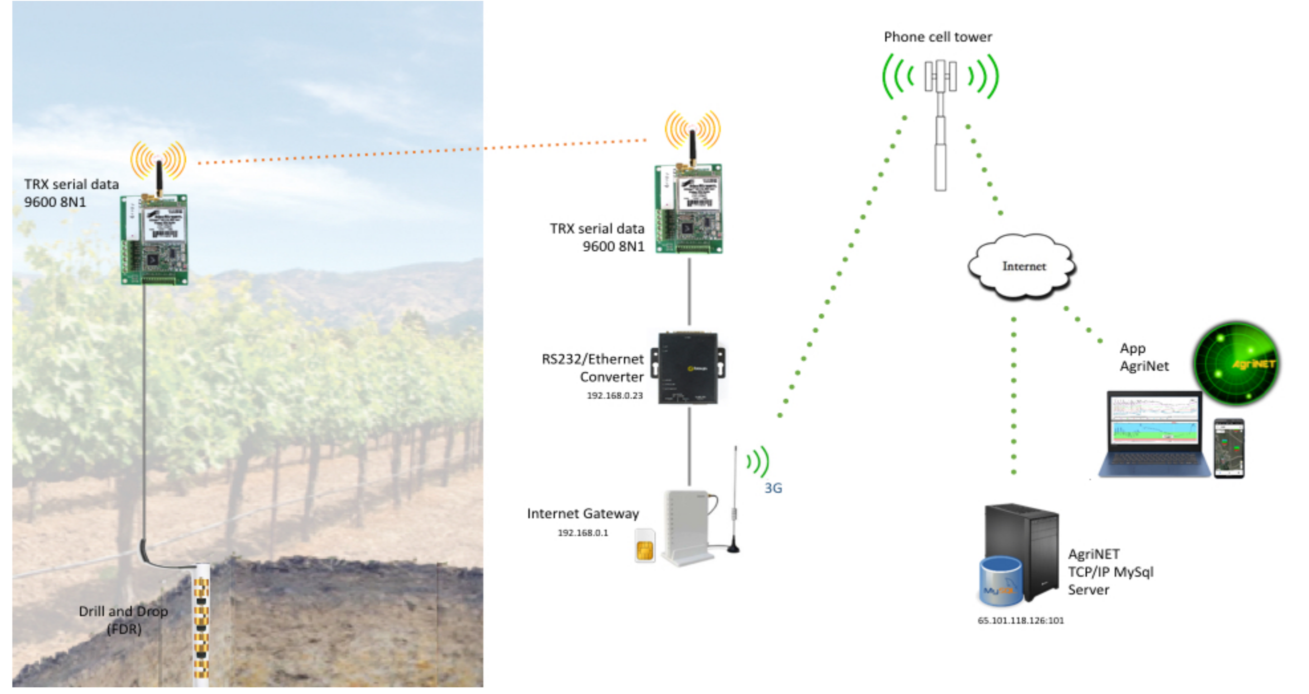
## WIRELESS SENSOR NETWORK

A Wireless Sensor Network (WSN) is an environment-embedded tool composed by sensors installed in the analyzed agro-ecosystem. The WSN is controlled by computer-based applications and integrated in web-cloud platforms.

Agrohydrological WSNs, based on the combination of soil-crop water status sensing technologies, represent robust systems to monitor, in real time, environmental forcing useful for the decision making processes related to smart and eco-friendly water management, as well as to detect the functioning status of the crop system.

Generally, a soil moisture based WSN includes easy-to-install down hole sensors probes.

