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MONITORING SOLUTIONS FOR SMART AGRICULTURE

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ABSTRACT. Over time, due to the increase in greenhouse gas emissions, several climatic changes have taken place: temperatures have risen, precipitation patterns have changed, glaciers have melted, sea and ocean levels have increased. The contemporary population needs irrigation systems adapted to the current environmental conditions. The introduction of monitoring solutions for smart agriculture represents a new way for implementation of an information system that can provide data on irrigation during all year. The need for a monitoring system for agriculture is argued by the market's interest in having access to fully automated solutions for energy-efficient and cost-effective crops. The advantages of system architecture: very low energy consumption, low management costs, scalability, forecasting functions, diagnosis, enlargement facility lead to an essential technical impact and high potential for marketing. This paper aims to use a monitoring system that will bring benefit to smart agriculture, considering energy efficiency criteria and the latest technologies available on the market.

Keywords: agriculture, irrigation, monitoring system, IoT

1. INTRODUCTION

Protecting natural water resources through rational and effective use of water is one of the issues with which it faces global specialists, and concrete and sustainable measures are needed. Irrigated agriculture accounts for 20% of the total cultivated land, with different irrigation solutions currently available, such as drip irrigation, irrigation surface leakage and sprinkler irrigation.

Irrigation programming have become the main subjects in numerous studies in recent years through the prism of importance in precision agriculture. Irrigation quality is an indicator of performance, the influence which can be perceived both directly and indirectly. The need for crop irrigation differs depending on the climate of the area, so energy efficiency and the economic use of water resources are strong interdependence with the type of plantation and soil (Suciu et al, 2017).

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Agricultural plants are extremely sensitive to climate change such as higher temperatures and changes in the precipitation area increase the chance of disease occurrence, leading to crop damage and even irreversible destruction of plants. Current advances in Internet of things (IoT) and Cloud Computing have led to the development of new applications based on highly innovative and scalable service platforms. IoT solutions have great potential in assuring the quality and safety of agricultural products.

Agriculture represents one of the important roles in the lives and well-being of people, is a process of producing food and a source of food for both the population and domestic animals.

Over time, the climate has undergone changes that people have had to adapt to and implicitly adapt the solutions used to ensure food or water quality, both irrigated and used daily (Jianyun et al, 2017). In the field of agriculture, crops need to be irrigated whenever necessary and only with the amount of soil required at that certain time of irrigation.

Determining the right time and quantity for irrigation is a complex process that considers certain information and parameters such as:

- type of culture;
- amount of water comes from the rainfall and lost by evapotranspiration;
- moisture level from plant roots;
- amount of water used for irrigation.

Irrigations are important in terms of:

- quality;
- efficiency of fertilizer application;
- soil salinity and oxygen content at its level;
- soil microorganisms;
- energy consumption.

The article gives the main control methods used in irrigation management, so that in the end to propose an integrated automation and telemetry solution for water management in precision agriculture, by considering the criteria of energy and economic efficiency, as well as the leading driving technologies presented.

The novelty of the work is to monitoring solutions for energy efficiency of the agricultural crops.

The rest of the paper is structured as follows: Section II presents related work for smart agriculture, Section III discusses about parameters monitored in irrigation, Section IV presents the experimental data, Section V results, and lastly, Section VI concludes the paper.

2. RELATED WORK

Researchers have wholly investigated factors influencing the adoption of advanced irrigation technology. Though, almost a few studies have introduced climate variables in functional analyses. Knowledge of irrigation technology adoption has often centered on small geographic areas, such as a single irrigation region. The geographic scope of such reviews can be too narrow to measure impacts of climate. Long-term climate proportions change limited over time, and localized studies may have deficient variation in climate to recognize for econometric analysis. Put, over too narrow a geographic range; potential climate variables do not vary (Frisvold et al, 2016).

Patricia Mejias Moreno addressed a survey of irrigation in the meaning of climate change. She set out several levels for climate change response in irrigation and focused the attention of (a) climate-proofing of investment plans for expanding large-scale irrigation systems, (b) location-specific appraisals for the credentials of response options, and (c) the attention of climatic drivers in the water cycle.

The fundamental climate change influences on the water cycle that affect irrigation are likely to shift in precipitation patterns (including increased intensity or lack of rainfall), inducing floods and droughts; raising air temperatures, causing heightened evapotranspiration, increased crop water demand; and rising sea levels, causing salinization of water supplies (FAO, 2017).

It is challenging to associate any single event directly to climate change; rising temperatures signify that the atmosphere can endure more water vapor, providing both for higher rates of rainfall and runoff when the air is steeped and for drier conditions unless. In other words, though overall rates of evaporation are not changing much, utmost in precipitation are becoming less familiar but more intense, and as an end, rainfall patterns are downshifting across the world.