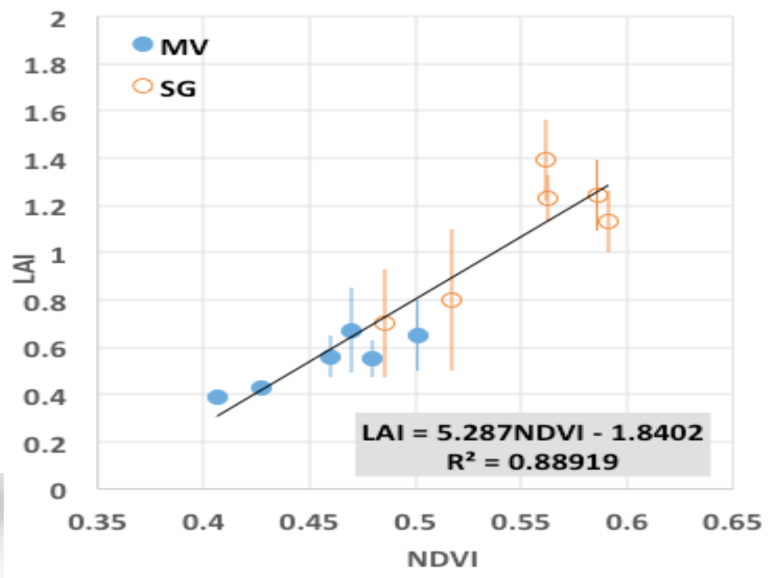
AgriNET (Tuctronics Inc.), is a smart platform in which probes use the MODBUS RTU protocol to be interfaced with a communications board, connected on internet by means of the cellular 3G data network. The connection is used to become a client of a TCP/IP server, that decodes the packet transmission and saves the data into a MySQL database operated by an user-friendly web interface.

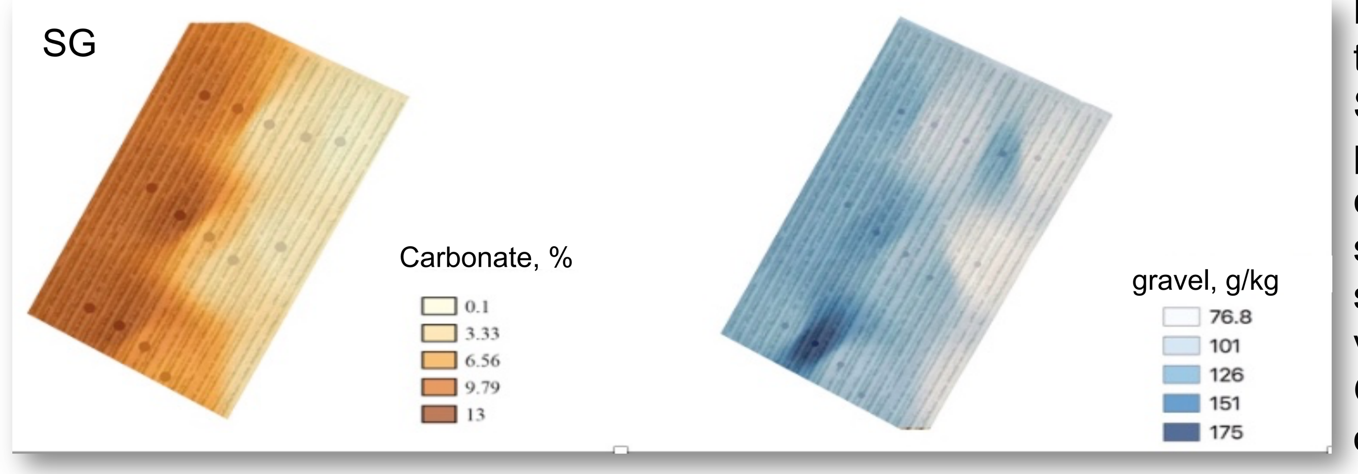


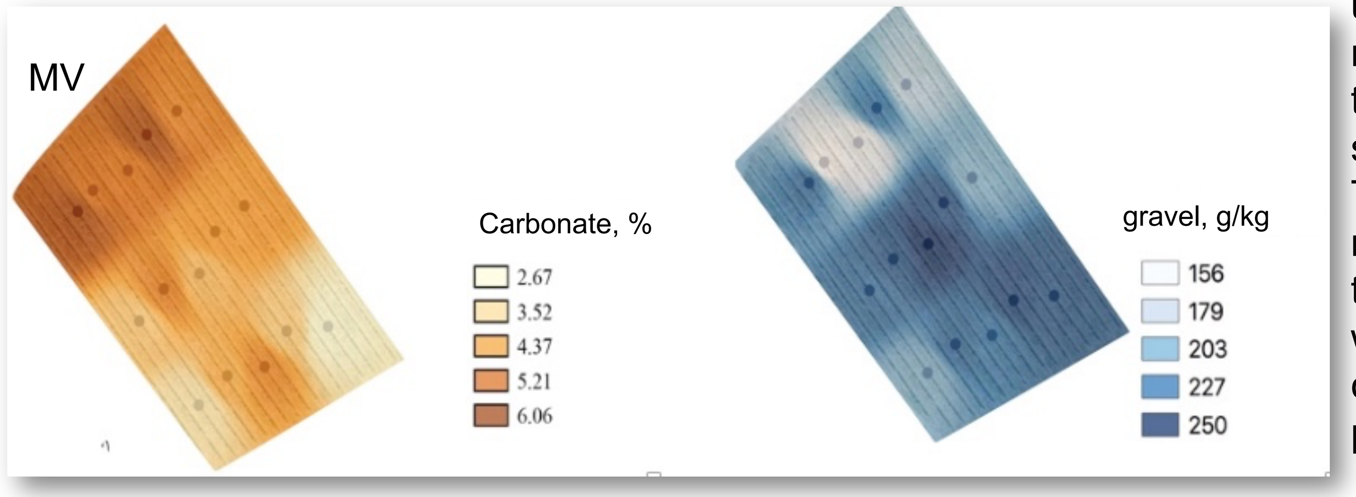

## ZONING PROCESS

The zoning analysis aimed to design the zones where at least one node of the WSN has to be installed. Unmanned aerial vehicle (Zephyr Exos) mounting a spectral camera (Parrot Sequoia +) allowed obtaining spectral vegetation index for an in-depth analysis of the spatial variability of the vineyards.






Normalize Difference Vegetation Index (NDVI, Rouse et al.,1974), Transforme Chlorophyll Absorption in Reflectance Index, (TCARI, Haboudane et al., 2002) and the Optimized Soil-Adjusted Vegetation Index, OSAVI (Rondeaux et al., 1996) were computed for this study.

Ground-based measurements of biophysical parameters were used for calibration purposes. Leaf Area Index, measured with LAI-2000 (Licor, Inc.), allowed the calibration of NDVI maps.

Soil physical and chemical properties, based on the content of carbonate and skeleton, allowed to explain the spatial variability of the vineyards.