Water is eternally a needy part of everyone's survival. Due to an environmental condition, water management and conservation will play a requisite role for human survivals. Lately, there were tremendous needs for consumer-based humanitarian projects that could be immediately improved using the Internet of Things (IoT). This introduces an IoT-based water monitoring scheme that measures the water level in real-time. The ideals are based on the level of the water can be an essential parameter when it comes to the flood particularly in disaster regions.

3. PARAMETERS FOR SMART AGRICULTURE

Measurement accuracy is essential in agriculture. Parameters monitored in a plantation are dependent on the type of soil and the climate of the region.

Proper irrigations and measurements are importance for agricultural productivity. Too much or too little water can affect plant health and, implicitly, crops (Gainwar et all, 2015).

There are several generally applicable parameters that influence crop quality:

- **pH value -** A pH of less than 7 indicates an acidic soil. If its value is greater than 7, then the soil is alkaline. A neutral soil has a pH value about 7. Typically, the most fertile soils are those with pH 6.5 and organic soils with pH 5.5;

- **air humidity -** Most of the crops are destroyed in predominantly wet climates. At the same time, moisture can be an essential factor for plants that grow best in high humidity conditions;
- **air temperature -** Temperature is a valuable physical property of the soil and controls many chemical and biological processes in the soil. To germinate the seeds, they need a specific temperature of the soil. If the temperature is too high or too low, the roots of the plants will be destroyed;
- **moisture** - Irrigations are completely dependent on the level of soil moisture. For good plant growth, it is necessary to maintain a certain level of moisture in the soil. A too high or very low level can harm or even damage the culture;
- **evapotranspiration** - refers to the estimation of the amount of water required to irrigate crops, based on evaporation physics (Jensen et al. 2016). Climate change can intensify the hydrological cycle and bring about changes in evapotranspiration, so this parameter requires thorough monitoring (Jung et al. 2010);
- **precipitations** - The limiting of water is decisive regarding plant development and maintenance of physiological and chemical processes. Regardless of the area where agricultural land is located, water has a fundamental role, and aspects of the quantity, duration, frequency, and intensity of precipitations are particularly important;
- **wind speed** - Prolonged exposure to strong winds increases the water demand for crops, due to increased evapotranspiration, and increases the risk of root cropping. At the same time, the strong wind has negative influences regarding pollination. Wheat gluten content and protein content in pasture grasses decreased due to the protection of these crops from total exposure to wind;

4. DESCRIPTION OF THE EXPERIMENTAL DATA

Telemetry for the crop monitoring system is performed with an ADCON station that will measure the field parameters, and these parameters are transmitted through the SCADA (Supervisory Control and Data Acquisition) system via a Remote Terminal Unit (RTU) and a communications server.

For the connection of these elements with the computer, Open Platform Communication (OPC) connections are required through a Gateway (e.g. IoT 2020 from Siemens).

The communication between programmable logic controllers (PLCs) and appropriate drive devices is achieved through GSM modules to reduce the physical complexity of the network (SCADA, 2018).

Based on the available data from the telemetry stations installed for crops, the parameters required for monitoring (air temperature, solar radiation, wind speed, relative air humidity, soil humidity) were determined to achieve the control and decision algorithm.

Figure 1 shows the farm and the main pipelines installed on the farm, from which the feed to drip crops is provided. The diameter of the pipe is 16 mm in diameter.

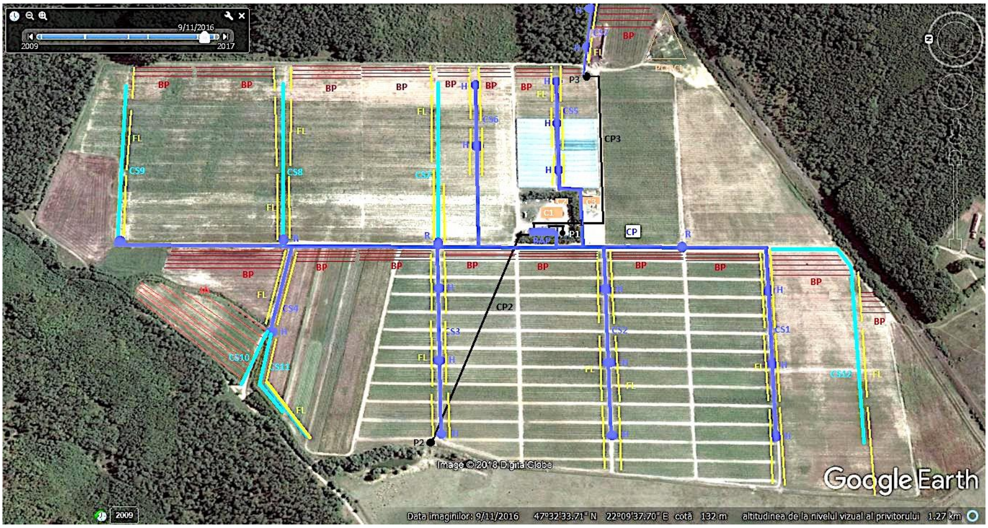

Fig. 1. The pipeline diagrams

The irrigation system was designed considering the necessary input data as well as the output data. Depending on the output data that is transmitted through a Cloud platform, it is determined how much water is needed to irrigate a farm farmed with tomatoes.