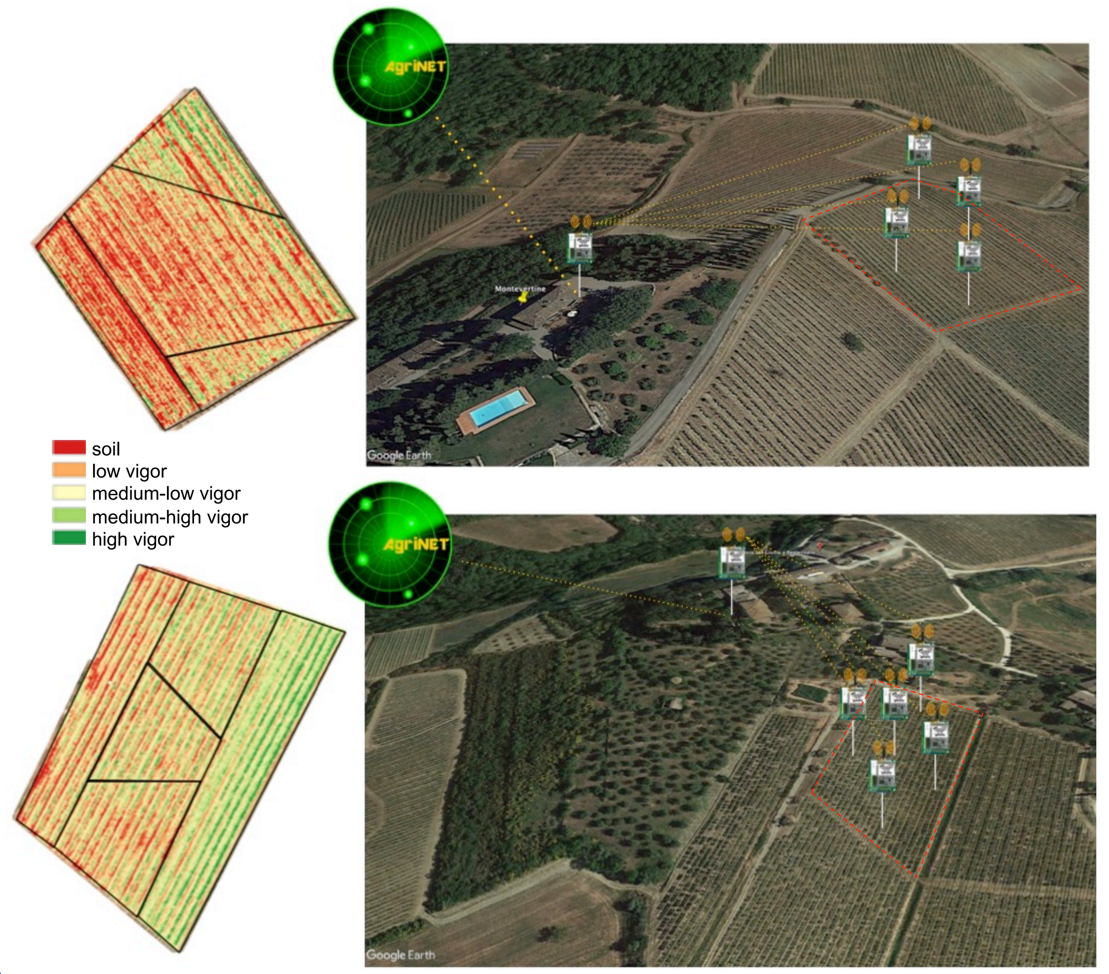
Geostatistical analysis, using open source GIS technology (Quantum GIS, QGIS) was used to represent the vigour maps as well as to spatialize the georeferenced data of the soil carbonate and the content. The skeleton percentage resulted higher, on average, in the soils collected in MV, whereas soils from SG were characterized by higher percentage of carbonate.

## FIRST RESULTS

The high correlation between the NDVI and LAI values ($R^2$= 0.89) indicates the appropriate calibration of the vigor maps for both farms using this parameter. The LAI values were generally higher in SG than in MV vineyard. Furthermore, SG shows a higher variability of LAI.

The two LAI-NDVI coupled data align on the same regression line, confirming that the NDVI is affected by the structure of the vineyard crown. In particular, this result is due at the same crop variety, as well as to the same soil and canopy management followed in both farms.

The map of spectral index in SG farm shows a gradient from NW to SE. This gradient is likely to be dependent on the combined action of soil skeleton and active carbonate, both more concentrated in the NW zone and degrading in the direction of SE. Thus, the topology for the WSN must be able to explain this gradient. Contrarily, MV, does not have homogeneous gradients, but a variability mainly associated to the distribution of gravel content.




The vineyard rows appear more vigorous in the area of the field around the north-corner, where a smaller content of gravel was observed. Therefore, the size and placement of the homogeneous areas are influenced by the presence of gravel and the active carbonate content.

The gravel content plays an important role on the hydrological features of the soil (strong effect on water retention), which affects the vigor of the plants. Moreover, the active carbonate content may immobilize iron and phosphorus, resulting in a nutritional deficiency for plants.

According to the experimental evidences, four and five zones have been identified in MV and SG, respectively.

## FUTURE DEVELOPMENTS

1. Installation of the WSN in both farms and implementation of sap-flux sensor (thermal dissipation probe, TDP) in each node.
2. Identification of specific drought index based on the forcing of soil-crop water status
3. Development of a Decision Support System (DSS) able to quantify the magnitude of the drought phenomena and to identify the timing of supplemental irrigation at local farm. The latter will represent an useful tool for policy makers in order to perform specific drought risk mitigation measures.

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