Input data

- air temperature (the value of interval is presented in Table 1)

Table 1. ***Range value of air temperature***

Air temperature [°C]	Color of value	Range
The ambient temperature in Celsius degrees obtained from the temperature sensor	very cold	[0 -15]
	cold	[15- 25]
	normal	[25- 35]
	warm	[35 - 45]
	very warm	[45 - 50]

- relative humidity (the value of interval is presented in Table 2)

Table 2. Air r*elative humidity*

Air humidity [%]	Language value	Range
	low	[0 - 30]
	medium	[30 - 60]

Relative humidity (RH) of the medium expressed as a percentage [0% - 100%]	high	[60 -90]
	very high	[90 - 100]

- leaf – level humidity (the value of interval is presented in Table 3)

The most important thing is measure humidity at the level of the lowest leaves of the plant. The sensor is designed to work by mimicking the characteristics of leaf plants in terms of size, weight and dew

Table 3. Leaf-level humidity

Leaf level humidity [U]	Language value	Range
Lead moisture expressed in units [0 - 20]	dry	[0 – 6]
	normal	[6 -12]
	wet	[12 -18]
	very wet	[18 -20]

- precipitations (the value of interval is presented in Table 4)

Table 4. Precipitations - the amount of rain

Precipitations [mm/h]	Language value	Range
Precipitation in mm / h [0 - 20]	low	[0 - 3]
	medium	[1 - 3]
	high	[5 - 7]
	very high	[7 -20]

Precipitations have a significant role, contributing directly to soil moisture.

After they have been input as input data, they are analyzed using the SCADA system via a RTU and the output data show if the soil has enough humidity and if irrigation is required.

Output data represented by water shortage is presented in Table 5.

Table 5. ***Water shortage***

Water shortage	Language value	Range
Water deficit refers to the missing water requirement to have a good soil moisture	normal	[0 -0.51]
	low	[0.51 - 1.52]
	medium	[1.52 - 2.53]
	high	[2.53 - 3.5]

5. RESULT DATA

For simulation, a series of real data from the ADCON platform was used as input data (Suciu et al, 2015). An example is shown in Figure 2, in which we have a graph plotted over a chosen time interval, the four inputs: relative humidity, leaf-level humidity, precipitation, and temperature.

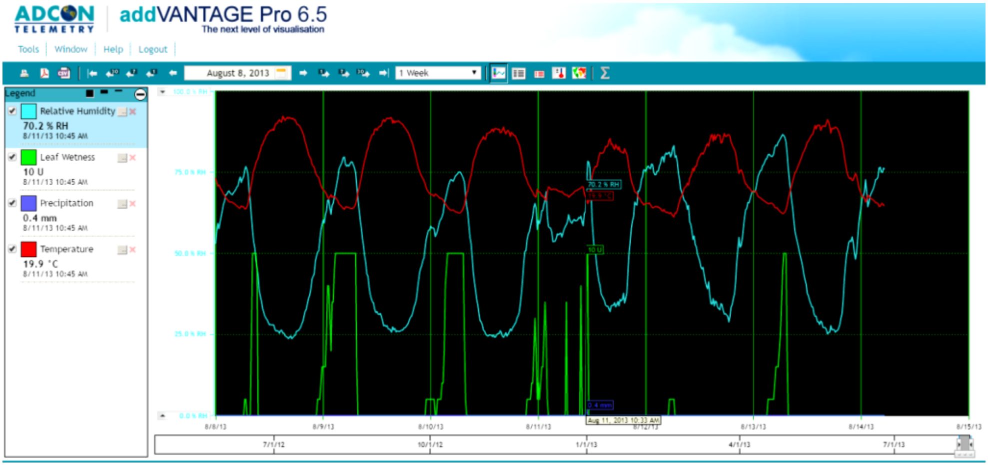

Fig. 2. ADCON input data

Experimentation using input data:

- air temperature = 19.9 ° C
- relative humidity = 70.2%
- leaf-level humidity = 10 U
- precipitations = 0.4 mm. As we can see the value of precipitation is low and is in the range [0 – 3]

We generate these input values in the set using the SCADA system via a RTU. According to this data set we obtained the output:

- deficit-water = 1.75 with the low-medium water deficit.

The output flow difference with reference flow is "low-positive". Which results to fit the "open a little" valve. According with Table 5 the water deficit refers to the missing water requirement to have soil moisture is medium, so the soil is almost irrigated.

6. CONCLUSION

All irrigation management and control systems should adapt to current climate conditions and respond to water need to increase crop productivity. The proposed method can have applications in various fields involving smart irrigation, ranging from agriculture and viticulture to vegetable greenhouses, fruit trees or flowers.

The solution also provides increased efficiency because it has low energy consumption, reduces the risk of disease, low administration costs and features forecasting and diagnosis functions that lead to a high technical and marketing impact.

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